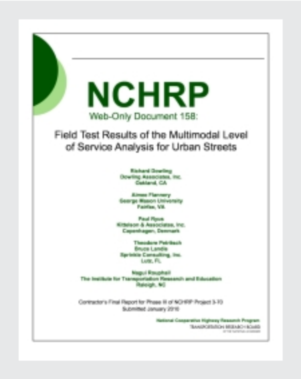


Field Test Results of the Multimodal Level of Service Analysis for Urban Streets

DETAILS

0 pages | null | PAPERBACK
ISBN 978-0-309-43002-9 | DOI 10.17226/22953

AUTHORS

NCHRP

Web-Only Document 158:

Field Test Results of the Multimodal Level of Service Analysis for Urban Streets

Richard Dowling
Dowling Associates, Inc.
Oakland, CA

Aimee Flannery
George Mason University
Fairfax, VA

Paul Ryus
Kittelson & Associates, Inc.
Copenhagen, Denmark

Theodore Petritsch
Bruce Landis
Sprinkle Consulting, Inc.
Lutz, FL

Nagui Rouphail
The Institute for Transportation Research and Education
Raleigh, NC

Contractor's Final Report for Phase III of NCHRP Project 3-70
Submitted January 2010

National Cooperative Highway Research Program
TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

ACKNOWLEDGMENT

This work was sponsored by the American Association of State Highway and Transportation Officials (AASHTO), in cooperation with the Federal Highway Administration, and was conducted in the National Cooperative Highway Research Program (NCHRP), which is administered by the Transportation Research Board (TRB) of the National Academies.

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. On the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Ralph J. Cicerone is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Charles M. Vest is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, on its own initiative, to identify issues of medical care, research, and education. Dr. Harvey V. Fineberg is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both the Academies and the Institute of Medicine. Dr. Ralph J. Cicerone and Dr. Charles M. Vest are chair and vice chair, respectively, of the National Research Council.

The **Transportation Research Board** is one of six major divisions of the National Research Council. The mission of the Transportation Research Board is to provide leadership in transportation innovation and progress through research and information exchange, conducted within a setting that is objective, interdisciplinary, and multimodal. The Board's varied activities annually engage about 7,000 engineers, scientists, and other transportation researchers and practitioners from the public and private sectors and academia, all of whom contribute their expertise in the public interest. The program is supported by state transportation departments, federal agencies including the component administrations of the U.S. Department of Transportation, and other organizations and individuals interested in the development of transportation. **www.TRB.org**

www.national-academies.org

Table of Contents

List of Exhibits

Acknowledgments

The research reported herein is Phase 3 of NCHRP Project 3-70. It was performed by Dowling Associates, Inc., Oakland, California.

Dr. Aimee Flannery of George Mason University conducted the Arlington County, Virginia workshop, assisted in data collection and analysis, and provided advice regarding the performance and assessment of the auto level of service model.

Dr. Nagui Rouphail of the North Carolina State University conducted the assessment of the field test results for the auto level of service model.

Mr. Paul Ryus, with the assistance of Mark Vandehey, Christopher Tiesler, and Nick Foster, all of Kittelson Associates conducted the Boise, Idaho and Portland, Oregon workshops, and assisted local agency personnel in the data collection and analysis.

Mr. Bruce Landis, Mr. Theodore Petritsch, and Peyton McLeod of Sprinkle Consulting, Inc., conducted the Atlanta, Georgia, and San Antonio, Texas workshops. They also assisted local agency personnel in data collection and analysis. They provided advice on the assessment and refinement of the bicycle and pedestrian LOS models.

The authors would like to thank the management and staff at the following agencies for participating in the field testing of the NCHRP 3-70 multimodal level of service models.

Arlington County, Virginia
Atlanta Regional Commission, Georgia
City of Boise and ADA County Highway District, Boise, Idaho
Delaware Valley Regional Planning Commission, Philadelphia, Pennsylvania
City of Portland, City of Hillsboro, City of Gresham, Oregon
San Antonio-Bexar County Metropolitan Planning Organization, San Antonio, Texas
City of San Diego, California

The authors are indebted to the Florida Department of Transportation for funding and hosting their own extensive series of workshops and field tests of the NCHRP 3-70 method by the metropolitan planning organizations of Tallahassee, Tampa, and Orlando, Florida.

Abstract

The objective of the first two phases of NCHRP 3-70 project was to develop and test a framework and enhanced methods for determining levels of service for automobile, transit, bicycle, and pedestrian modes on urban streets, in particular with respect to the interaction among the modes. Phase 2 resulted in the multimodal level of service method (MMLOS) described in NCHRP Report 616, *Multimodal Level of Service for Urban Streets*.

The objective of phase 3 of NCHRP 3-70 was to field test the MMLOS method with various public agencies around the United States. This Final Report presents the results of this third phase 3 of the research

During Phase 3 the MMLOS method was field tested in 10 metropolitan areas of the United States. Public agency staffs were trained on the MMLOS method and it's implementing software. They assisted in data collection and evaluated the suitability the MMLOS method for use within their agency. Based on the results of these field tests several revisions were made to the spreadsheet software for implementing MMLOS. Additional guidance was provided to deal with conditions encountered in the field that were not anticipated when the original guide, NCHRP Web-Only Document 128, was written. Finally, a few minor modifications to the pedestrian level of service model are recommended to improve its sensitivity to some of the conditions encountered in the field tests.

Executive Summary

Phases 1 and 2 of NCHRP 3-70 resulted in the multimodal level of service method (MMLOS) described in NCHRP Report 616, Multimodal Level of Service for Urban Streets. A Users' Guide was also prepared, NCHRP Web-Only Document 128. Both documents were published in the second half of 2008. The Final Report is available in both printed and electronic forms.

The objective of phase 3 of NCHRP 3-70 was to field test the MMLOS method with various public agencies around the United States. This Final Report presents the results of Phase 3 of this research

During Phase 3 the MMLOS method was field tested in 10 metropolitan areas of the United States. The field tests had the following objectives:

1) To obtain public agency perspectives on the accuracy of the MMLOS level of service ratings for their community,
2) To identify any data collection difficulties that might discourage public agencies from applying the MMLSO method,
3) To identify any gaps in the guidance provided with MMLOS, and
4) To determine if any refinements to the MMLOS models would be appropriate.

Public agency staff was extensively involved in the field tests. Agency staff was trained on the MMLOS method and software. They often performed the data collection, with assistance from the research team. This extensive involvement was primarily for the reason of helping public agency staff completely understand the MMLOS method so they could give accurate feedback on the method. But it also had the serendipitous result of establishing a core group of knowledgeable MMLOS users to help spread the news about MMLOS among public agencies in the United States. These field tests have resulted in several requests from additional agencies and local sections of the Institute of Transportation Engineers for presentations and workshops on the MMLOS method.

Based on the results of these field tests several revisions were made to the spreadsheet software for implementing MMLOS. The spreadsheet reached version 10.5b by the conclusion of the field tests. The mid-block pedestrian crossing delay calculation was refined to take into account large medians. Several additional input error checks were added to the software. Input formats were revised to better facilitate data entry by public agency personnel.

Additional guidance was provided during the course of the workshops and field tests to deal with conditions encountered in the field that were not anticipated when the original guide, NCHRP Web-Only Document 128, was written. This additional guidance is documented in the "Results" section of this final report.

Finally, a few minor modifications to the pedestrian level of service model are recommended to improve its sensitivity to some of the conditions encountered in the field tests. These are also documented in the "Results" section of this final report.

1. Introduction

Public agencies need to be able to evaluate the transportation services of their roadways from a multimodal perspective. They need to be able to assess the tradeoffs when they reconstruct existing streets or design new streets to better serve all of the modal users of their facilities (auto, transit, bicycle, and pedestrian). This ability is needed to better meet the objectives of the Transportation Equity Act for the 21st Century (TEA-21) and its predecessor the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) for better incorporating the perspectives and needs of transit, pedestrian, and bicycle users into the planning, design, and operation of the U.S. transportation system.

The objective of the first two phases of the NCHRP 3-70 project was to develop and test a framework and enhanced methods for determining levels of service for automobile, transit, bicycle, and pedestrian modes on urban streets, in particular with respect for the interaction among the modes. The first two phases of NCHRP 3-70 resulted in a published final report, NCHRP Report Number 616, "Multimodal Level of Service for Urban Streets", and a "User's Guide", NCHRP web-only document Number 128.

Research Objective

The objective of Phase 3 of the NCHRP 3-70 project has been to field test the recommended methodology with various public agencies around the United States.

This objective was accomplished through training of public agency technical staff on the NCHRP 3-70 multimodal level of service (MMLOS) method, testing the method on various prototypical urban streets, and obtaining feedback from public agencies on any needed refinements to make the MMLOS method a useful tool for evaluating the multimodal level of service provided by urban streets.

The Research Plan

The research plan consisted of the following tasks:

0. Development of Amplified Work Plan
1. Recruit Volunteer Agencies
2. Training of Agencies
3. Data Collection for Test Arterials
4. Analysis of Level of Service for Test Arterials
5. Assessment of Results of Tests
6. Refinement of Multimodal LOS Methods
7. Final Report

This Report

This report is organized into three chapters.

Chapter 1: Introduction, describes the objectives of the Phase 3 research, its work plan, and the organization of this report.

Chapter 2: Field Test Procedures, describes the various steps of the field testing process.

Chapter 3: Results, presents the results of the field tests for each modal level of service model and identifies any recommended refinements to the models and any suggested additional guidance for applying the level of service methods.

2. Field Test Procedures

This chapter describes the steps (tasks) involved in the field testing procedures employed in Phase 3 of the NCHRP 3-70 project.

Task 0. Amplified Work Plan

The objective of this task was to provide a detailed expansion of the approved research plan, along with refinements to the budget and schedule in response to Senior Program Officer and Panel comments. The Amplified Work Plan was submitted April 22, 2008. Panel comments were received June 3, 2008. The Revised Amplified Work Plan was submitted August 26, 2008.

Task 1. Recruit Volunteer Agencies

The objective of this task was to identify and recruit volunteer public agencies willing to contribute staff time learning, applying, and evaluating the NCHRP 3-70 Multimodal Level of Service (MMLOS) method. An adequate cross section of agencies operating urban streets in the United States was desired within the time and budget resources of the Phase 3 Continuation Project.

The following volunteer agencies were selected and recruited to participate in the Phase 3 field tests:

1. Arlington County, Virginia
2. Atlanta Regional Commission (ARC), Georgia
3. City of Boise and ADA County Highway District, Boise, Idaho
4. Delaware Valley Regional Planning Commission (DVRPC), Philadelphia, Pennsylvania
5. City of Portland, City of Hillsboro, and City of Gresham, Oregon
6. San Antonio-Bexar County Metropolitan Planning Organization, San Antonio, Texas
7. City of San Diego, California

The Florida Department of Transportation (FDOT), through a separate contract, also arranged for the participation of state highway planners and engineers, metropolitan planning organizations and cities in the following metropolitan areas: Tallahassee, Gainesville, and Tampa, Florida. These workshops and field tests were conducted by Scott Washburn of the University of Florida and his team, who prepared a report on the results of those workshops for FDOT.

Task 2. Training Session, Selection of Field Test Arterials

The objective of this task was to train the agency personnel on the NCHRP 3-70 MMLOS method and to select arterials for testing the method. Initial workshops and arterial selection were conducted at the locations and dates listed below. Summaries of the workshops, the arterial test results, and agency comments are provided in the attachments.

Exhibit 1: Test Agencies

Agency/Location	Initial Workshop	Arterials Tested	Comments
1. Gainesville, Florida	October 2, 2008	4	sponsored by FDOT
2. Tampa, Florida	October 2, 2008	4	sponsored by FDOT
3. Tallahassee, Florida	October 2, 2008	4	sponsored by FDOT
4. Orlando, Florida	October 2, 2008	3	sponsored by FDOT
5. Philadelphia, Pennsylvania	November 13, 2008	3	Hosted by DVRPC
6. San Diego, California	December 10, 2008	2	Hosted by City of San Diego
7. Arlington, Virginia	January 9, 2009	3	Hosted by Arlington County
8. Atlanta, Georgia	January 22, 2009	5	Hosted by ARC
9. San Antonio, Texas	March 4, 2009	3	Hosted by San Antonio-Bexar
10. Boise, Idaho	March 18, 2009	3	Hosted by Kittelson Associates
11. Portland, Oregon	March 19, 2009	4	Hosted by Kittelson Associates

Task 3. Data Collection

The objective of this task was to perform the data collection necessary to apply the 3-70 MMLOS method in each jurisdiction. The Philadelphia and San Diego area data collection efforts were completed on the same day as the workshop. The Florida test arterials data collection was funded by FDOT and completed by their contractor under their supervision. The data collection efforts for the remaining cities were conducted by NCHRP 3-70 team members and the host agencies prior to the day of the workshop. The data collection efforts are described in more detail in the attached summaries of the arterial testing by metropolitan area.

Task 4. Analysis

The objective of this task was to estimate the existing level of service for each selected street within each jurisdiction. Agency staff entered the data into the MMLOS spreadsheet under the supervision and guidance of members of the NCHRP 3-70 research team. The MMLOS spreadsheet then estimated the LOS using 4 different auto models (the recommended NCHRP 3-70 stops model, the alternative NCHRP 3-70 speed model, the current HCM 2000 model, and the proposed NCHRP 3-79 percent free-flow speed model, plus the NCHRP 3-70 recommended transit, bike, and pedestrian models. For San Antonio, Texas two additional variations on the bike model and two additional variations on the pedestrian LOS model were tested. Details of these tests are provided in the attached test summaries.

Exhibit 2: Field Test Results

City	Street	HCM Auto LOS	3-70 Auto LOS	3-70 Transit LOS	3-70 Bike LOS	3-70 Ped LOS
Arlington	Wilson	**F**	D	A	**F**	C
	Glebe	D	C	B	E	D
	George Mason	C	B	**F**	D	B
Atlanta	Bullsboro	D	B	**F**	E	E
	17th	B	B	B	B	C
	Buford	C	B	B	**F**	E
	Cobb	C	B	C	**F**	**F**
Boise	Capitol	E	D	C	D	D
	Broadway	E	B	A	E	D
	State	A	B	C	E	E
Gainesville	Archer	A	B	E	E	D
	13th St	C	B	C	E	D
	University	C	B	C	D	C
	Tower	B	B	E	E	C
Philadelphia	Spruce	D	E	**F**	D	B
	Broad	C	B	A	E	B
	Chestnut	E	B	A	C	A
Portland	Burnside	D	C	C	D	D
	39th Ave	E	C	B	**F**	D
	185th Ave	**F**	C	B	C	C
	Powell	B	B	A	C	C
San Antonio	San Pedro	A	B	A	**F**	D
	Zarzamora	B	B	C	E	D
	Broadway	B	B	A	E	D
	Basse	C	**F**	**F**	E	E
San Diego	Broadway	E	D	A	D	B
	India	A	B	**F**	D	C
Tallahassee	Capital Circ	A	B	**F**	E	D
	Macomb	A	B	**F**	D	C
	Tennessee	B	B	A	E	C
	Appleyard	A	B	D	D	C
Tampa	Himes	C	**F**	D	**F**	D
	Nebraska	D	B	B	E	E
	US 41	A	B	**F**	E	E
	Kennedy	A	B	A	D	D

Level of service "E" and "F" results are shaded.

Task 5. Assessment

The objective of this task was to obtain local agency assessments of the 3-70 MMLOS method (data requirements, analytical methods, and results). Detailed summaries of participant comments are provided in the workshop reports attached.

The workshops suggested the strong need for improved guidance on the use of the methodologies. Users not accustomed to multimodal LOS analysis were put-off by the data collection requirements. Information on variable defaults, data collection short cuts, and sensitivities would be an extremely valuable addition to the model guidance. FDOT has already done much to simplify data needs for its agencies by developing software, reducing the range of conditions that can be evaluated and embedding defaults in the software.

Florida and Portland believed that the bike LOS results should have been better than what they obtained using MMLOS. San Diego thought the MMLOS bike LOS results were too good, but that was for a case of bikes using a bus street where the buses stopped in the only available travel lane in each direction.

Florida users, accustomed to the FDOT bike and pedestrian models, were puzzled why the overall facility LOS produced by the MMLOS models were so different at times from the individual segment and intersection results produced by the FDOT models upon which the MMLOS models were based.

The driveway interference (for bikes) and roadway crossing difficulty (for pedestrians) are two new factors in the NCHRP 3-70 MMLOS bike and pedestrian models that were not present in the original FDOT bike and pedestrian segment and intersection models. These new factors can cause the overall LOS for the whole street to be worse than FDOT LOS for the individual segment and intersection components.

Portland was concerned that their bike boulevards might produce an unrealistically low bicycle LOS in the MMLOS because of the numerous low volume, low speed driveways on these streets. This potential problem could conceivably be solved by combining a series of low volume, low speed driveways into a single high volume driveway for the purposes of coding the MMLOS model inputs. For example, 10 single family residential driveways in the field might be considered to be the equivalent of 2 standard driveways for the purposes of the MMLOS model inputs.

Reactions to the four auto LOS models varied. The results of the 4 models were within 1 level of service of each other in the preponderance of field tests (see attached evaluation of the auto model results by Dr. Nagui Rouphail). Portland had one case where the auto speed LOS and the auto stops LOS diverged significantly. This happened on one street with closely spaced signals where there were few stops measured in the field, but speeds in the field were significantly below the free-flow speed. It is a short segment with long delays at the downstream signal. Thus, only one stop was measured, but the average speed was quite low.

