2013 CMP Update: Approach to use of HCM 2010 and Multimodal Level of Service Methodologies in LOS Monitoring and Land Use Analysis Program

Presented to ACTAC
July 2, 2013

ALAMEDA County Transportation Commission

Overview of Presentation

- CMP Legislation Requirements
- LOS Monitoring and Land Use Analysis Programs – Process, Purpose & Methodology
- Exploring use of HCM 2010
- Applying HCM 2010 for LOS Monitoring and LUAP – auto LOS
  - *Assessment, Findings, and Recommendations*
- Applying HCM 2010 for LOS Monitoring and LUAP – multimodal LOS
  - *Assessment, Findings, and Recommendations*
- Summary of Recommendations and Action Requested

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CMP Legislation Requirements

- Alameda CTC as the Congestion Management Agency (CMA) is required to prepare and update the Congestion Management Program (CMP) every two years
- The CMP is required to include five elements:
  - *Level of Service Monitoring*
  - *Land Use Analysis Program*
  - *Travel Demand Management*
  - *Capital Improvement Program*
  - *Multimodal System Performance*

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LOS Monitoring and Land Use Analysis Program CMP elements

- LOS Monitoring
  - *Purpose - Monitor CMP roadway performance biennially and identify deficient segments*
  - *Scope - 232 miles of Tier 1 roadways (freeways, state highways and arterials) & 90 miles of Tier 2 roadways (arterials)*
    - Tier 1 is for Conformity and Tier 2 is for informational purposes
  - *Focused monitoring for auto based roadway LOS & limited information on transit travel and bicycle/pedestrian counts*
- Land Use Analysis Program
  - *Purpose - Identify impacts on regional transportation system from significant land use actions and development projects*
  - *Current scope – MTS roadways and transit operators*
  - *Conducted via review of environmental documents/ Transportation Impact Analyses*

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Current use of HCM in Alameda County CMP

	Level of Service (LOS) Monitoring	Land Use Analysis (LUAP) Program
Purpose	Monitor CMP roadway performance biennially and identify deficient segments	Identify impacts on MTS roadways and study mitigations from significant land use actions and development projects
HCM version currently used	1985	2000
Applied by	Alameda CTC	Local jurisdictions preparing the Transportation Impact Analysis (TIA) reviewed by Alameda CTC
Data Source	Field surveys (travel time runs)	Computed based on projected traffic volumes using the Countywide Travel Demand Model

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Exploring use of HCM 2010 for CMP purposes

- 2011 CMP identified exploring use of HCM 2010 as next steps for applying
  - *Auto based LOS methodology*
  - *Multimodal level of service (MMLOS) methodologies for alternative modes*
- Reasons for evaluating HCM 2010:
  - *Legislative requirement – LOS monitoring must use "most recent HCM or an adopted uniform methodology that is consistent with the HCM"*
  - *Regional Draft CMP guidance – "encourage use of HCM 2010"*
  - *Test suitability of MMLOS to support Alameda CTC's growing multimodal focus in its CMP monitoring activities and development impact analysis review*

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HCM 2010 Auto LOS Methodology Assessment

- Activities undertaken:
  - *Comparative analysis of data needs and analysis of HCMs1985, 2000, and 2010*
  - *Consultation with other CMAs*
- Findings:
  - *Freeways – post-1985, LOS is estimated based on density, not speed*
  - *Arterials – many new data inputs, some very detailed; change in arterial classifications or no classifications*
  - *Other CMAs – not all have adopted HCM 2010*

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Comparison of HCM 1985, 2000, and 2010 Auto LOS Methodologies

		1985	2000	2010
Freeway Segments	LOS Basis	• Speed OR • Density	Density	Density
	Data Needs for LOS Monitoring Application	• Speed* OR • Density	• Flow (Volume) & Speed OR • Density	Flow (Volume)** & Speed OR Density
	Data Needs for LUAP Application	N/A	• Number lanes,* • ramp density*, • hourly demand*	Same as HCM 2000
Arterial Segments	LOS Basis	Speed (3 arterial classes)	Speed (4 arterial classes)	Travel speed as a percent of free flow speed (no arterial classification)
	Data Needs for LOS Monitoring Application	• Speed* AND • Free Flow Speed*/ Arterial Class	Speed AND Free Flow Speed/ Arterial Class	• Speed, • Posted speed limit, • Restrictive median length, • Number through lanes, • Upstream intersection width, & • Segment length
	Data Needs for LUAP Application	N/A	• Segment length,* • Flow rate*, • Cycle length* • Green-to-cycle length ratio*, • Capacity*, • Initial queue*	All inputs from HCM 2000 plus: • Upstream intersection width**, • Turn bay length**, • Restrictive median length**, • Presence of curb**, • Posted speed limit**, • Number receiving lanes**, • Pedestrian & bike flow rates**, • Presence of on-street parking**

Note: * indicates the methodology currently used.
**indicate additional data that would be needed to transition to using HCM 2010.

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Other CMAs' use of HCM 2010 Auto LOS Methodology - LOS Monitoring

	SFCTA	VTA	CCTA	Alameda CTC
Data collection	• Historically: GPS-based floating car runs • 2013 onwards: private, commercially available data (speed)	• Historically: Aerial photography • Testing in 2014: Private, commercially available data (speed) & PeMS data (flow)	• Historically: GPS-based floating car runs, PeMS • 2013 onwards: PeMS, private, commercially available (Bluetooth™) data (speed)	• Currently: GPS-based floating car runs • Interest in testing private, commercially available data (speed)
Freeway HCM methodology (auto)	• HCM 1985 (decided in 2011 CMP to continue to use speed as the LOS measure based on 1985 HCM to maintain historical comparisons, monitor exempt segments and identify potential deficiencies)	• HCM 2000 (since density data was collected historically, it was easy to move to using HCM 2000) • Testing in 2014 - use of HCM 2010.	• Historically: HCM 1985 • Currently testing HCM 2010	• Currently: HCM 1985 • Proposed: maintain