Agency personnel from Florida, Portland, and San Diego expressed a strong preference for keeping the current HCM 2000 Auto LOS model. San Diego was concerned about explaining the new auto LOS model to developers currently undergoing their development review process.

Task 6. Refinement

The objective of this task was to make the refinements to the MMLOS method, its User's Guide, and the software engine identified in the previous task.

The majority of the refinement work was on the software engine implementation of the MMLOS method. However a few methodological refinements have also been made to improve the midblock pedestrian crossing delay computation.

Two new versions of MMLOS (version 7 and 8) were made in November 2008 in response to comments received from the Florida users of MMLOS version 6, and in response to comments raised at the Philadelphia workshop. The following refinements to the methodology were implemented in version 8 of MMLOS.xls:

1. Reduced the arterial crossing distance used in the computation of the roadway crossing difficulty factor to exclude the shoulder/parking lanes, bike lanes, and median.
2. Changed guidance for applying roadway crossing difficulty factor. It is no longer recommended that it be turned off if jay-walking is illegal. It is now user discretion whether or not to include it in the Pedestrian LOS computation.
3. Corrected the computation of the traffic volume for pedestrian and bike LOS. This was a software error, not a methodological error.
4. Corrected computation of delay for pedestrians crossing midblock. Original method assumed that mean pedestrian wait time at a signal was equal to half the wait time per cycle. The correct value is one half of the wait time per cycle squared divided by the cycle length.
5. Defined the distance between intersections as being from stop bar to stop bar to be consistent with HCM 2010 definition. Delay at downstream signal to get to downstream cross bar is included in upstream segment.

Questions from the NCHRP 3-92 contractor about the computations for the bicycle segment LOS were addressed and resolved. The NCHRP 3-92 contractor also identified some computational inconsistencies (described below) which were addressed in version 9 of MMLOS.

The following refinements identified by the NCHRP 3-92 contractor and others identified by the NCHRP 3-70 team were incorporated in Version 9:

6. Added new pedestrian space computation (area per pedestrian). Needed for next fix below.
7. Fixed discrepancy between pedestrian density and non-density LOS numerical equivalencies. (identified by NCHRP 3-92 contractor)
8. Added two stage pedestrian midblock crossing delay computation if median is 6 feet or greater.(employs method suggested by NCHRP 3-92 contractor)
9. Corrected incorrect bus PTTR parameters for CBD and non-CBD (identified by NCHRP 3-92 contractor)
10. Fixed transit Fh equation to match users guide (identified by NCHRP 3-92 contractor)

11. Macros written and added to automate printing, updating, and clearing (identified by NCHRP 3-70 team)
12. Removed references to external spreadsheets (identified by NCHRP 3-70 team)
13. Fixed error in computation of average stops per mile over whole arterial (identified by user)
14. Various cosmetic improvements to improve usability of software engine (identified by users and the NCHRP 3-70 team).

The following refinements were added to version 10 of the MMLOS spreadsheet in late January 2009 to facilitate data entry and provide warnings about a few user coding errors:

15. Changed “feet per tree” fields to “number of trees”
16. Added warning message if Buffer space is zero and trees are non-zero
17. Added warning message if parking lane is <=7 feet and parking occupancy is non-zero
18. Added warning message if Buffer is zero and trees are non-zero
19. Added warning message if parking lane is <=7 feet and parking occupancy is non-zero
20. Changes to several fields to trap for divide by zero problems if less than 5 segments present
21. Changed pedestrian multistage crossing formula to use values in "parameters" sheet. The formula now tests for minimum median width and type.

The following refinements were added to version 10.3 of the MMLOS spreadsheet in late March 2009 in response to Boise and Portland workshop comments.

22. Fixed bad reference in segment 5 to left turn type for auto los computation.
23. Changed description of cross-street data entry field from 2-way vph to 1-way vph/lane to match definition of variable for pedestrian intersection LOS computation
24. Changed bike and pedestrian segment LOS reports to show segment and intersection results separately, The pedestrian and bicycle facility LOS is now shown only for total facility
25. Added check to pedestrian density computation for zero or negative ped flow rates
26. Highlighted all data entry fields with orange background (user request).
27. Added ability to select among the 4 auto LOS models for reporting auto LOS results

A special version 11 of the MMLOS spreadsheet was created for Sprinkle Consulting on March 1, 2009 to test alternative bicycle and pedestrian LOS models. The results of those tests are reported in their attached summary of the San Antonio field tests.

The following refinements were added to version 10.5 of the MMLOS spreadsheet in late April, early May 2009 to address issues identified by the NCHRP 3-92 contractor and Sprinkle Consulting regarding the bicycle and pedestrian LOS computations:

28. Removed duplicate application of peak hour factor to auto volumes in bike intersection and segment LOS.
29. Removed duplicate application of peak hour factor to auto volumes in ped segment LOS.
30. Fixed computation of average effective width for bike LOS to match eqn 31, page 83 Report 616.
31. Added Check for Less Than Zero effective width for bike LOS model.

3. Results

Based upon the field tests and the feedback obtained from the various agencies participating in the field tests, the research team recommends the refinements to the MMLOS method and User's Guide described in the sections below.

Auto LOS Model

An extensive field evaluation of the NCHRP 3-70 auto model and three alternative models was conducted (see attached evaluation white paper by Dr. Nagui Rouphail).

Methodology

The NCHRP 3-70 model and the current HCM auto LOS model produced LOS grades equal to or within 1 letter grade of service for 26 out of the 35 streets field tested.

As shown in the Final Report (NCHRP 616) (reproduced in Exhibit 4 below) the NCHRP 3-70 auto model fits the laboratory results much better than the current HCM auto LOS model. The 3-70 model matched the laboratory results for 69% of the clips, while the HCM 2000 model matched only 26% of the clip results.

Consequently no changes are recommended for the NCHRP 3-70 auto LOS model.

User Guide

The research team spotted a few typos in Exhibit 9 of the User's Guide. The parameters for the Adverse Signal Progression and No Signal Coordination rows have been switched. These parameters are used to predict stops per mile if the analyst cannot field measure stops or obtain a satisfactory analytical tool for predicting stops. The corrected table is provided below.

Exhibit 3: Parameters for Auto Stops per Mile Equation

Signal Progression	Arrival Type	A1	A2	A3
Adverse Signal Progression	1,2	0.636	5.133	0.051
No Signal Coordination	3	0.478	6.650	0.028
Good Signal Progression	4,5,6	0.327	9.572	0.013

Exhibit 4: Evaluation of Proposed Auto LOS Models

Clip #	Street	Art Class	Spd Lim (mph)	Actual (mph)	Stops (stps/mi)	Left Ln (%)	Med (1,2,3)	Video LOS	HCM LOS	Model #1 LOS	Model #2 LOS
61	Rt 50	1	50	28	1.4	100%	0.00	A	C	B	C
56	Sunset Hills Rd	2	40	23	2.0	100%	3.00	A	C	B	A
2	Gallows Road	3	35	35	0.0	100%	3.00	B	A	B	A
65	Lee Hwy	2	40	36	0.0	100%	2.00	B	A	B	A
63	Rt 50	1	50	42	0.0	100%	3.00	B	A	B	A
5	Wilson Blvd	3	35	30	0.0	100%	3.00	B	B	B	A
62	Rt 50	1	50	37	0.0	100%	0.00	B	B	B	A
13	Washington Blvd	3	35	25	0.0	0%	0.00	B	B	B	A
7	Wilson Blvd	3	35	20	0.0	100%	1.00	B	C	B	B
54	Lee Hwy	2	40	25	3.3	100%	2.00	B	C	B	A
53	Prosperity	2	40	19	1.7	100%	3.00	B	D	B	B
6	Clarendon	3	35	18	2.3	100%	1.00	B	D	B	B
10	Washington Blvd	3	35	17	3.8	0%	0.00	B	D	C	C
20	Rt 50	1	50	16	1.8	100%	3.00	B	E	B	C
64	Rt 50	1	50	20	2.0	100%	3.00	B	E	B	B
58	Sunrise Valley Rd	2	40	11	1.7	100%	3.00	B	F	B	C
1	Rt 234	1	50	15	2.0	100%	3.00	B	F	B	C
29	Rt 234	2	40	23	2.0	100%	3.00	C	C	B	A
19	23rd St	4	30	16	5.8	0%	0.00	C	C	C	C
12	Wilson Blvd	3	35	14	4.3	0%	0.00	C	D	C	D
60	Lee Hwy	2	40	15	2.0	100%	2.00	C	E	B	C
21	Rt 50	1	50	20	4.0	100%	3.00	C	E	C	B
8	Wilson Blvd	3	35	14	4.1	100%	1.00	C	E	C	C
52	M St	4	30	8	7.3	0%	0.00	C	E	D	E
55	Braddock Rd	2	40	13	2.2	100%	3.00	C	F	B	C
59	Sunset Hills Rd	2	40	12	4.9	0%	0.00	C	F	C	E
15	Glebe Road	2	40	8	6.0	100%	3.00	C	F	C	D
14	Glebe Road	2	40	11	6.0	100%	3.00	C	F	C	C
57	Sunset Hills Rd	2	40	17	3.3	0%	0.00	D	D	C	D
16	Fairfax Drive	3	35	12	7.3	100%	3.00	D	F	C	C
51	M St	4	30	7	9.1	0%	0.00	D	F	D	E
25	M St	4	30	11	3.7	0%	0.00	E	D	C	D
23	M St	4	30	8	5.6	0%	0.00	E	E	C	E
30	M St	4	30	7	14.5	0%	0.00	F	F	F	E
31	M St	4	30	4	18.0	0%	0.00	F	F	F	F
% Exact Match To Video								100%	26%	69%	37%
% Within 1 LOS of Video								100%	46%	94%	89%

Source: NCHRP Report 616
Note that several different sections or time periods of the same street were used for many of the clips.

Transit LOS Model

The field tests indicated no issues with the output of the transit LOS model. The difficulties were generally on the data collection side. Engineers and planners unfamiliar with working with local transit agency personnel generally expressed the most concerns about gathering the transit service data.

Methodology

No changes are recommended for the transit LOS model.

User Guide

Obtaining field data on transit service characteristics for the specific section of the routes serving the analysis street section was a concern to many potential users of the transit LOS method. Over the course of several workshops various methods were developed for approximating field measurements through the use of data already being regularly collected by transit agencies for their own management needs.

Many transit agencies regularly collect data on the peak passenger load points and on-time performance for each of the routes they operate. This data is not usually available by specific street segments. However, if one considers that the transit riders on any given street probably experienced the peak loading conditions and reliability of the route somewhere during their trip; it can be a reasonable approximation to apply this route data to the street being evaluated for transit LOS. This approach appeared to provide a cost-effective and reasonable substitute for measuring reliability and passenger load factors in the field.

Similarly, rather than going to the expense of measuring bus speeds in the field an analyst can consult the published bus route schedules to obtain an average point to point speed for the portion of the bus route within which the analysis street section is located. The schedule speed will not be identical to the actual street section speed for the bus, but unless conditions on the analysis street section are very different from the rest of the bus route, it should be close enough to assess the transit level of service for the street.

In the field tests, these approximations to field data collection appeared to be sufficiently accurate for planning purposes.

The remaining transit data on bus stop amenities is relatively easy to gather in the field.

Bicycle LOS Model

Field application of the bike LOS model ran into some street measurement issues. Most of these measurement issues had long since been solved by Sprinkle Consulting. Thus the guidance for measurement of street widths for bike LOS is explained in a bit more detail below.

Methodology

The field tests did not indicate that changes were required for the bike LOS methodology, thus no changes are recommended.

User Guide

In San Diego the research team confronted problem of assessing bicycle LOS on a street where buses frequently stop in the only available travel lane for both bicycle and bus. The current method was not developed or calibrated for such a situation, so it is recommended that the MMLOS method not be applied in such situations to estimate bicycle LOS. The analyst might query bicycle riders on the bus street to obtain an assessment of bicycle LOS for those specific conditions.

In an assessment of bicycle LOS for a residential street in Oakland, California, the research team noted that frequent single family driveways on the street caused the bicycle LOS to come out at a much poorer level than expected. The frequency of residential driveways caused the poor bicycle LOS to be unmitigatable short of closing the driveways. Consequently, it is recommended that users of the MMLOS method discount low volume single family driveways when computing bicycle LOS using the MMLOS method. The percentage discount would be left to the discretion of the analyst.

Pedestrian LOS Model

There are a couple of typos in the description of the Pedestrian LOS model in NCHRP 616 and web document 128. Both of these documents show the following equation for pedestrian intersection level of service:

$$\text{Pedestrian LOS for Signalized Intersections} = 0.00569(\text{RTOR+PermLefts}) + 0.00013(\text{PerpTrafVol*PerpTrafSpeed}) + 0.0681(\text{LanesCrossed}^{0.514}) + 0.0401\ln(\text{PedDelay}) - \text{RTCI}(0.0027\text{PerpTrafVol} - 0.1946) + 1.7806$$

The highlighted parameters are incorrect. They should be 0.681 (instead of 0.0681) and 0.5997 (instead of 1.7806). This is equation 37, page 88 of NCHRP 616, and equation 22, Page 19 of the User's Guide (Web Document 128).

Sprinkle Consulting has also recommended the refinements described below for the NCHRP 3-70 MMLOS pedestrian model.

The original segment level Pedestrian Level of Service model was developed for FDOT in 2000 and presented at the Transportation Research Board's Annual Meeting in 2001. That original model was developed based upon data obtained during an in-field Walk-for-Science event. As with other models used to evaluate transportation facilities, as the Pedestrian LOS model for segments was implemented by transportation practitioners, it was applied in roadway environments not captured during the original data collection event. This practical application of models often leads to refinements based upon insights obtained during application. For example, operational use of the Pedestrian LOS model for segments has led to one such refinement of the original model. The NCHRP 3-70 model evaluation process has included highly focused sensitivity analyses of the model in additional settings. Based upon the results of these analyses and other prior applications across the U.S., we suggest a couple of further refinements.

Four minor refinements are discussed in this section.

1. A modification of the on-street parking effect coefficient,

2. The inclusion of the impacts of shoulder striping on the lateral separation to motor vehicle traffic,
3. A maximum placed on the effect of additional sidewalk width, and
4. A low-volume roadway adjustment for streets without sidewalks.

This paper first discusses the initial three potential revisions and the limited impact they would have on the form of the model. The final revision is discussed separately as it is typically associated with rural roadways or residential streets.

Methodology

On-Street Parking Coefficient

The first recommended refinement to the model is to increase the on-street parking coefficient (f_p) from 0.2 to 0.5. The original Walk-for-Science route used for data collection during the original Pedestrian LOS model (for a variety of course continuity/logistical reasons) did not have a wide range of traffic volumes along segments with on-street parking. The value of the on-street parking coefficient ($f_p = 0.2$) was based upon those data points.

Our application of the Pedestrian LOS model for segments across the country has led us to think that the influence of on-street parking on pedestrians' perceptions of safety and comfort might be greater than is represented by the on-street parking adjustment currently in the model. During the NCHRP 3-70 Phase III analyses, the evaluating agencies tested additional locations along their roadways for the impacts of on-street parking in conditions with an increased upper range of adjacent traffic volumes. This yielded additional "data points" for the refinement of the segment level model. These "data points" confirmed our observations that a higher value for f_p might be appropriate. Consequently, Sprinkle staff has now tested various values for f_p and now recommend $f_p = 0.5$ as a value for this coefficient to represent a greater range of adjacent traffic volumes.

Impacts of Shoulder Striping

The second proposed refinement is to represent expected improvements to pedestrian LOS from the inclusion of a bike lane or other paved space to the right of the travel lane.

The original Pedestrian LOS data analysis and modeling did not reveal a significant correlation between the presence of a striped shoulder or a bike lane or a parking lane without cars and the perceptions of pedestrians. This is not to say that such a correlation did not exist, just that in the presence of the additional space it was not found to be statistically significant. Consequently, the overall pavement width from the edge of pavement to the left side of the rightmost lane, W_t, is used to represent the portion of the lateral separation term represented by pavement width. While providing "acceptable" and accurate results, this term does not capture subtle improvement in pedestrian LOS that may be expected by analysts or agencies contemplating including bike lanes (or possibly striping low use on-street parking).

To illustrate this idea, imagine a total lane width, W_t, of 17 feet. If motorists drive in the center of the lane then cars would be centered 8.5 feet from the edge of pavement. If this outside lane width is striped as a 12-foot lane with a 5-foot bike lane, the motorists would drive centered in the 12-foot lane, centered 11 feet from the edge of the pavement. Additionally, on a roadway with a 20-foot outside lane with non-striped but allowed on-street parking, but no cars actually parking on it, motorists would likely track centered 10 feet from the curb. However if there are some parked cars, we've assumed 25% or greater, motorists would likely shift left about 10 feet and drive centered 15 feet from the edge of the roadway. As can be seen in the above examples, the potential additional separation is one-half any space provided to the right of the travel lane.

We thus recommend replacing W_{ol}, width of the outside lane, with W_t, total width of outside lane (and shoulder) pavement. This would also make the variables consistent with the Bicycle LOS segment model. To accommodate the additional separation between motor vehicles and pedestrians resulting from the striping of a shoulder, we also recommend adding $0.5W_l$ into the lateral separation term. Further, we recommend setting $W_l = 10$ if un-striped on-street parking occupancy is 25% or greater.

Maximum Effect of Sidewalk Width

Several users of the segment model have noted that the sidewalk presence coefficient, f_{sw}, reaches a maximum effect at 10 feet; application for wider sections reduces the sidewalk presence coefficient. The original (current) model development addressed this by setting $f_{sw} = 3$ for the infrequent cases when sidewalk widths (exclusive of buffers) exceed 10 feet.

We recommend introducing this control condition into the sidewalk presence coefficient definition.

Comparison of Pedestrian LOS for Segments Model with Proposed Refinement

The current Pedestrian Level of Service Model for segments is as follows:

$$PLOS = -I.2276 \ln (W_{ol} + W_l + f_p \times \%OSP + f_b \times W_b + f_{sw} \times W_s) + 0.0091 (Vol_{15}/L) + 0.0004\ SPD_2 + 6.0468$$

Where
ln = Natural log
W_{ol} = Width of outside lane
W_l = Width of shoulder or bicycle lane
f_p = On-street parking effect coefficient (=0.20)
%OSP = Percent of segment with on-street parking
f_b = Buffer area barrier coefficient (=5.37 for trees spaced 20 feet on center)
W_b = Buffer width (distance between edge of pavement and sidewalk, feet)
f_{sw} = Sidewalk presence coefficient (= 6 – 0.3Ws)
W_s = Width of sidewalk
Vol_{15} = Volume of motorized vehicles in the peak 15 minute period
L = Total number of directional through lanes
SPD = Average running speed of motorized vehicles traffic (mi/hr)

The proposed refinement to the Pedestrian Level of Service Model for segments is provided below:

$$PLOS = -I.2276 \ln (W_t + 0.5W_l + f_p \times \%OSP + f_b \times W_b + f_{sw} \times W_s) + 0.0091 (Vol_{15}/L) + 0.0004\ SPD_2 + 6.0468$$

Where
ln = Natural log

W_t = total width of outside lane (and shoulder) pavement
W_l = Width of shoulder, bicycle lane, and striped parking; or
If there is un-striped parking and %OSP≥25 then W_l=10' to account for lateral displacement of traffic
f_p = On-street parking effect coefficient (=0.50)
%OSP = Percent of segment with on-street parking
f_b = Buffer area barrier coefficient (=5.37 for trees spaced 20 feet on center)
W_b = Buffer width (distance between edge of pavement and sidewalk, feet)
f_{sw} = Sidewalk presence coefficient ($f_{sw} = 6 – 0.3Ws$ if Ws≤10, otherwise $f_{sw} = 3$)
W_s = Width of sidewalk
Vol_{15} = Volume of motorized vehicles in the peak 15 minute period
L = Total number of directional through lanes
SPD = Average running speed of motorized vehicles traffic (mi/hr)

Low Volume Roadways without Sidewalks

Sprinkle Consulting has applied the Pedestrian LOS model for sidewalks on a wide variety of roadways across the United States including low volume rural roadways and residential streets without sidewalks. On these streets without sidewalks, we have observed that the fixed geometric definition of W_t and W_l seems to overestimate the impact of motorists on pedestrians when the volume of motor vehicles is relatively low; on very low volume streets or roads, the effective width approaches two times the geometric width as the traffic volume approaches zero. While this might be a relatively uncommon occurrence on urban arterial roadways, we feel it is worth consideration when the Pedestrian LOS model for segments is applied on across a rural network or neighborhood streets.

Thus, just as is the case with the Bicycle LOS for segments model, when we apply the Pedestrian LOS model for segments to a network that includes low volume streets, we incorporate a low volume adjustment into our Pedestrian LOS calculations. The adjustment is the same as the adjustment factor for the Bicycle LOS for segments:

Where the AADT ≤ 4000 vpd, W_v is substituted for W_t, and

$$W_v = W_t*(2-0.00025*AADT)$$

To accommodate the full range of potential roadway volumes, under conditions where no sidewalk exists, we feel this volume adjustment should be included in the Pedestrian LOS for segments model.

User Guide

In the field tests that occurred in central business districts, the users of the MMLOS method had frequent questions about the treatment of street furniture and planter boxes (as opposed to planter strips) in the pedestrian LOS model. The guidance given was for the user to assess the extent to which street furniture provided the same perceived degree of separation between pedestrian and traffic as a tree and to use an approximate equivalent value in the MMLOS method. If planter boxes were spaced so that they acted as the equivalent of a continuous planter strip (i.e. the pedestrians effectively use only the strip of the sidewalk further removed from the street), then the distance between the street curb and the planter boxes should be treated as the equivalent of a planter strip of that same width.

Attachments: Agency Workshop and Testing Results

A. FDOT, Florida
B. Philadelphia, Pennsylvania
C. San Diego, California
D. Arlington, Virginia
E. Atlanta, Georgia
F. San Antonio, Texas
G. Boise, Idaho
H. Portland, Oregon
I. Auto LOS Models Evaluation

A. FDOT Test Results

A brief summary of the work by FDOT and its contractor is provided below based on a report by Scott Washburn[1] .

The MMLOS method was tested on urban arterial streets in 4 cities in Florida, Gainesville, Tampa, Tallahassee, and Orlando. Four arterials were tested in each of 3 cities. Orlando tested only the auto LOS model, and performed these tests on only 3 arterial streets.

A joint project kick-off meeting was held on October 2, 1008 in Gainesville, Florida for all 4 agencies. A total of 21 people (of which 7 were project personnel) were present.

The following arterials were selected for testing:

City/Arterial (Limits)	HCM Class	Lanes	Length
Gainesville, FL			
Archer Road (State Road 24) (I-75 to Tower Road)	Class 1	4-lane Divided	2.5 miles
Northwest 13th Street (US 441) (NW 16th Ave to NW 39th Ave)	Class II	4-lane Divided	1.5 miles
West University Ave (SR 26) (W. 13th Street to Gale Lemerand)	Class III	4-lane Divided	0.6 miles
Tower Road (Newberry to SW 24th Ave)	?	4-lane Divided	2.0 miles
Tallahassee			
North Macomb St. (Tennessee to Pensacola)	?	4-lane Divided	0.4 miles
Capital Circle SE (Apalachee to Shumard Oak)	Class I	Variable, Mostly 2-lane Divided	3.0 miles
Appleyard Dr. (Tennessee to Jackson Bluff)	Class II	4-lane Divided	1.3 miles
West Tennessee St. (Woodward to Bronough)	Class IV	6-lane Divided	0.8 miles
Tampa			
US 41 (Crenshaw Lake to Pasco CtyLine Rd)	Class I	6-lane Divided	3.9 miles
Himes Ave. (Hillsborough to Busch)	?	2-lanes	2.8 miles
Nebraska Ave (MLK (Buffalo) to Hillsborough)	Class II	2-lanes	1.0 miles
Kennedy Boulevard. (Jefferson to Franklin)	Class III	4-lanes, One-Way	0.3 miles

HCM Class I = 45-55 mph free-flow speed
HCM Class II = 35-45 mph free-flow speed
HCM Class III = 30-35 mph free-flow speed
HCM Class IV – 25-35 mph free-flow speed

[1] Executive Summary from Draft Final Report, "Multimodal Arterial LOS Modeling and Testing", by Dr. Scott Washburn, Bruce Landis, Peyton McLeod, Benito Perez, Jorge Barrios, TRC-FDOT-76293-2009, University of Florida, Gainesville, FL, February 2009.

Data collection was conducted by consultant personnel.

A follow-up meeting was then held with all agencies present to assess the results.

Based on the results of the tests the draft University of Florida recommendations are as follows:

1. Adopt the NCHRP 3-70 transit LOS model and bicycle and pedestrian segment and intersection LOS models for use in the HCM 2010 and Florida Q/LOS Handbook, with some minor revisions.
2. Do not adopt the bicycle and pedestrian LOS models until an LOS threshold scale can be developed that is consistent with the segment and intersection models.
3. Pursue research that will result in the development of a side-path model.
4. Continue with the HCM 2000 auto LOS methodology at this time, but with revisions to the LOS threshold classification scheme."

B. Philadelphia, Pennsylvania

This section discusses the street segments evaluated during the MMLOS training workshop conducted on Thursday, November 14, 2008 in the hearing/conference facility for the Delaware Valley Regional Planning Commission (DVRPC) in Philadelphia, Pennsylvania. It was prepared by Mike Carroll of Dowling Associates.

The study locations were:

- Spruce Street from 6th Street to 9th Street
- Chestnut Street from 34th street to 38th street
- Broad Street from Walnut Street to Lombard Street

The workshop was attended by fourteen participants from five agencies including DVRPC as well as to two members from Dowling Associates who presented the workshop. Each of the participants was assigned to a team for fieldwork and analysis. Three teams were responsible for data collection and analysis, each at a respective location, while one roving team was responsible for performing auto travel time runs on each study segment.

The following sections provide background on the streets including maps and visual images as well as a discussion of the results of the workshop analysis at Spruce Street, Broad Street and Chestnut Street.[2]

Spruce Street

Spruce Street is located in the Old City section of Philadelphia and is among the original grid of streets established during the founding of the city in the late 17th Century. Structures dating from the colonial period survive to this day along the street and the road dimensions have not changed since well before the advent of automobiles. Today traffic along Spruce Street operates as a one-way, two-lane arterial extending across the south edge of Independence Hall, a historical landmark and major tourist attraction. Traffic flows in the westbound direction. The area is predominantly residential with small shops and restaurants located in the immediate vicinity. The commercial center of the city is within walking distance. The narrowness of the street and the presence of street trees provide for a pedestrian friendly environment.

[2] The aerial images including the forced perspective images have been obtained using the Google Earth applet. The maps have been obtained from www.mapquest.com.

The segment of Spruce Street identified for the study was from 6th Street to 9th Street. This was selected in consultation with the research team's partners with the Delaware Valley Regional Planning Commission.

Spruce Street Study Process

Due to inclement weather, the workshop group assigned to evaluate Spruce Street opted to rely on internet accessible information to perform the analysis. This included web accessible aerial imagery and time tables. This information was supplemented with count data available from the DVRPC archives. Assumptions were made regarding the operation of signals in order to evaluate auto levels of service. Concurrently auto travel time and stop observations were performed for Spruce Street which provided for comparison but these actual runs were not used in the results. The actual runs revealed fewer stops than were estimated based on previous assumptions.

Spruce Street Study Results

Table 1 summarizes the MMLOS results for the segment of Spruce Street form 6th Street to 10th Street. Pedestrian LOS outperformed auto and transit LOS which is not surprising given the narrowness of the street and the pedestrian friendly characteristics. The presence of on street parking and the absence of any buffer negatively influenced the bicycle LOS whereas the absence of transit service along several blocks of the street dictated poor transit LOS

Table 1 – WB Spruce Street from 6th Street to 10th Street

Segment & Downstream Signal	**Auto Stops LOS #1**	**Auto Speed LOS #2**	**Auto HCM LOS #3**	**Auto NCHRP 379 LOS #4**	**Transit LOS**	**Bicycle LOS**	**Pedestrian LOS**
1	E	C	D	D	C	E	B
2	E	C	D	D	F	D	B
3	E	C	D	D	F	D	B
4	E	C	D	D	F	D	B

Issues Raised Pertaining to Analysis of Spruce Street

The evaluation of Spruce Street indicated some of the shortcomings of using assumed data to evaluate auto travel times. On the other hand the ability to evaluate the facility remotely was considered a strength by at least on group member who questioned the need to perform fieldwork altogether.

Discussion on the analysis of Spruce Street revealed uncertainty as to whether pedestrian LOS should be evaluated for the left hand side of a one way street. For Spruce Street it was decided that it made sense to evaluate each side and use the worst case of the two pedestrian results. The placement of street trees with no dedicated planting buffer (i.e. trunks surrounded by pavement) challenged assumptions over how to calculate the effect in buffering pedestrians from traffic. To resolve this, the estimated average diameter of the tree trunk was entered as the buffer dimension.

Broad Street

Broad Street is the major north south arterial running from the Delaware River at t southern limit of the city of Philadelphia to the city-county line in the northwest section of the city. City Hall lies roughly midway along the length of Broad Street. Broad Street is a six-lane, two-way facility with a median and as its name implies is among the wider streets in the central portion of Philadelphia, this supports its role as a traditional route for parades as does the fact that it extends to the professional sports complexes to the south.

Immediately south and adjacent of City Hall Broad Street has been designation as the Avenue of the Arts. This is the site of The Kimmel Center for Performing arts which opened its doors in 2001, as well as a number of retail, recreational and dining establishments. This portion of Broad Street includes the study area for the MMLOS training which extended from Walnut Street to Lombard Street in the southbound direction.

Although Broad Street plays a significant role in serving transit and auto traffic to and from the Center City area, along the study segment there is a considerable amount of pedestrian traffic that is generated by recreational activity along the street, and the administrative and commercial destinations at its north end in Center City proper, as well as by some of the dense neighborhoods located within a block or two of the street segment.

<u>Broad Street Study Process</u>

Broad Street was evaluated in the field by a team of four analysts and the roving team assigned to perform auto travel time/stop runs. The field team was divided among the blocks and measured the cross sectional layout with a Roll-a-Tape™ rolling measurement device.

Transit frequencies were obtained from printed schedules and transit loading was estimated by visual observation of buses. Volumes were counted manually and recorded on a tally sheet developed by Dowling Associates for the training.

The results were entered and analysis conducted during the afternoon portion of the workshop at the DVRPC headquarters.

Broad Street Study Results

Table 2 Summarizes the MMLOS results for the study segment of Broad Street in Philadelphia. Level of service for transit was uniformly found to be LOS A based on a high frequency of service. Setting aside the results of the NCHRP 379 Auto method, other modes operated at or near LOS C except for bicycles which ranged from D to F.

The prevailing factors in determining bike LOS were the presence of parked cars and the volume of right turns off of Broad Street. Each of these patterns is quite typical of arterial streets in the area though interestingly, DVRPC staff revealed that the parking activity was in fact illegal parking occurring during non-commute hours within a designated peak hour bus only lane.

Table 2 – SB Broad Street from Walnut to Locust

Segment & Downstream Signal	Auto Stops LOS #1	Auto Speed LOS #2	Auto HCM LOS #3	Auto NCHRP 379 LOS #4	Transit LOS	Bicycle LOS	Pedestrian LOS
1	D	C	C	D	A	F	C
2	C	C	C	D	A	D	C
3	C	C	C	D	A	E	C
4	B	C	C	C	A	E	B

Issues Raised Pertaining to Analysis of Broad Street

An interesting concern was discussed regarding the median along Broad Street. It was not clear to analysts whether a median which was marginally raised by an inch or so but easily traversed should be entered as a painted median or a raised median. The rule established in the workshop was that any median that, through pavement treatment or through physical design, was clearly intended to discourage vehicle movements could be considered a superior refuge for street crossing and should be treated as a raised median.

A second related issue dealt with coding the permissibility of mid-block crossing or jaywalking. It was noted that the term jaywalking explicitly refers to an illegal pedestrian movement, however the guidance provided was that if jaywalking was plainly tolerated it should be coded as permissible.

Finally, the question arose as to how traffic flow in the bus of lane should be coded for determining bike LOS. This was of interest despite the fact that for most of the blocks the bus only lane was filled with illegally parked vehicles. It was suggested that the bike LOS calculations should only consider the volume in this lane and that the heavy vehicle percentage should be set at 100 percent.

Chestnut Street

Chestnut Street is a one way, eastbound arterial extending from the western limits of the City to the Delaware River waterfront at the eastern city limit. It forms the eastbound part of a couplet of one-way arterials together with Walnut Street which is located two blocks to the south and runs westbound. Chestnut Street is three lanes wide with parking on the left side along the portion which includes the study segment from 38th Street to 36th Street. From 36th Street to 34th Street there are also three travel lanes with parking along the left side but during off peak hours the right hand lane is converted to a parking lane.

This area forms the northern boundary of the University of Pennsylvania campus and is a few blocks south of Drexel University. The area is referred to as "University City". Among to the nearby educational facilities are numerous dormitories and college apartment buildings, auxiliary facilities and campus centered shops and commercial destinations.

Chestnut Street Study Process

Thirty-fifth Street does not intersect Chestnut Street. Unfortunately, due to an error in planning the fieldwork it was overlooked that 37th Street does form a full intersection with Chestnut Street. As a result, for the analysis the segment was treated as a two block segment. For the purposes of the workshop, this was deemed to be inconsequential.

Chestnut Street was observed by a team of four analysts in a manner similar to the fieldwork performed for Broad Street. A Roll-a-Tape device was available to measure road cross section dimensions, and volumes and transit loading factors were observed visually. Transit travel time was obtained from printed schedules and auto stops and travel time were recorded by the roving team. The data was entered and analysis performed during the afternoon session.

Chestnut Street Study Results

MMLOS results for the study segment of Chestnut Street are summarized in Table 3. Low turning volumes along with 13-foot wide sidewalks with 5-foot buffers contribute to excellent pedestrian levels of service and this combined with frequent bus service are reflected in transit level of service at LOS A as well. Low travel speed and consistent stopping along the block from 38th Street to 36th Street contribute to LOS C for that block and lower auto LOS (again, ignoring 37th street as indicated above).

Bike LOS was constrained primarily by the presence of parking along the side of the street. In this analysis bike level of service was calculated for the more favorable right side of the street along the second block from 36th Street to 34th Street. The off peak parking in the wider travel lane is less detrimental to bike levels of service than the narrower left hand side parking lane. If the analysis were performed for that side bike LOS would have matched the results for block #1 at LOS D.

Table 3 – EB Chestnut from 38th to 34th

Segment & Downstream Signal	Auto Stops LOS #1	Auto Speed LOS #2	Auto HCM LOS #3	Auto NCHRP 379 LOS #4	Transit LOS	Bicycle LOS	Pedestrian LOS
1	C	C	D	D	A	D	A
2	B	C	E	E	A	C	A

Issues Raised Pertaining to Analysis of Chestnut Street

Conditions on Chestnut Street raised issues similar to Spruce Street regarding whether pedestrian and bike LOS should be calculated for both or one side of the street only. The guidance that the worst case should be evaluated was not followed in this analysis as is reflected in the disparate results between blocks #1 and #2 in Table 3 above.

The sensitivity of the method to coding errors was revealed in the analysis of Chestnut Street when the analyst apparently entered the volume of right turns in place of a dummy value intended to establish the kind of right turn channelization. This drove the result to LOS E when in fact coded properly the result is LOS A.

C. San Diego, California

This section discusses the street segments evaluated during the MMLOS Training Workshop conducted on Wednesday, December 10, 2008 in the Concourse Training Room 216 for the City of San Diego in San Diego, California. It was prepared by Kamala Parks of Dowling Associates.

The study locations were:

- Broadway from 5th Avenue to Front Street
- India Street from Laurel Street to Washington Street

The workshop was attended by ten participants from five agencies including the City of San Diego. This was in addition to two members of Dowling Associates who presented the workshop. Each of the participants was assigned to a team with two teams each responsible for data collection and analysis and one roving team responsible for performing auto travel time runs on each study segment.

The following sections provide background on the streets including maps and visual images as well as a discussion of the results of the workshop analysis.

Broadway

Broadway runs through downtown San Diego and is generally flanked by tall office buildings in the study area. Its western end terminates at San Diego Bay and it provides access to Interstate 5 and the eastern side of town. Broadway is a busy two-way, four- to six-lane arterial with extensive bus transit service. The study area is predominantly office commercial with retail, hotels and restaurants. On-street parking is not allowed on Broadway, and delivery vehicles can be frequently found loading and unloading in the outside lane. Sidewalks are wide and there was a lot of pedestrian activity observed during fieldwork conducted in the early afternoon. There are no bikeway facilities on Broadway in the study area.

The limits of Broadway identified for the study was from 5th Avenue to Front Street in the westbound direction. This corridor was selected in consultation with the staff at the City of San Diego.

<u>Broadway Study Process</u>

Broadway was evaluated in the field by a team of four analysts with a leader and the roving team of two analysts was assigned to perform auto speed/stop runs. Each member of the field team was given one section of the data sheets to fill out and the team walked together so that the leader could answer any questions. The cross-sectional layout was measured using a rolling measurement instrument. The team gathered data in the eastbound direction as well, which was ultimately not analyzed in the MMLOS spreadsheet because of time constraints. The field team also did ten minutes of pedestrian counts at each intersection. The roving team traversed the corridor three times in order to capture average speeds and number of stops. Transit frequencies and scheduled speeds for four of the most frequent routes were obtained from printed schedules by Dowling ahead of time. Vehicle volumes at intersections and signal timing sheets were provided by the City of San Diego.

The results were entered and analysis conducted during the afternoon portion of the workshop at the City of San Diego's Concourse Training Room.

Broadway Study Results

Table 1 summarizes the MMLOS results for the segment of Broadway from 5th Avenue to Front Street. Originally, transit LOS came out to LOS F, because the transit information was only entered on segments with bus stops. Once the transit information was added to all segments, Transit LOS outperformed all the other modes, which was expected given the high level of transit service on this street. Pedestrian LOS outperformed auto and bicycle LOS, which is not surprising given the traffic congestion, lack of bikeways and pedestrian friendly characteristics.

Table 1: Westbound Broadway from 5th Avenue to Front Street

Segment & Downstream Signal	Auto Stops LOS #1	Auto Speed LOS #2	Auto HCM LOS #3	Auto NCHRP 379 LOS #4	Transit LOS	Bicycle LOS	Pedestrian LOS
1	B	B	C	B	A	D	C
2	F	D	F	F	A	D	B
3	B	C	E	E	A	D	B
4	F	C	E	F	A	C	B
5	B	B	B	B	A	C	B
Facility	**D**	**C**	**E**	**E**	**A**	**D**	**B**

Issues Raised Pertaining to Analysis of Broadway

The evaluation of Broadway indicated some of the shortcomings of the Bicycle LOS and the Transit LOS. Evaluation of the Bicycle LOS led to LOS D, which was judged by a couple of workshop attendees as being too good. Due to the high volumes vehicles, frequent interaction with transit vehicles, preponderance of delivery vehicles loading and unloading in the right hand travel lane, and lack of bikeways, it was thought that LOS F should be the result. The Transit LOS initially came out to be LOS F for the corridor, due to the transit data only being included on segments with bus stops. Adding the transit data to all segments corrected this problem and provided expected results for excellent and frequent transit service. There were also questions about coding bus-only travel lanes.

India Street

India Street is a two- to three-lane, one-way northbound frontage roadway located east of Interstate 5. Vehicle volumes and speeds are fairly high in the corridor. On-street parking is allowed on most segments on the eastern side. There are continuous, standard sidewalks on the eastern side of the roadway, but not on the western side, which abuts the freeway. Driveways are frequent and land uses are predominantly industrial and vehicle-oriented.

The limits of India Street identified for the study was from Laurel Street to Washington Street in the northbound direction, a one-mile extent. In this study area, India Street is intersected by freeway ramps and contains a bike lane on one segment. There is no transit service on this roadway or in close proximity and there was minimal pedestrian activity observed in the early afternoon. This corridor was selected in consultation with the staff at the City of San Diego.

India Street Study Process

India Street was evaluated in the field by a team of three analysts with a leader and the roving team of two analysts was assigned to perform auto speed/stop runs. Each member of the field team was given one section of the data sheets to fill out and the team walked together so that the leader could answer any questions. The cross-sectional layout was measured using a rolling measurement instrument. The roving team traversed the corridor three times in order to capture average speeds and number of stops. Vehicle volumes at intersections and signal timing sheets were provided by the City of San Diego.

The results were entered and analysis conducted during the afternoon portion of the workshop at the City of San Diego's Concourse Training Room.

India Street Study Results

Table 2 summarizes the MMLOS results for the study segment of India Street in San Diego. The Automobile LOS ranges from A to B, which appears to be consistent with observations and the facility type. Originally, transit came out to LOS D and A for segments 1 and 2, respectively, because of the default settings in the spreadsheets. Once the transit information was removed, level of service for transit was found to be F. Pedestrian LOS came out as C and Bicycle LOS as D and E.

Table 2: Northbound India Street from Laurel Street to Washington Street

Segment & Downstream Signal	Auto Stops LOS #1	Auto Speed LOS #2	Auto HCM LOS #3	Auto NCHRP 379 LOS #4	Transit LOS	Bicycle LOS	Pedestrian LOS
1	B	A	A	A	F	E	C
2	B	A	A	A	F	D	C

Issues Raised Pertaining to Analysis of India Street

The issue of what to call an unsignalized freeway ramp was raised. Participants felt that freeway ramps intersecting the roadway posed a special challenge to bicyclists. It was determined to treat the ramps as unsignalized intersections in the analysis, but acknowledged that such coding would not necessarily capture the extent of bicyclist challenges at these locations.

D. Arlington, Virginia

This section documents the findings of the Multimodal Level of Service Workshop that was held on January 9, 2009 from 8:30am to 3:30pm at the Arlington County Office Building at 2100 Clarendon Boulevard in Arlington, Virginia. This workshop and field test summary was prepared by Dr. Aimee Flannery, George Mason University.

Several arterials were selected by County officials in the fall of 2008 to be considered for inclusion in the study. In the end three arterials were included in the analysis:

- Wilson Boulevard between Glebe Road and N. Monroe Street
- Glebe Road between Washington Boulevard and Carlin Springs
- George Mason Drive between Lee Highway and N. Henderson

The workshop was attended by four Arlington County Division of Transportation staff, Rick Dowling, and Aimee Flannery. The attendees all work within the Transportation Engineering area of the Engineering Division of Arlington County. More information on the participants is included in Table 1:

Name	Agency	Email address	Specialty
Andrea Wilkinson	Arlington Co.	awilkinson@arlingtonva.us	Traffic Engineering/data collection
Susan Finotti	Arlington Co.	sfinotti@arlingtonva.us	Neighborhood traffic calming/arterial planning
David Patton	Arlington Co.	dpatton@arlingtonva.us	Pedestrian and Bicycle
David Goodman	Arlington Co.	dgoodman@arlingtonva.us	Pedestrian and Bicycle

Table 1 Workshop Participants

Since the completion of the workshop, Mr. Steve Yaffe, Transit Services Manager of Arlington County, has also reviewed the MMLOS approach and has provided his input regarding data requirements for transit. His thoughts are included in latter portions of this discussion.

Data collection for the study arterials was carried out through field studies conducted in early December and using data readily available from Arlington County including maps, transit schedules, traffic and pedestrian counts taken at each intersection on the same day, traffic signal timing from signal database, and Google Street View maps.

The following sections provide background on the streets including maps and visual images as well as a discussion of the results of the workshop analysis of Wilson Boulevard, Glebe Road, and George Mason Drive.

Wilson Boulevard

Wilson Boulevard is a major arterial in the northern Virginia region that runs east-west from Fairfax County's 7-Corners area to the west through Rossyln (near major Metro rail station) to the east and ends at the Washington, DC border. Wilson Boulevard is primarily a commercially developed arterial with heavy fixed bus route service, nearly continuous sidewalks, and on occasion on-street bicycle lane facilities.

Wilson Boulevard runs primarily east-west and is a two-way arterial for the majority of its length until it becomes a one-way pair just east of Washington Boulevard. The segment considered for the study was between Glebe Road (Rt 120) and N. Monroe, approximately 0.42 miles in length.

Wilson Boulevard MMLOS Results

Table 2 contains the overall MMLOS results for Wilson Boulevard between Glebe Road and N. Monroe.

Segment & Downstream Signal	Auto Stops LOS #1	Auto Speed LOS #2	Auto HCM LOS #3	Auto NCHRP 379 LOS #4	Transit LOS	Bicycle LOS	Pedestrian LOS
1	E	C	F	F	A	D	C
2	D	C	F	F	A	D	C
3	F	C	F	F	A	F	D
4	C	D	F	F	A	D	D
5	E	D	F	F	A	F	D
Facility	D	C	F	F	A	F	C

Table 2 MMLOS Results for Wilson Boulevard

The transit service achieved a LOS of A given the high frequency of bus service on Wilson Boulevard in the study area. The section of Wilson Boulevard that was included in this analysis is nearby the Ballston Metro rail station and is serviced by both the local Arlington Transit Service and the Metro Bus Transit Service. During the peak hours, the Metro bus service has four scheduled stops per hour and the Arlington Transit service has two scheduled stops per hour. Also, the majority of trips are short lengths with users coming from nearby suburbs to access the Metro rail system. Bicycle LOS is fairly low due to the lack of on-street facilities and the relatively high volume of traffic, though the vehicles are traveling at low speeds and there are very few heavy vehicles. Two intersections/segments have failing bicycle LOS scoring an F. The low LOS for bicycles on these two sections appears to be driven by the number of driveway cuts. Pedestrian LOS could be improved with the addition of a buffer strip between the travel lanes and the sidewalk along some stretches of Wilson Boulevard. Pedestrian LOS is worse, scoring a LOS D, at the three downstream segments perhaps due to the increase in auto traffic. The auto LOS varies depending on the model utilized. The methods based on the HCM 2000 methodology and the NCHRP 3-79 study the arterial is failing with LOS F along the length of the arterial. These methods potentially reflect the lower travel speed for the auto mode due to the interaction with transit service. Wilson Boulevard is not considered a failing arterial by Arlington County and the results of the auto stops LOS #1 and auto speed LOS #2 models are considered a better representation of the conditions for auto users on Wilson Boulevard in the study location.

Glebe Road (Rt 120)

Glebe Road is a major arterial that runs primarily north-south between the George-Washington Parkway to the north to Jefferson Davis Highway (Rt1) to the south. The arterial connects the low-density single family homes near the border of northwest Washington, DC to the highly populated area near Jefferson Davis Highway, just south of Regan National Airport. The arterial primarily serves auto traffic on the northern portion of the arterial, but slowly becomes an arterial servicing more pedestrian and transit service near the Ballston Mall metro rail station and in the southern portion of the arterial.

Figure 1 contains a screen shot of Glebe Road as was included in the video laboratory studies in Phase II of NCHRP 3-70.

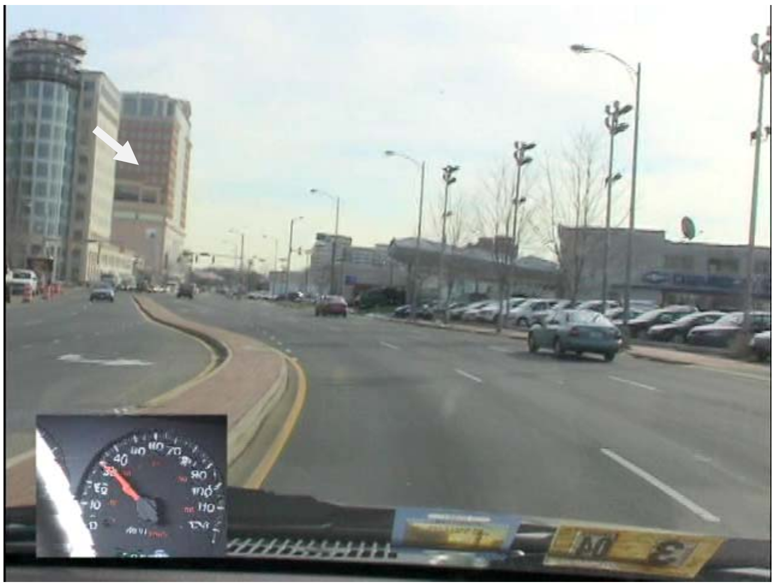


Figure 1: Photo of Glebe Road as Included in Video Studies of NCHRP 3-70

Glebe Road MMLOS Results

Table 3 contains the results for MMLOS Glebe Road study.

Segment & Downstream Signal	**Auto Stops LOS #1**	**Auto Speed LOS #2**	**Auto HCM LOS #3**	**Auto NCHRP 379 LOS #4**	**Transit LOS**	**Bicycle LOS**	**Pedestrian LOS**
1	C	C	D	E	B	E	E
2	C	C	D	E	A	D	D
3	C	C	D	E	A	E	D
4	B	C	D	E	B	F	D
5	B	C	D	E	B	E	D
Facility	C	C	D	E	B	E	D

Table 3 MMLOS Results for Glebe Road

Glebe Road is serviced by several transit lines included three regional Metro bus lines and the local Arlington Transit service bus line. The headways of the bus service are quite low during the peak hour with high on-time performance and acceptable passenger loads resulting in high transit LOS. Pedestrian LOS could be improved with the inclusion of buffer strips along the entire length of Glebe Road and increased tree plantings. Bicycle LOS could be improved with the addition of on-street bicycle facilities which do not currently exist on this portion of Glebe Road. The auto LOS estimated using the models #3 and #4 are lower or worse than the LOS is predicted for Glebe Road using models #1 and #2. Glebe Road was actually included in the video laboratory sessions in Phase II of NCHRP 3-70. Given this fact, it would appear that LOS models 1 and 2 most likely reflect the perceptions of service by Arlington and Fairfax County residents given many were included in the study.

George Mason Drive

George Mason Drive is a minor arterial that runs primarily north-south from Old Dominion Drive in the north to Seminary Road to the south. George Mason Drive parallels Glebe Road for much of its length through Arlington County, but serves more local trips than through trips as it does not continue into Fairfax County to the north. George Mason Drive is primarily residential to the north with single family residences, but does include a hospital, post office, two elementary schools, and a McDonald's restaurant on the corner at Wilson Boulevard. The study section of George Mason Drive is between Lee Highway (Rt 29) to the north and N. Henderson to the south, a total of approximately 2.16 miles in length. This section of George Mason is heavily traveled due to the location of Arlington Hospital Center south of Lee Highway (Rt 29), however, standing queues or rolling queues during peak periods would not be expected during the peak hour. The study section of George Mason Drive is serviced by the Arlington Transit Service but does not include Metro Bus service. The study section includes sidewalks, but does not have any setback from the street or buffer strips. In addition, the study section does not include on-street bicycle facilities. All of the signalized intersections in the study section contain left turn lanes and in some cases protected left turn phases.

George Mason MMLOS Results

Table 4 contains the MMLOS results for George Mason Drive between Lee Highway (Rt 29) and N. Henderson.

Segment & Downstream Signal	Auto Stops LOS #1	Auto Speed LOS #2	Auto HCM LOS #3	Auto NCHRP 379 LOS #4	Transit LOS	Bicycle LOS	Pedestrian LOS
1	B	B	C	C	B	D	B
2	C	B	C	C	B	F	B
3	C	B	C	C	F	E	C
4	B	B	C	C	B	D	B
5	B	B	C	C	F	C	B
Facility	B	B	C	C	F	D	B

Table 4. MMLOS Results for George Mason Drive

The bicycle LOS appears to be suffering from the lack of on-street facilities as well as the heavily traveled intersections of Washington Boulevard and Wilson Boulevard. The cross-street traffic at these intersections is high, as they are major east-west arterials that lead into Washington, DC. Pedestrian LOS appears to be operating at an acceptable LOS with perhaps some improvements that could be achieved at signal 3 with the addition of pedestrian islands or a median to help in two-stage crossing of Washington Boulevard. Washington Boulevard is owned by Virginia

Department of Transportation and perhaps the wide lanes are required by the state, but the impact on pedestrian crossings can be seen with the drop in LOS at Washington Boulevard. Figure 2 contains a picture of pedestrians crossing Washington Boulevard at George Mason Drive. Transit LOS along George Mason Drive is a very acceptable LOS B in sections where the Arlington Transit service runs. Metro bus service does run along Washington Boulevard in the east-west direction (segment 3) but was not included in this analysis because the service does not run north-south. The auto LOS appears to be acceptable ranging from LOS B to C along all segments of the arterial for all models. The stops model (model #1) appears to better reflect the higher volume present at the intersections with Washington Boulevard and Wilson Boulevard than the other three models and the expected increased stops and delays at these intersections with these major arterials. The auto LOS predicted by models 2, 3, and 4 does not fluctuate despite the higher traffic at these intersections and higher delay and stops incurred due to the dominate east-west movement present at Washington Boulevard and Wilson Boulevard.

Figure 2: Pedestrians Crossing Washington Boulevard at George Mason Drive

Figure 3 Intersection of George Mason (horizontal cross-street) and Washington Boulevard (vertical cross-street)

Data Collection Concerns

As noted previously, since the January meeting with Arlington County, Mr. Steve Yaffe the Arlington County Transit Manager has weighed in on the MMLOS in particular to the transit data needs. Mr. Yaffe expressed concerns over the ability to provide two particular pieces of data, passenger load and on-time performance for the local Arlington Transit service or ART. The ART service does not have automatic passenger counters and therefore it is difficult to provide this piece of information. In addition, little on-time performance information has been collected due to the lack of funding for the service. As a result, estimates were made of these two pieces of information based on observations of the ART buses as they travel Arlington County (typically far from full of passengers) and the on-time service performance of the Metro regional transit lines in the area.

Other observations by Arlington County participants, were that the information needed for pedestrian LOS, in particular tree density and driveway cuts, were labor intensive and reduced the time available to study other arterials in Arlington County.

E. Atlanta, Georgia

This section describes the testing of several arterial roadway facilities in the Atlanta metropolitan region as part of NCHRP 3-70 Phase III. The workshop and this summary of the field test results were prepared by Peyton McLeod of Sprinkle Consulting.

Unlike some other Phase III evaluations, which were completed in one day, this evaluation took place over a longer period of time. The reason for this difference was the expressed desire to select study facilities that were geographically diverse and representative of several of the jurisdictions which participated in the testing. Such a goal would not have been attainable in a single-day setting. Accordingly, the evaluation process included two participant workshops conducted on January 22, 2009 and March 11, 2009, the latter of which included limited field data collection for one study facility, as well as a larger data collection effort that took place during the time between the two workshops.

The workshops were hosted by the Atlanta Regional Commission (the region's Metropolitan Planning Organization). The first workshop was conducted jointly by staff from Dowling Associates and Sprinkle Consulting. The intent of this workshop was to introduce participants to the NCHRP 3-70 methodology and techniques, describe the data collection requirements, and analyze a sample facility. The field data collection for the remaining study facilities and the second workshop were conducted by Sprinkle Consulting staff. At the second workshop, participants reviewed the results of the analysis and provided comments on the analysis process and the reasonability of results from a local perspective. The workshops were attended by eleven participants from five transportation agencies.

The selected study facilities were the following:

- Auburn Avenue (Jesse Hill, Jr. Drive to Peachtree Street; workshop test example);
- 17th Street (Northside Drive to Market Street);
- Bullsboro Drive (Amlajack Boulevard to Greison Trail);
- Buford Highway (Druid Hills Road to Clairmont Road); and
- Cobb Parkway (Frey's Gin Road to Allgood Road).

The data collection procedure was similar for all five study facilities and included four primary components: office-based data collection, field measurements and observations, intersection turning movement counts, and travel time runs. Office-based data collection was typically performed in advance of the field work and included such data items as segment lengths and crossing distances, transit routes' headways and travel speeds, and traffic volumes. Field measurements and observations included cross sectional elements (widths of sidewalks, bike lanes, travel lanes, and medians), pavement condition determinations, speed limit, and transit amenities. Turning movement counts were used to determine cross-street volumes, turning percentages, truck percentages, and directional factors. Signal timing observations and pedestrian counts were performed in concert with the turning movement counts. Travel time runs were conducted to determine average travel speeds and stops per mile; five travel time runs were conducted for each corridor.

Both turning movement counts and travel time runs were performed during the desired analysis period (typically PM peak or AM peak). The one exception to this protocol was the Auburn Avenue analysis, which was done during an off-peak period to coincide with the first workshop.[3]

The following sections describe the settings, multimodal level of service results, and discussion items for each facility. Because the study process did not typically vary from location to location, the process is not discussed for each individual facility.

Bullsboro Drive

Bullsboro Drive (State Road 34) is a divided multi-lane roadway, the study boundaries of which comprise the corridor between Interstate 85 and the City of Newnan. Newnan is the county seat of recently urbanizing Coweta County. The location is approximately 30 miles southwest of downtown Atlanta. The eastern portion of the corridor has six lanes of traffic, while the western portion narrows to four lanes. Sidewalks and transit service (with the exception of a park and ride lot located at the extreme east end of the corridor) are absent; wide paved shoulders exist on the western portion only. Many new shopping centers and other commercial developments have been constructed along the corridor during the past several years. The selected direction of travel is westbound (away from the regional center of Atlanta), the peak direction during the PM peak period. The results of the analysis are shown in the Table 1.

Table 1: WB Bullsboro Drive from Amlajack Boulevard to Greison Trail

Segment	Auto LOS 1 (stops)	Auto LOS 2 (speed)	Auto LOS 3 (HCM)	Auto LOS 4 (3-79)	Transit LOS	Bike LOS	Bike LOS (stretch) [4]	Bike LOS (seg) [5]	Ped LOS	Ped LOS (stretch)	Ped LOS (seg)
1	B	B	D	D	F	E	E	D	E	F	F
2	B	A	A	B	F	E	E	E	E	F	F
3	B	B	D	D	F	F	F	E	E	F	F
4	B	B	D	D	F	D	B	B	E	F	F
5	B	B	D	D	F	D	B	B	E	F	F
Overall	B	B	D	D	F	E	D	C	E	F	F

[3] Because the Auburn Avenue analysis was conducted during an off-peak period and, more importantly, because it is not an arterial roadway, the results of the workshop-based analysis are not representative of the NCHRP 3-70 modeling effort and are not included in this report.

[4] This is the "Bicycle LOS Model 2," as described in NCHRP Report 616; the same is true for the stretched pedestrian model.

[5] This is the stand-alone segment bicycle level of service model; the same is true for the segment pedestrian model.

Workshop participants agreed with the overall results indicating that accommodation of bicyclists, pedestrians, and transit riders is worse than for motorists. There were mixed opinions as to whether the stops and speed models or the HCM and NCHRP 3-70 models produced the most reasonable auto results. The bicycling conditions were believed to be best represented by the proposed bicycle facility model. One data collection issue, the proper treatment of rumble strips located within the paved shoulder, arose for this corridor. The researchers recommended reducing the width of the paved shoulder to include only the area outside the rumble strips and reassigning the width of the rumble strips to the outside travel lane, which showed marginally worse conditions.

17th Street

17th Street is an east-west corridor in the Midtown region of Atlanta. Midtown is approximately two miles north of downtown Atlanta and has developed into a major office and commercial district. The section of 17th Street between Northside Drive and Interstate 75/85, most of which is contained within the study limits, is locally considered an ideal multi-modal corridor. It is a four-lane roadway with sidewalks, designated bus lanes, and designated bike lanes in both directions. The selected direction of travel is eastbound, the peak direction during the AM peak period during which data were collected. The results of the analysis are shown in the Table 2.

Table 2: EB 17th Street from Northside Drive to Market Street

Segment	Auto LOS 1 (stops)	Auto LOS 2 (speed)	Auto LOS 3 (HCM)	Auto LOS 4 (3-79)	Transit LOS	Bike LOS	Bike LOS (stretch)	Bike LOS (seg)	Ped LOS	Ped LOS (stretch)	Ped LOS (seg)
1	B	B	A	A	B	C	A	A	C	C	A
2	B	B	B	A	B	B	A	A	C	C	A
3	C	B	C	C	B	B	A	A	C	C	A
4	B	B	C	C	B	B	A	A	C	C	A
5	B	A	A	A	B	B	A	A	C	D	A
Overall	B	B	B	B	B	B	A	A	C	C	A

The 17th Street cross section, with its dedicated bus lane located inside of a designated bike lane, is highly atypical and not well suited for the NCHRP 3-70 analysis. Participants indicated that motorists frequently use the bus lane as a general use lane. Several options were discussed regarding how to code this cross section to produce the most reasonable possible results. Options included 1) treating the bus lane as an additional travel lane (which would overstate the impact of traffic volume on bicyclists and pedestrians), 2) reducing the traffic volume to include only the buses traveling in the outermost lane (this might best reflect impacts to the non-motorized modes, but is not representative of overall motor vehicle traffic, and 3) treating the bus lane as a parking lane with only 10% occupancy. While this last option may produce unrealistically good bicycle segment level of service results, it was chosen as the best alternative and was used to produce the results in Table 2. The 17th Street analysis produced similar results for the auto mode among the four models tested.

Buford Highway

Buford Highway is a six-lane road paralleling Interstate 85 in suburban Gwinnett County. The road serves as an alternative route to the interstate, especially during periods of interstate congestion. The study section of Buford Highway is approximately seven miles northeast of downtown Atlanta. This section has abundant commercial driveways, provides intermittent sidewalks near its southern end, and is served by two transit routes. It is the highest pedestrian crash corridor in the State of Georgia; most of these crashes are associated with mid-block crossings. The selected direction of travel is northeast bound (away from the regional center of Atlanta), the peak direction during the PM peak period. The results of the analysis are shown in Table 3.

Table 3: NEB Buford Highway from Druid Hills Road to Clairmont Road

Segment	*Auto LOS 1 (stops)*	*Auto LOS 2 (speed)*	*Auto LOS 3 (HCM)*	*Auto LOS 4 (3-79)*	*Transit LOS*	*Bike LOS*	*Bike LOS (stretch)*	*Bike LOS (seg)*	*Ped LOS*	*Ped LOS (stretch)*	*Ped LOS (seg)*
1	B	A	B	B	B	F	F	D	E	F	F
2	B	A	A	A	B	F	F	D	D	E	D
3	B	A	B	B	B	F	F	D	E	F	F
4	B	A	A	A	B	F	F	D	E	F	F
5	B	C	E	E	B	D	D	D	E	F	E
Overall	B	B	C	C	B	F	F	D	E	F	E

Participants agreed with the indication of available capacity for the auto mode and generally good transit service. If anything, they tended to agree with the poorest results for the bicycle and pedestrian modes, which were produced by the stretched models for those modes. No data collection difficulties or anomalies were observed for this facility, although one participant stated that the roadway crossing difficulty factor may be understated in the analysis because it is capped at a value of 1.2.

Cobb Parkway

Cobb Parkway is located between the suburban City of Marietta and Interstate 75. The study section has a four-lane cross section and is located approximately fifteen miles northwest of downtown Atlanta. Intermittent paved shoulders and sidewalks are present, and transit service is provided by Cobb Community Transit. The selected direction of travel is northwest bound (away from the regional center of Atlanta), the peak direction during the PM peak period. The results of the analysis are shown in Table 4.

Table 4: NWB Cobb Parkway from Frey's Gin Road to Allgood Road

Segment	*Auto LOS 1 (stops)*	*Auto LOS 2 (speed)*	*Auto LOS 3 (HCM)*	*Auto LOS 4 (3-79)*	*Transit LOS*	*Bike LOS*	*Bike LOS (stretch)*	*Bike LOS (seg)*	*Ped LOS*	*Ped LOS (stretch)*	*Ped LOS (seg)*
1	*B*	*B*	*D*	*D*	*C*	*E*	*E*	*B*	*E*	*F*	*F*
2	*B*	*C*	*E*	*E*	*C*	*E*	*E*	*C*	*E*	*F*	*D*
3	*B*	*B*	*D*	*D*	*C*	*F*	*F*	*E*	*E*	*F*	*F*
4	*B*	*B*	*C*	*C*	*C*	*F*	*F*	*E*	*F*	*F*	*F*
5	*B*	*B*	*C*	*C*	*C*	*E*	*D*	*A*	*E*	*F*	*E*
Overall	*B*	*B*	*C*	*D*	*C*	*F*	*F*	*C*	*F*	*F*	*F*

The auto results for Cobb Parkway were generally viewed as overstating the quality of accommodation, with the NCHRP 3-70 methodology producing the most reasonable results. The relatively good bicycle segment results were deemed reasonable, but the facility models were thought to provide the best overall picture because of the numerous driveway crossings and busy signalized intersections located throughout the corridor. No data collection difficulties or arose as part of this analysis.

General Comments

Numerous general comments regarding the general methodology, data collection, and results were offered by participants. These comments are summarized in the following list.

- This methodology will be most useful for corridor analyses and related scenario testing.
- The data collection effort is likely too intense to allow for a regional system-wide analysis.
- There was discussion about the difficulty to achieve good levels of service for the bicycle and pedestrian facility models. The consensus is that this situation makes sense given that the roadways being analyzed are arterials, which are generally geared toward the fast movement of many travelers. However, there was also a sense that if agencies view the clustering of results in the middle range as a

problem, something will nonetheless need to be done (perhaps including the incorporation of the stretched models).

- One participant stated that he was generally more comfortable with the bicycle, pedestrian, and transit results than he was with the auto results.
- One participant suggested that the application of the transit analysis might spur transit agencies to collect many of the data items that are frequently unknown.
- The group felt that the timing for this type of multi modal approach is ideal.

Atlanta Workshop Participants

Name	***Agency***	***E-mail Address***
Regan Hammond	*Atlanta Regional Commission*	*RHammand@atlantaregional.com*
Michael Klahr	*City of Newnan*	*mklahr@cityofnewnan.org*
Amos Fernandes	*Jacobs*	*amos.fernandes@jacobs.com*
Kyung-Hwa Kim	*Atlanta Regional Commission*	*KKim@atlantaregional.com*
Kofi Wakhisi	*Atlanta Regional Commission*	*KWakhisi@atlantaregional.com*
Mshadoni Smith	*Georgia Tech*	*mshadoni@gatech.edu*
David Emory	*Atlanta Regional Commission*	*demory@atlantaregional.com*
Todd Long	*GRTA*	*tlong@grta.org*
Valentin Vulov	*GRTA*	*vvulov@grta.org*
David Haynes	*Atlanta Regional Commission*	*dhaynes@atlantaregional.com*
Guy Rousseau	*Atlanta Regional Commission*	*grousseau@atlantaregional.com*

F. San Antonio, Texas

This section describes the testing of several arterial roadway facilities in the San Antonio metropolitan region as part of NCHRP 3-70 Phase III. The workshop and this summary of the field test results were prepared by Peyton McLeod of Sprinkle Consulting.

Unlike some other Phase III evaluations, which were completed in one day, this evaluation took place over a longer period of time. The reason for this difference was the expressed desire to select study facilities that were geographically diverse and representative of several of the jurisdictions which participated in the testing. Such a goal would not have been attainable in a single-day setting. Accordingly, the evaluation process included two participant workshops conducted on March 4, 2009 and April 8, 2009, the former of which included limited field data collection for one study facility. A more extensive data collection effort took place during the time between the two workshops.

The workshops were hosted by the San Antonio-Bexar County Metropolitan Planning Organization, and were conducted by Sprinkle Consulting. The intent of the first workshop was to introduce participants to the NCHRP 3-70 methodology and techniques, describe the data collection requirements, and analyze a sample facility. At the second workshop, participants reviewed the results of the analyses and provided comments on the analysis process and the reasonability of results from a local perspective. The workshops were attended by seven participants from four transportation agencies.

The selected study facilities were the following:

- San Pedro (Park to Mulberry; workshop test example);
- Zarzamora (Frio City to Centennial);
- Broadway (Mulberry to Casa Blanca); and
- Basse (Blanco to Quarry Market entrance).

The data collection procedure was similar for all four study facilities and included four primary components: office-based data collection, field measurements and observations, intersection turning movement counts, and travel time runs. Office-based data collection was typically performed in advance of the field work and included such data items as segment lengths and crossing distances, transit routes' headways and travel speeds, and traffic volumes. Field measurements and observations included cross sectional elements (widths of sidewalks, bike lanes, travel lanes, and medians), pavement condition determinations, speed limit, and transit amenities. Turning movement counts were used to determine cross-street volumes, turning percentages, truck percentages, and directional factors. Signal timing observations and pedestrian counts were performed in concert with the turning movement counts. Travel time runs were conducted to determine average travel speeds and stops per mile; five travel time runs were conducted for each corridor. Both turning movement counts and travel time runs were performed during the desired analysis period (PM peak or AM peak).

The following sections describe the settings, multimodal level of service results, and discussion items for each facility. Because the study process did not typically vary from location to location, the process is not discussed for each individual facility.

San Pedro

The study portion of San Pedro is located just north of downtown San Antonio. The surrounding land use is a mix of commercial and residential. It is a four-lane roadway with relatively narrow lanes and sidewalks throughout. The selected direction of travel is northbound (away from downtown San Antonio), the peak direction during the PM peak period. The results of the analysis are shown in the Table 1.

Table 1: NB San Pedro from Park to Mulberry

Segment	Auto LOS 1 (stops)	Auto LOS 2 (speed)	Auto LOS 3 (HCM)	Auto LOS 4 (3-79)	Transit LOS	Bike LOS	Bike LOS (stretch)[6]	Bike LOS (seg)[7]	Ped LOS	Ped LOS (stretch)	Ped LOS (seg)
1	C	B	C	C	A	D	C	D	D	E	D
2	B	B	B	B	A	D	C	E	D	E	D
3	B	A	A	A	A	E	E	E	E	E	E
4	B	B	A	A	A	F	F	E	E	E	E
5	B	B	A	A	A	F	F	E	E	E	E
Overall	B	B	A	A	A	F	F	E	D	E	D

The workshop participants generally agreed with the level of service results for each mode relative to the other modes, but there was not enough variability within the mode-specific model alternatives to allow for preferences. While the transit level of service of "A" was viewed as accurate, a couple of concerns related to the transit analysis were raised. One was the treatment of parallel routes. Some participants stated that it makes sense to include nearby parallel routes as part of the analysis, but at least one person believed that would create an unequal situation between the modes (*i.e.,* a parallel transit route would be counted but a parallel bicycle route with better conditions than the nearby arterial would not be shown to provide any benefit in the analysis). A question was also posed about the reasonability of having an average passenger trip length that is longer than the facility length and the resulting (unmeasured) importance of transit conditions outside the designated facility.

[6] This is the "Bicycle LOS Model 2," as described in NCHRP Report 616; the same is true for the stretched pedestrian model.

[7] This is the stand-alone segment bicycle level of service model; the same is true for the segment pedestrian model.

Zarzamora

Zarzamora is a major north-south travel corridor on the west side of San Antonio, located within a relatively high-density residential section of the City. The study corridor consists of a four-lane cross section; sidewalks are generally present, though a few gaps exist. The selected direction of travel is southbound, the peak direction during the PM peak period during which data were collected. The results of the analysis are shown in the Table 2.

Table 2: SB Zarzamora from Frio City to Centennial

Segment	Auto LOS 1 (stops)	Auto LOS 2 (speed)	Auto LOS 3 (HCM)	Auto LOS 4 (3-79)	Transit LOS	Bike LOS	Bike LOS (stretch)	Bike LOS (seg)	Ped LOS	Ped LOS (stretch)	Ped LOS (seg)
1	B	B	B	B	C	E	D	D	D	E	D
2	B	B	B	B	C	E	E	D	D	E	D
3	B	B	C	C	C	F	E	D	E	E	E
4	B	B	B	B	C	E	D	D	D	E	D
5	B	B	B	B	C	C	B	A	D	D	C
Overall	B	B	B	B	C	E	D	C	D	D	D

As with San Pedro, the mode-specific model results did not generally produce significant variability. One exception that led to some discussion is the bicycle level of service for the southernmost segment of the facility. For the length of this segment, there is a paved area approximately fifteen feet wide outside of the generally traveled area. By definition, this width is included in the outside lane width and not as a separate lane because it is not striped. Field observers reported that the only vehicles using the space were buses making stops and right turning vehicles into the few driveways present. The effect of this very wide outside lane is to produce a better level of accommodation for bicyclists (ranging from “A” for the segment model to “C” for the recommended NCHRP 3-70 model) relative to the facility’s other segments. Interestingly, participants felt that the segment model result of “A” represented the most reasonable result for the segment itself, but that the corresponding segment-based result of “C” for the entire facility was too heavily influenced by that one segment.

Broadway

Broadway is a narrow six-lane road in the City of San Antonio. The study corridor, which is immediately surrounded by commercial properties, is served by three transit routes and has sidewalks in both directions. The selected direction of travel is southbound (toward downtown San Antonio), the peak direction during the PM peak period. The results of the analysis are shown in Table 3.

Table 3: SB Broadway from Mulberry to Casa Blanca

Segment	Auto LOS 1 (stops)	Auto LOS 2 (speed)	Auto LOS 3 (HCM)	Auto LOS 4 (3-79)	Transit LOS	Bike LOS	Bike LOS (stretch)	Bike LOS (seg)	Ped LOS	Ped LOS (stretch)	Ped LOS (seg)
1	B	A	A	A	A	D	C	D	C	C	B
2	B	A	A	A	A	F	E	D	C	D	B
3	B	B	B	B	A	E	D	D	D	E	C
4	B	B	B	B	A	F	F	D	D	D	C
5	B	B	B	B	A	F	F	D	D	E	C
Overall	B	B	B	B	A	E	E	D	D	D	C

Participants agreed with the indication of available capacity for the auto mode and generally good transit service. The pedestrian segment model was believed to produce the most reasonable result, given the presence of sidewalks and buffer zones, while the bicycle segment model was thought to produce the least reasonable result. This situation underscores the general consensus that, for the non-motorized modes, the segment model is generally a better predictor of travel conditions when conditions are good but not necessarily when conditions are poor.

Basse

Basse is a major east-west travel corridor in the northern portion of San Antonio. The study corridor spans both a primarily residential area for the western portion and a major upscale retail district on the eastern end east of Highway 281. Sidewalks are present for most of the corridor, and a wide paved shoulder exists along the segment east of Highway 281. The selected direction of travel is eastbound, the peak direction during the PM peak period. The results of the analysis are shown in Table 4.

Table 4: EB Basse from Blanco to Quarry Market entrance

Segment	Auto LOS 1 (stops)	Auto LOS 2 (speed)	Auto LOS 3 (HCM)	Auto LOS 4 (3-79)	Transit LOS	Bike LOS	Bike LOS (stretch)	Bike LOS (seg)	Ped LOS	Ped LOS (stretch)	Ped LOS (seg)
1	F	F	D	D	F	F	F	D	E	F	D
2	F	F	D	D	F	E	E	D	F	F	E
3	B	B	B	B	F	D	D	B	E	F	E
4	B	B	D	D	F	D	C	D	D	E	D
5	B	B	B	D	F	E	D	D	D	E	D
Overall	F	F	C	C	F	E	F	C	E	F	E

The most discussed aspect of the multi-modal level of service results for Basse was the discrepancy amongst the tested auto models. This variation is primarily the result of the stops and speed models indicating over-capacity conditions for the two westernmost segments. While the cross section remains similar throughout most of the facility and the traffic volume does not vary significantly, the two intersections associated with the capacity failure both have low effective green (g/C) ratios. The participants understood the reason for the failure, but did not generally associate the segments in question with over-capacity conditions and wondered whether the models were accurately capturing the actual conditions.

Workshop Participants

Name	**Agency**	**E-mail Address**
Jeanne Geiger	SA-BC MPO	geiger@sametroplan.org
Abigail Kinnison	VIA Metropolitan Transit	abigail.kinnison@viainfo.net
Lydia Kelly	SA-BC MPO	kelly@sametroplan.org
Ken Zigrang	Texas Department of Transportation	kzigran@dot.state.tx.us
Cecilio Martinez	SA-BC MPO	martinez@sametroplan.org
Richard Higby	Bexar County	rhigby@bexar.org
Clayton Elkins	SA-BC MPO	elkins@sametroplan.org

G. Boise, Idaho

This section provides an overview of the Multimodal Level of Service Workshop held on March 18th, 2009 from 8:30 a.m. to 4:00 p.m. at the offices of Kittelson & Associates, Inc., at 101 S Capitol Boulevard., Suite 301; Boise, Idaho. The workshop and this summary of the field test results were prepared by Paul Ryus and Nick Foster of Kittelson & Associates.

This section covers the following topics:

I. Workshop participants
II. Workshop study locations
III. Summary of workshop
IV. LOS results of the MMLOS analysis
V. Post-workshop questionnaire highlights
VI. Expected utilization of the MMLOS method

I. Workshop participants

The workshop was attended by individuals from public agencies in Boise and the greater Treasure Valley Region. The participating agencies included:

- **City of Boise**
- **Ada County Highway District (ACHD)**
- **Valley Regional Transit (VRT)**
- **Community Planning Association of Southwest Idaho (COMPASS)**

Table 1 provides a summary of the individuals that attended the workshop.

Table 1: Workshop Participants

Name	Agency	Email
Kathleen Lacey	City of Boise	klacey@cityofboise.org
Josh Saak	ACHD	jsaak@achd.ada.id.us
Justin Lucas	ACHD	jlucas@achd.ada.id.us
Mary Barker	VRT	mbarker@valleyregionaltransit.org
Margaret Havey	VRT	mhavey@vallyregionaltransit.org
Liisa Itkonen	COMPASS	litkonen@compassidaho.org

II. Workshop Study Arterials

Nick Foster (Kittelson & Associates, Inc.) worked with the City of Boise and ACHD in the winter of 2009 to identify study locations that would be of most use to the participants. Three arterials were identified, representing a mix of conditions and surroundings. Arterials analyzed in the workshop include:

- Capitol Blvd. between Battery St. and Idaho St.: A 0.39 mile section of three-lane to four-lane urban arterial in downtown Boise. The arterial has bus service and high traffic volumes throughout its length. Certain segments also have high pedestrian volumes, on-street parking, and/or a shoulder. Vehicular travel on the road is one-way.
- Broadway Ave. between Beacon St. and Warm Springs Ave.: A 0.85 mile section of four-lane to seven-lane arterial on the east edge of downtown Boise. This arterial has bus service, relatively low pedestrian and bicycle volumes, and high traffic volumes. It does not have any bicycle facilities, nor is on-street parking allowed.
- State St. between Veterans Memorial Parkway and Marketplace Ln.: A 1.18 mile section of five-lane arterial in northwest Boise. The arterial has bus service, high traffic volumes, and shoulders of varying width and quality. Pedestrian facilities are fragmented throughout the study corridor.

Data was collected for a fourth corridor, Vista Ave. between Rose Hill St. and Overland Rd., but was not analyzed due to the number of participants in the workshop.

III. Summary of Workshop

Overview of Workshop

Attendees arrived at the workshop around 8:30 a.m. The training started around 8:45 a.m. Introductions were made and a presentation was given by Paul Ryus and Rick Dowling outlining the agenda for the day, providing an overview of NCHRP 3-70, and reviewing the data needs. Nick Foster had collected much of the field data before the workshop including driveway cuts, number of stops per mile, average travel speed, speed limits, bicycle and pedestrian facilities, traffic volumes, pedestrian counts, transit stops and headways, and cross-sectional data for the study arterials. ACHD provided the group with traffic signal timing information. Google Earth was used to verify cross-sectional information.

A field visit was performed at approximately 11:00 a.m. to Capitol Boulevard, which is located adjacent to the workshop location. Lunch was taken at approximately 12:00 p.m. At 1:00 p.m. the participants were separated into three groups (one for each corridor) and work began on the study arterial spreadsheets. One VRT representative did have to leave the workshop after the field visit, while the rest were able to stay for the remainder of the workshop.

Advanced Planning

Nick Foster has been in regular communication with most of the participants through previous and/or on-going projects (unrelated to this project). The workshop was originally scheduled for October 2008, but due to unforeseen circumstances was rescheduled for the March date. The date of the workshop was finalized in February and was chosen to allow Rick Dowling to make one trip to the northwest to conduct the Boise and Portland (March 19th, 2009) workshops. Spreadsheets containing the MMLOS methodology and presentation slides were not shared with the participants prior to the workshop, although several emails were sent to the participants in advance with background information and links to relevant websites to provide additional details. Nick Foster worked with participating agency staff to identify data readily available for the case studies and also coordinated the collection of additional data to fill in gaps as necessary.

Week of the Event

Nick Foster e-mailed the agenda and workshop details to the participants. In preparation for the workshop, several hours were spent putting together the required materials including:

- creating spreadsheets for each study arterial;
- making paper copies of the presentations;
- collecting and summarizing transit data available through VRT;
- coordinating the collection of additional traffic count, number of stop, and travel time data for each corridor; and,
- preparing packets for each arterial containing the necessary data.

IV. LOS Results from MMLOS Analysis

The following tables summarize the MMLOS results from the three study arterials included in the Boise MMLOS workshop. As was previously described, all arterials are located within Boise city limits.

Capitol Boulevard

Segment & Downstream Signal	Auto Stops LOS #1	Auto Speed LOS #2	Auto HCM LOS #3	Auto NCHRP 379 LOS #4	Transit LOS	Bicycle LOS	Pedestrian LOS
1	C	C	D	E	C	D	D
2	D	D	F	F	C	D	E
3	E	D	F	F	C	E	D
4	D	C	D	E	C	D	D
Facility D		**D**	**E**	**F**	**C**	**D**	**D**

Broadway Avenue

Segment & Downstream Signal	Auto Stops LOS #1	Auto Speed LOS #2	Auto HCM LOS #3	Auto NCHRP 379 LOS #4	Transit LOS	Bicycle LOS	Pedestrian LOS
1	B	C	C	C	A	F	D
2	B	C	D	D	B	D	D
3	B	C	C	C	A	D	E
4	C	D	F	F	A	E	D
Facility B		**C**	**E**	**E**	**A**	**E**	**D**

State Street

Segment & Downstream Signal	Auto Stops LOS #1	Auto Speed LOS #2	Auto HCM LOS #3	Auto NCHRP 379 LOS #4	Transit LOS	Bicycle LOS	Pedestrian LOS
1	B	B	B	B	C	E	E
2	B	A	A	A	C	E	E
3	B	A	A	A	C	E	E
Facility B		**A**	**A**	**A**	**C**	**E**	**E**

In general, the workshop participants felt that the MMLOS results seemed reasonable. The one exception is the transit LOS rating on Broadway Avenue. Most participants, as well as the presenters, felt it was probably too high.

V. Post Workshop Questionnaire Highlights

At the writing of this summary, the post-workshop questionnaire had only been returned by two participants (one from COMPASS and one from ACHD). A reminder e-mail reiterating the request for feedback was sent out on March 26. The responses from the two questionnaires are included here:

Question #1: What is your overall impression of the MMLOS method?

- My overall impression is that this could be a useful tool on a planning level, but the complexities inherent of any model of this scope lends me to believe this is best used as a preliminary tool only and not to be used for true decision making purposes.
- The method takes in a lot of "professional judgment" and people's perceptions. Adding more to explain/document how the judgments were make would strengthen the method.

Question #2: How do you feel the MMLOS method might be used to support your agency's mission?

- On a planning level, it may have some uses, but I don't know that it will help or hinder our mission.
- This could be a planning and outreach tool for regional long-range transportation planning to help "test" different scenarios and their effects on a variety of modes, as well as the community at large.

Question #3: Describe your experience with applying the MMLOS method in the course of the training?

- The examples provided in applying the MMLOS were varied and gave a good picture of the types of roadways that could be analyzed.
- Once you know what data you need, applying the method should be quite straight forward.

Question #6: How do you feel the MMLOS spreadsheet could be improved?

- Both questionnaire respondents, as well as comments made at the meeting, indicated that it would be helpful if the cells that need to be completed would be shaded in some sort of color. This would help individuals identify where and what data needs to be input.

Question #7: How did the MMLOS results compare with your expectations?

- Overall, the results compared somewhat favorably with what I expected. I think everyone is going to have different perceptions on how a roadway's design does or doesn't address the needs of all users, which makes a model like this difficult to calibrate.
- Close enough to be credible.

Question #9: What further support might you require adopting or implementing the MMLOS method?

- I would like to see more agencies take the MMLOS concept and apply it to a ranking system for improvements and see how it compares to a different ranking system they may currently be employing.
- I'll probably forget some specifics about entering the data, or could use help explaining the method to others in COMPASS

Question #10: Will your agency be applying the MMLOS method in the future?

- It is unlikely that we as an agency will be applying the MMLOS in the future, largely because of the enormous amount of data required to perform an adequate analysis.
- Possibly/probably in the long-range planning process.

Question #11: Would you recommend the MMLOS method to other agencies.

- I would be interested in learning the results that other agencies can provide, though I don't know if I would recommend this particular approach. Using one "unified theory" of LOS is too simple a concept, and many folks have different perceptions on what LOS a roadway should meet.
- Yes.

VI. Expected Utilization of MMLOS Method

All of the agencies that participated in the workshop were intrigued by the use of the MMLOS methodology and found that it provided a reasonable representation of the actual conditions on the study arterials. The receptiveness to use the methodology did vary by agency, with certain representatives eager to see it applied to upcoming projects, while others were skeptical about the work that would need to go into properly utilizing the method, as well as how it might be received by the public. Overall, there seemed to be a general support for the MMLOS methodology and participants thought the method would help better analyze and portray the operational performance characteristics for all users on urban arterials.

H. Portland, Oregon

This section provides an overview of the Multimodal Level of Service Workshop held on March 19th, 2009 from 8:30 a.m. to 4:00 p.m. at the offices of Kittelson & Associates, Inc. at 610 SW Alder Street, Suite 700; Portland, Oregon. The workshop and this summary of the field test results were prepared by Paul Ryus and Nick Foster of Kittelson & Associates.

This section is broken into six subsections:

I. Workshop participants
II. Workshop study locations
III. Summary of workshop
IV. LOS results of the MMLOS analysis
V. Post-workshop questionnaire highlights
VI. Expected utilization of the MMLOS method

I. Workshop participants

The workshop was attended by individuals from several public agencies and private consulting firms. The attendees all work within the field of transportation engineering/planning in the greater Portland metropolitan region. Table 1 summarizes the participants.

Table 1: Workshop Participants

Name	Agency	Email
Alan Snook	DKS Associates	aws@dksassociates.com
Ric Vrana	TriMet	vranar@trimet.org
Kurt Krueger	City of Portland	kurt.krueger@pdxtrans.org
Mike McCarthy	City of Tigard	mikem@tigard-or.gov
Mike Tressider	Alta Planning Group	miket@altaplanning.com
Mark Sullivan	City of Hillsboro	marks@ci.hillsboro.or.us
Anthony Butzek	Metro	anthony.butzek@oregonmetro.gov
Don Gustafson	City of Beaverton	dgustafson@ci.beaverton.or.us
Jinde Zhu	Washington County	jinde_zhu@co.washington.or.us
Ahmad Qayoumi	City of Vancouver	ahmad.qayoumi@ci.vancouver.wa.us
Trevor Coolidge	City of Gresham	trevor.coolidge@ci.gresham.or.us
Michael Wolfe	Portland State University	mwolfe@pdx.edu
Lidwien Rahman	Oregon Department of Transportation	lidwein.rahman@odot.state.or.us
Michelle Dewey	City of Portland	Michelle.dewey@pdxtrans.org

II. Workshop Study Arterials

Chris Tiesler (Kittelson & Associates, Inc.) worked with several local agencies in the early winter of 2009 to identify study locations that would be of most use to the participants. Four arterials were identified, representing a mix of conditions and surroundings. Arterials analyzed in the workshop include:

- West Burnside St. between 14th and 6th: A 0.42 mile section of four-lane to six-lane urban arterial in downtown Portland. The arterial has bus service, high pedestrian and traffic volumes, and no bicycle facilities. Certain segments include on-street parking and the presence of a raised median.
- SE 39th Ave. between Burnside St. and Division St.: A 1.29 mile section of four-lane arterial on the east side of Portland. This arterial has bus service, relatively low pedestrian and bicycle volumes, and no bicycle facilities.
- 185th Ave. between Evergreen Pkwy. and Walker Rd.: A 1.24 mile section of four-lane to six-lane arterial in Hillsboro, Oregon. The arterial has bus service, high traffic volumes, and bicycle lanes.
- Powell Boulevard. between Eastman Pkwy. and Cleveland Ave.: A 0.85 mile section of five-lane arterial in Gresham, Oregon The arterial has bus service, high traffic volumes, bicycle lanes, and on-street parking.

III. Summary of Workshop

Overview of Workshop

Attendees arrived at the workshop around 8:30 a.m. The training started around 8:45 a.m. Introductions were made and a presentation was made by Paul Ryus and Rick Dowling outlining the agenda for the day, providing an overview of NCHRP 3-70, and reviewing the data needs. Chris Tiesler had collected much of the field before the workshop including driveway cuts, number of stops per mile, average travel speed, and cross-sectional data for the study arterials. A variety of public agencies provided the group with traffic signal timing, traffic volumes, and pedestrian count information. Google Earth was used to gather missing data including landscaping information, speed limits, and bicycle facilities. A field visit was performed at approximately 11:15 a.m. to the Burnside corridor, located nearby the workshop location. Lunch was taken at approximately 12:15 p.m. At 1:00 p.m. the participants were separated into four groups (one for each corridor) and work began on the study arterial spreadsheets. Most participants were able to stay for the entire workshop.

Advanced Planning

Chris Tiesler has been in regular communication with several of the participants through previous and/or on-going projects (unrelated to this project). The date for the workshop was established in February and was chosen to coincide with Rick Dowling's travel to the northwest for this workshop and one in Boise, Idaho (March 18th, 2009). Spreadsheets containing the MMLOS and presentation slides were not shared with the participants prior to the workshop, although several emails were sent to the participants in advance with background information and links to relevant websites to provide additional details. Chris Tiesler worked with participating agency staff to identify data readily available for the case studies, and also coordinated the collection of additional data to fill in gaps as necessary.

Week of the Event

Chris Tiesler e-mailed the agenda and workshop details to the participants of the workshop. In preparation for the workshop, several hours were spent putting together the required materials including:

- creating spreadsheets for each study arterial;
- making paper copies of the presentations;
- collecting and summarizing transit data available through TriMet;
- coordinating the collection of additional traffic count, number of stop, and travel time data for each corridor; and,
- preparing plots of aerials of each study corridor.

IV. LOS Results from MMLOS Analysis

The following tables summarize the MMLOS results from the four study locations included in the Portland MMLOS workshop.

Burnside Street (Portland, OR)

Segment & Downstream Signal	Auto Stops LOS #1	Auto Speed LOS #2	Auto HCM LOS #3	Auto NCHRP 379 LOS #4	Transit LOS	Bicycle LOS	Pedestrian LOS
1	C	C	D	D	C	C	C
2	C	C	D	D	C	E	D
3	D	C	D	D	C	D	D
4	D	C	D	D	C	D	D
5	D	C	D	D	C	D	D
Facility	C	C	D	D	C	D	D

SE 39th Avenue (Portland, OR)

Segment & Downstream Signal	Auto Stops LOS #1	Auto Speed LOS #2	Auto HCM LOS #3	Auto NCHRP 379 LOS #4	Transit LOS	Bicycle LOS	Pedestrian LOS
1	B	C	D	D	B	F	D
2	E	C	E	F	B	F	D
3	D	D	F	F	B	F	D
4	B	C	C	C	B	F	D
5	-	-	-	-	-	-	-
Facility	C	C	E	E	B	F	D

185th Avenue (Hillsboro, OR)

Segment & Downstream Signal	Auto Stops LOS #1	Auto Speed LOS #2	Auto HCM LOS #3	Auto NCHRP 379 LOS #4	Transit LOS	Bicycle LOS	Pedestrian LOS
1	C	B	D	D	B	D	C
2	C	C	F	F	B	C	D
3	B	C	E	E	B	C	C
4	C	B	D	D	B	D	C
5	C	C	F	F	B	C	C
Facility	C	C	F	F	B	C	C

Powell Boulevard (Gresham, OR)

Segment & Downstream Signal	Auto Stops LOS #1	Auto Speed LOS #2	Auto HCM LOS #3	Auto NCHRP 379 LOS #4	Transit LOS	Bicycle LOS	Pedestrian LOS
1	B	B	A	A	A	D	C
2	B	B	C	C	B	C	D
3	B	B	B	B	A	C	C
4	B	B	A	A	A	C	C
5	-	-	-	-	-	-	-
Facility	B	B	B	B	A	C	C

V. Post Workshop Questionnaire Highlights

Some of repeated responses that were captured on the post-workshop questionnaire are included here for review and consideration:

Question #1: What is your overall impression of the MMLOS method?

- Interesting. I find it fascinating (and appropriate) that the team decided to report the results in 4 different modal LOS measures, rather than combining them into one measure.
- I think it's a good attempt at quantifying something that is very subjective. I think there needs to be a lot of cautions used in its application.

Question #2: How do you feel the MMLOS method might be used to support your agency's mission?

- The Oregon Transportation Plan supports and encourages alternative modes. As an agency, ODOT struggles with how to manage urban arterials. The MMLOS method gives our Traffic analysts a tool to more comprehensively evaluate the performance of urban arterials.
- TriMet can use such a methodology to evaluate the street capacity for transit and especially for pedestrian access to transit and TOD as part of a corridor evaluation. Such evaluations might be made with the objective of establishing new service, considering where to make service expansions or cutbacks, and where to invest in transit oriented development.

Question #3: Describe your experience with applying the MMLOS method in the course of the training?

- I liked the balance struck between ease of use and comprehensiveness, and the fact that the method uses data familiar to traffic analysts. As a pedestrian and bicycle user and advocate, the factors appear to match my perceptions of what constitutes various levels of service and comfort.

- We were able to work through the formulas fairly easily once some of the team members understood the exact details were not that important. I think a quick run through to see the preliminary results would have been helpful, then go back and enter more detail to see how it affected the results. That would give you a sense of why you got the result you did. It does not seem to depend on acquiring a lot of data.

Question #7: How did the MMLOS results compare with your expectations?
- Very close correlation with our observations.
- Useful be maybe not as comprehensive as I anticipated. Bicycling LOS is a major advance of course, but all transit is basically treated the same (and it is all bus service) and there was no freight mode considerations.
- I found them pretty dead-on.
- Very good.

Overall, participants noticed a large difference in Auto LOS results between the HCM methodology and the MMLOS methodology. Based on field data collected during the weekday p.m. peak hour and used in the case study corridors, the HCM LOS methodology tended to produce a worse LOS (LOS “D” or “E”) compared to the MMLOS (LOS “B” or “C”) based on travel speeds along the corridor. This discrepancy appears to be larger than what one might expect.

Question #10: Will your agency be applying the MMLOS method in the future?
- I don’t know.
- Quite possibly.
- Most certainly.

Question #11: Would you recommend the MMLOS method to other agencies.
- All answered “Yes.”

VI. Expected Utilization of MMLOS Method

Most if not all of the agencies that participated in the workshop found it the MMLOS methodology relevant and applicable to arterials within their jurisdiction. The private sector participants suggested that the methodology could be a valuable tool to use in their work with public jurisdictions. Overall, there seemed to be a general support for the MMLOS methodology and participants thought the method would help better analyze and portray the operational performance characteristics for all users on urban arterials.

I. Evaluation of Auto LOS Model Results

An In-depth Assessment of the Auto Models by Nagui M. Rouphail

This review is based on documentation provided by the Phase III workshop coordinators regarding the agency assessment of the NCHRP 3-70 MMLOS models and spreadsheet, along with general comments on usability, data needs, ease of understanding, etc. The objective of Phase III is to: *"... assess how well the LOS produced by NCHRP 3-70 MMLOS method and its data analysis requirements match local agency expectations*…" The objective of the NCHRP 3-70 project as stated in the RFP was to *"... Collect data on LOS perceptions of the traveling public; Fit LOS models to data; prepare Interim Report and develop a draft chapter for the HCM, that presents the framework and enhanced methods for multimodal LOS analysis for urban streets.*.." This review is focused exclusively on the auto models, with particular attention to the NCHRP 3-79 (herein called **N3-79**), the HCM2K arterial LOS model, and the NCHRP herein called the **Stops** and **Speed** models.

HCM 2000 and N3-79

The first assessment was to compare the HCM2000 and N3-79 models since they are considered to produce similar LOS measures. The N3-79 model bases the LOS on the % FFS, thus eliminating the need for the use of arterial class. This elimination of arterial class is in line with the findings of the NCHRP 3-70 auto model research, which concluded that arterial class was not a significant contributor to traveler perceived LOS. To gain further insight into how the two models compare the HCM2000 LOS speed thresholds were converted into % of the typical FFS. Exhibit 1 shows the comparison of HCM2000 LOS and N3-79 LOS thresholds as defined by %FFS across the existing four arterial classes.

It is evident from Exhibit 1 that, on average using the % FFS is a good approximation to the HCM2K approach (compare HCM2K and N3-79 rows, blue and yellow cells, in the Average column). A notable exception is the class IV urban arterials and the Class II 40mph FFS LOS A condition, highlighted in orange. In the Class IV cases, the N3-79 model will predict a worse LOS than then HCM 2K. This change in LOS is because the averaged %FFS *implicit in the HCM2K for Arterial Class IV* (the dark orange shaded cells in exhibit 1) are much lower than the N3-79 thresholds. Thus, the expectation in moving to the N3-79 model is that more arterials that have low FFS will be reported as failing. This fact is important to remember as that model is contrasted with the NCHRP 3-70 models. In the Class II 40mph LOS A example, the N3-79 model reports a better LOS at 85% FFS than the HCM 2K, though given the high LOS range, this change is not expected to cause my concern. As a side note, the University of Florida report recommends a new arterial classification at three levels based on functionality, signal density and posted speed limit.

Exhibit I Comparing HCM2000 and N3-79 LOS Thresholds (%FFS)

FFS		CLASS I 50	CLASS II 40	CLASS III 35	CLASS IV 30	AVERAGE	Max Diff.
LOS A	HCM2K	HIGHER THAN 84.0%	87.5%	85.7%	83.3%	85.1%	
	N3-79					85.0%	2.5% (III)
LOS B	HCM2K	HIGHER THAN 68.0%	70.0%	68.6%	63.3%	67.5%	
	N3-79					67.0%	3.7%(IV)
LOS C	HCM2K	HIGHER THAN 54.0%	55.0%	51.4%	43.3%	50.9%	
	N3-79					50.0%	6.7% (IV)
LOS D	HCM2K	HIGHER THAN 42.0%	42.5%	40.0%	30.0%	38.6%	
	N3-79					40.0%	10%(IV)
LOS E	HCM2K	HIGHER THAN 32.0%	32.5%	28.6%	23.3%	29.1%	
	N3-79					30.0%	6.7% (IV)
LOSF	HCM2K	LESS THAN 32.0%	32.5%	28.6%	23.3%	29.1%	
	N3-79					30.0%	6.7%(IV)

Phase III Workshop Findings

Several workshops were held in late 2008 and early 2009 that were intended to train local agencies on the use of the MMLOS methods, models and software. Separate reports have been provided by the workshop coordinators, and in the case of the Florida sites, by researchers at UF under contract from FDOT. This section attempts to summarize the findings from the auto LOS comparison. In general, four auto models were compared at all locations: **Stops LOS#1; Speed LOS#2; HCM LOS#3 and N3-79 LOS#4.** In some cases, the travel time runs were carried out as part of the workshop and in other there were done by 3-70 staff prior to the workshop. A total of 31 sites nationally were visited and LOS was computed by segment and for the entire facility according to the four auto models. The number of segments varied from 2 to 4 per facility. Detailed results for the 35 sites are summarized in Exhibit 2, which is shown on the next two and a half pages. Only the **N3-79** and **Stops** and **Speed** models are covered in the spreadsheet computations. The column definitions are as follows:

- Site number
- City/ State
- Arterial name
- Arterial class based on HM2K definitions
- Method, or Auto model specification
- Segment 1 through segment X LOS
- Facility LOS
- Delta

The last variable is defined as follows: delta is the number of LOS grades between the **Stops** and **Speed** model when compared to the N3-79 model as the baseline. Thus, a *positive* value of delta indicates that the Stops and Speed models produce a *better* LOS for the facility, while a negative value implies that the N3-79 model produces a better facility LOS. The numerical value itself refers to the number of LOS. For example, if the Stops model predicts a facility LOS C and the N3-79 model produces a LOS E then Delta = +3; if it were the reverse, then Delta would be = -3. It is informative to test a couple of hypotheses here. The first is whether there is a systematic difference between the three models LOS thresholds at the 35 sites visited.

This comparison can be conducted by looking at the distribution of delta values across the models. If the mean value of delta is close to zero, and the distribution shows no right or left side bias, the hypothesis is likely to be true. Exhibit 3 shows the delta distribution across the 31 sites. It is clear that the hypothesis does not hold very well. Delta is positively skewed, with only about 17% of the observations showing the LOS produced by the N3-79 model better than the 3-70 models, while 60% of the time the opposite is true. The mean delta for the stops model is about +0.75, while that for the speed model is +0.77. The bottom line is that the 3-70 models produce a facility LOS that is on average 0.75 LOS grades better than N3-79. This observation is corroborated further by looking at the resulting LOS Distributions produced by the 3 models, as shown in Exhibit 4. The Stops model, however, is much closer in its LOS predictions to the N3-79 than is the speed model as seen from the mean values at the bottom of Exhibit 4. Finally, there were little differences in facility LOS estimation between N3-79 and the HCM2000 model (not shown here).

Exhibit 2 Comparisons of Segment and Facility Auto LOS Models by Site

Site	City/State	Location	Art Class	Method	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5	Facility LOS	LOS DELTA Base 3-79
1	**Boise- Idaho**	Capitol Boulevard	3	N3-79	E	F	F	E		F	
			3	Stops	C	D	E	D		D	2
			3	Speed	C	D	D	C		D	2
2		Broadway Avenue	2	N3-79	C	D	C	F		E	
			2	Stops	B	B	B	C		B	3
			2	Speed	C	C	C	D		C	2
3		State Street	2	N3-79	B	A	A			A	
			2	Stops	B	B	B			B	-1
			2	Speed	B	A	A			A	0
4	**Portland-Oregon**	Burnside Street	4	N3-79	D	D	D	D	D	D	
			4	Stops	C	C	D	D	D	C	1
			4	Speed	C	C	C	C	C	C	1
5		SE 39th Ave.	3	N3-79	D	F	F	C		E	
			3	Stops	B	E	D	B		C	2
			3	Speed	C	C	D	C		C	2
6	**Hillsboro, Or.**	185th Avenue	2	N3-79	D	F	E	D	F	F	
			2	Stops	C	C	B	C	C	C	3
			2	Speed	B	C	C	B	C	C	3
7	**Powell Blvd,Gresham Oregon**		2	N3-79	A	C	B	A		B	
			2	Stops	B	B	B	B		B	0
			2	Speed	B	B	B	B		B	0
8	**Atlanta, GA**	Bullsboro Drive	1	N3-79	D	B	D	D	D	D	
			1	Stops	B	B	B	B	B	B	2
			1	Speed	B	A	B	B	B	B	2
9		EB 17th Street	3	N3-79	A	A	C	C	A	B	
			3	Stops	B	B	C	B	B	B	0
			3	Speed	B	B	B	B	A	B	0
10		Buford Highway	2	N3-79	B	A	B	A	E	C	
			2	Stops	B	B	B	B	B	B	1
			2	Speed	A	A	A	A	C	B	1
11		Cobb Parkway	2	N3-79	D	E	D	C	C	D	
			2	Stops	B	B	B	B	B	B	2
			2	Speed	B	C	B	B	B	B	2
12	**Philadelphia, PA**	WB Spruce Street	4	N3-79	D	D	D	D		D	
			4	Stops	E	E	E	E		E	-1
			4	Speed	C	C	C	C		C	1
13		SB Broad Street	4	N3-79	D	D	D	C		D	
			4	Stops	D	C	C	B		C	1
			4	Speed	C	C	C	C		C	1
14		Chestnut Street	4	N3-79	D	E				D	
			4	Stops	C	B				C	1
			4	Speed	C	C				C	1
15	**San Diego, CA**	Broadway Street	4	N3-79	B	F	E	F	B	E	
			4	Stops	B	F	B	F	B	D	1
			4	Speed	B	D	C	C	B	C	2
16		India Street	3	N3-79	A	A				A	
			3	Stops	B	B				B	1
			3	Speed	A	A				A	0

Note: Philadelphia results did not report facility LOS. Tabulated values are estimated from judgment based on individual segment LOS

Exhibit 2 Comparisons of Segment and Facility Auto LOS Models by Site (cont)

Site	City/State	Location	Art Class	Method	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5	Facility LOS	LOS DELTA Base 3-79
17	**Arlington, VA**	Wilson Blvd.	4	N3-79	F	F	F	F	F	F	
			4	Stops	E	D	F	C	E	D	2
			4	Speed	C	C	C	D	D	C	3
18		Glebe Road	3	N3-79	E	E	E	E	E	E	
			3	Stops	C	C	C	B	B	C	2
			3	Speed	C	C	C	C	C	C	2
19		George Mason Dr.	3	N3-79	C	C	C	C	C	C	
			3	Stops	B	cher	C	B	B	B	1
			3	Speed	B	B	B	B	B	B	1
20	**Gainesville, FL**	Archer Rd (WB)	1	N3-79	B	B	B			B	
			1	Stops	B	B	B			B	0
			1	Speed	A	A	A			A	1
21		NW 13th Street	2	N3-79	A	D	A	C	B	B	
			2	Stops	B	B	B	B	B	B	0
			2	Speed	A	C	A	B	A	B	0
22		W. University Ave.	3	N3-79	C	C	A	B		C	
			3	Stops	C	B	B	B		B	1
			3	Speed	C	C	B	B		B	1
23		Tower Rd. (SW75th)	4	N3-79	C	A	B	C		B	
			4	Stops	B	B	B	B		B	0
			4	Speed	B	A	A	B		B	0
24	**Tampa, FL**	Himes Avenue	4	N3-79	C	B	A	E		C	
			4	Stops	B	B	B	F		F	3
			4	Speed	C	C	B	F		F	3
		Nbreaska Avenue	2	N3-79	C	D	D			D	
25			2	Stops	B	C	B			B	2
			2	Speed	B	C	C			C	0
26		US 41	1	N3-79	A	A	A	A	A	A	
			1	Stops	B	B	B	B	B	B	1
			1	Speed	A	A	A	A	A	A	0
27		Kennedy Blvd.	3	N3-79	B	B	B	A	A	A	
			3	Stops	B	B	B	B	B	B	-1
			3	Speed	B	B	B	B	B	B	-1
28	**Talahassee, Fl.**	Capital Circle, SE	1	N3-79	A	A	C	B	A	B	
			1	Stops	B	B	B	B	B	B	0
			1	Speed	A	A	B	A	A	A	1
29		Macomb Street	4	N3-79	B	A	B	A	B	A	
			4	Stops	B	B	B	C	B	B	-1
			4	Speed	B	A	B	A	B	B	-1
30		West Tennessee	4	N3-79	A	C	E	A	C	C	
			4	Stops	B	C	C	C	B	B	1
			4	Speed	A	C	C	B	C	B	1
31		Appleyard Dr.	2	N3-79	A	A	A			A	
			2	Stops	B	B	B			B	1
			2	Speed	A	A	A			A	0

Note: Philadelphia results did not report facility LOS. Tabulated values are estimated from judgment based on individual segment LOS

Exhibit 2 Comparisons of Segment and Facility Auto LOS Models by Site (cont)

Site	City/State	Location	Art Class	Method	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5	Facility LOS	LOS DELTA Base 3-79
32	**San Antonio, Tx**	San Pedro		N3-79	C	B	A	A	A	A	
				Stops	C	B	B	B	B	B	-1
				Speed	B	B	A	B	B	B	-1
33		SB Zarzamora		N3-79	B	B	C	B	B	B	
				Stops	B	B	B	B	B	B	0
				Speed	B	B	B	B	B	B	0
34		Broadway		N3-79	A	A	B	B	B	B	
				Stops	B	B	B	B	B	B	0
				Speed	A	A	B	B	B	B	0
35		Basse		N3-79	D	D	B	D	D	C	
				Stops	F	F	B	B	B	F	-3
				Speed	F	F	B	B	B	F	-3

Note: Philadelphia results did not report facility LOS. Tabulated values are estimated from judgment based on individual segment LOS

Exhibit 3 Distribution of LOS Difference by Auto Model

Delta	Stops Model		Speed Model	
-3	1	2.9%	1	2.9%
-2	0	0.0%	0	0.0%
-1	5	14.3%	3	8.6%
0	8	22.9%	11	31.4%
1	8	22.9%	7	20%
2	10	28.6%	8	22.9%
3	3	8.6%	5	14.3%
Total	**35**		**35**	

Exhibit 4 Distribution of LOS by Auto Model

LOS	N3-79	Stops	Speed
A	7	0	6
B	8	19	13
C	6	8	11
D	7	4	2
E	3	1	0
F	4	3	3
Total	35	35	35
	3.1	2.9	2.6

The second hypothesis tested was whether there the difference in LOS estimation across models can be attributed to ignoring arterial class. The 31 site field sample included five Class 1, eight Class 2, nine Class 3 and nine Class 4 arterials. That hypothesis also was easily rejected with a correlation coefficient between the two variables (class and delta) near zero. In summary, it is evident that both NCHRP 3-70 auto models produce slightly higher LOS than the N3-79 approach, regardless of arterial class or any other variables. It is also important to recall that the HCM2000 models will produce slightly better/ higher LOS for arterial facilities Class 4 than N3-79.

Anecdotal Feedback from Workshop Participants from Post Workshop Discussions

- *Idaho:* Results of (all modal) models compared favorably with what I expected; Close enough to be credible.

- *Oregon:* Method useful especially to assess pedestrians access to transit; results very close to our expectations; pretty dead-on; noticed a large difference between HCM 2K and MMLOS auto LOS models, with HCM 2K/ N3-79 producing worse LOS (D/E) compared to MMLOS (B/C). Preference for maintaining the current HCM 2K auto LOS model.

- *Georgia (Atlanta):* Agree that overall results indicating that accommodation of bicyclists, pedestrian and transit users were worse than for motorists are accurate; Mixed opinions as to whether the stops/ speed models of NCHRP 3-70 produced the most reasonable results; NCHRP 3-70 results produced the most reasonable results for Cobb Street. *One participant* stated that he was more comfortable with the pedestrian, bike and transit model results than the auto models results *(the other participants did not venture an opinion)*

- *Pennsylvania (Philadelphia):* No facility LOS reported. No travel time or stop runs on Spruce Street (mostly estimations). No debriefing findings reported.

- *California (San Diego):* Questions about transit and bicycle LOS judged to be too good on Broadway. No debriefing questions were reported.

- *Virginia (Arlington):* Wilson Boulevard not considered a failing arterial as projected by N3-79/HCM 2K. The stops and speed models provide a better representation. Same comment for Glebe Road. Lack of sensitivity of the speeds, N3-79 and HCM 2K models to segment volume variations. Stops model showed higher sensitivity.

- *Florida (Tampa, Tallahassee and Gainesville):* In general, the reported LOS for all auto models was primarily in the uncongested region for most of the 12 sites studied in several Florida cities (LOS A → LOS C). The only exception is Himes

Ave. in Tampa (where the MMLOS model predicted a LOS F for segment 4 only—which then predicted a facility LOS F); and Nebraska Avenue, also in Tampa, where NCHRP 3-79 model and HCM 2K predicted a facility LOS D; Participants noted that it is not reasonable to collect speed and stops data in the field; must rely on MMLOS spreadsheet. The average LOS delta between the MMLOS and NCHRP 3-79 models is only ½ LOS grade.

- *Texas (San Antonio):* Out of the four sites studied, three had auto LOS A or B across all models. It was stated that the 3-70 models predicted an unrealistic LOS F for the Basse arterial, which was questioned by the participants. It was not explained to the participants that LOS F is NOT a function of the 3-70 models themselves, but rather that the computed v/c for this arterial using the MMLOS spreadsheet yielded a v/c > 1.0 and thus the entire arterial was deemed as failing. It is unclear why the same assumption for the other two auto models was not made since v/c > 1.0 is a site not a model specific feature. .

Model Application Issues

The Florida study brought up some legitimate issues regarding the range of LOS that can be generated by the NCHRP 3-70 stops and speed models (Figures 21-25 in the Fl. study report). However, the study failed to interpret the reason for that constraint, which has nothing to do with the model formulation, but with how the LOS thresholds are set. To address this issue, one needs to recall that the MMLOS stops and speed models *produce an entire distribution of LOS*, so the idea that the model cannot produce LOS A or F is erroneous. It actually produces ALL LOS values, although with different probabilities. Nevertheless, once that entire distribution is condensed into a single number (the mean LOS, which is what is being compared throughout the study), it is NOT likely that the mean will produce an extreme LOS observation unless the model predicts 100% LOS A or F, which is mathematically impossible. The reason for condensing it was not because the models are too complex, but simply to maintain consistency with the models for other modes.

As an illustration, Exhibit 5 below shows the stops model prediction for the extremely good case of zero stops and presence of LT lane throughout. This scenario should produce an easy LOS A since it is the ideal condition. Shown below the figure are the current NCHRP 3-70 **MEAN** LOS thresholds. These assume that an ***individual prediction*** of LOS A is rated at 1, LOS B at 2, etc., all the way to LOS F which is rated at 6.00 (*note that the Florida Study on page 5 also misinterprets the values 1 to 6 as giving higher weights to the lower LOS; this is incorrect: the weights are actually the probability values assigned to each LOS value; the mean is then simply the sum of x P(x), from elementary discrete random value statistics*). The thresholds again apply to the mean values only. In this case from the figure, the mean rating is: (0.3062 x 1) +(0.4183 x 2) + (0.1647 x 3) + (0.0655 x 4) + (0.0297 x 5) + (0.0156 X 6) = 2.14, which according to the threshold values listed is above 2, thus reporting a LOS B as the best LOS achievable (as shown in Figure

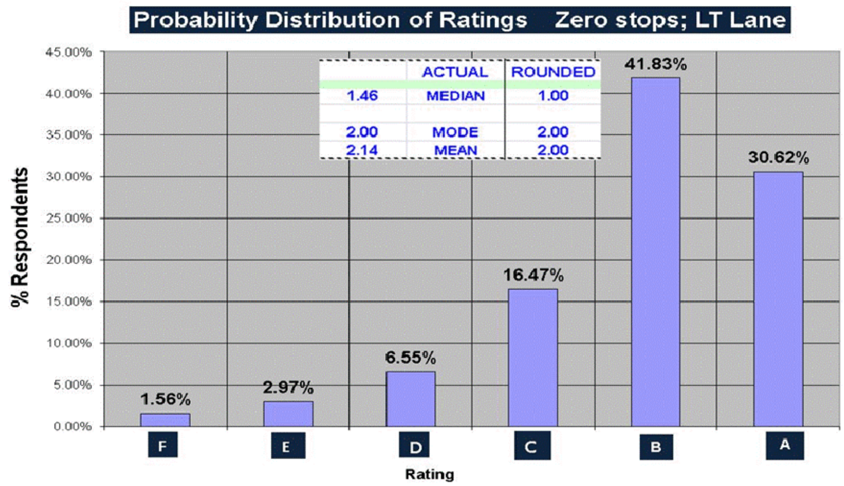
23 in the Florida Study). Had the **rather arbitrary LOS A threshold of 2 (**again nothing to do with the model itself) had been set at say 2.25 the method would have produced a LOS A. The issue is therefore NOT the model, but the thresholds.

More importantly, it is clear that the distribution provides a much richer set of information than the single number. It is obvious, for example, that if one chose the **median value** to estimate LOS, which is calculated at 1.46, and the LOS would have been A under the current thresholds. If the **mode** was picked (mode =2), then LOS A would also have ensued. Lost in this entire discussion is the fact that LOS designation itself is a committee creation. What the distribution shows is reality—in the sense that a group of travelers will perceive LOS very differently for the same operational conditions, and therefore **IF** we are to use user perception as the basis for LOS estimation, then opting for utilizing the mean value only, when the model can produce richer information upon which decisions can be made is undercutting its value considerably. On the other hand, one can use one's engineering judgment from just looking at distributions like those in Exhibit 5 and arrive at the obvious conclusion that the LOS is acceptable without the need to set arbitrary thresholds.

The author agrees with the criticism in the Florida study (as shown in Figures 23 and 25) that the NCHRP 3-70 Speed-based model produces less than intuitive and realistic results. In fact, compared to the Stops model which matched the video ratings 69% of the time, the Speed model was only half as good at a 37% match. Earlier work by Flannery for FHWA using in-vehicle driver experience to gather driver perception at several sites nationwide corroborates the fact that the stop model is superior. In that study, the number of times a person had to stop was cited as a principal determinant of perceived LOS. It is clear that speed perception is more varied than stops perception

The results for the speed model are much less reliable, as illustrated in Exhibit 6, which shows the worst case scenario with stopped traffic (speed= zero) on an undivided arterial. Regardless of what distribution metric is used, the results are unsatisfactory for the speed model. The mean value is 4.18, corresponding to a LOS D with the current thresholds. The mode is technically at 6, which is LOS F, but in reality there appear to be 3 modes at LOS F, E and D, indicating that LOS E is the more appropriate. Finally, the median value is at 4.80 also pointing to LOS E. What is most unsatisfactory with the speed model is that under the worse operating conditions one would expect a highly skewed distribution, with most of its responses centered on LOS E and F, which is obviously not the case in Exhibit 6.

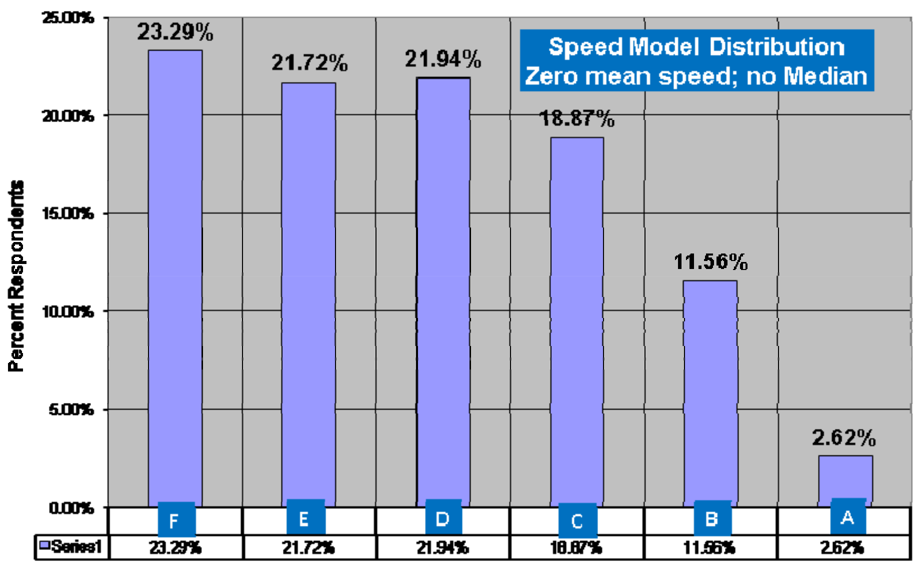
Exhibit 5 Stops Model LOS Predictions under Ideal Conditions



NCHRP 3-70 LOS CRITERIA

- A <= 2 B<= 2.75 C<= 3.50
- D<= 4.25 E<= 5.00 F>= 5.00

Exhibit 6 Speed Model LOS Prediction under Worse Case Scenario



Final Thoughts

This brief review of the auto model assessment across all phases of NCHRP 3-70 project was motivated by a variety of factors, some related to the perceived utility of the proposed auto models, and others by the somewhat unexpected result of having stops (or stops/mile) emerge as the best explanatory variable from the auto model study. It is also clear that there is some resistance in the HCS community to a new modeling paradigm, based on user perceptions particularly when it pertains to what is perceived to be the most important mode on urban arterials, the auto mode. Going back to the objective of NCHRP 3-70 (as per the published RFP), as stated in the first paragraph of this document, it appears that is had been achieved since (a) the cumulative logit model based on stops per mile had the highest correlation with user perceptions, compared to all other competing models, (b) there has not been any *scientific* evidence that the competing models are superior even after the Phase III workshops—at best there are mixed reviews, and (c) much of the criticism leveled at the models in terms of predicting the full range of LOS is unfounded since the modes predict a full distribution of LOS; the issue has to do with setting external thresholds for the mean.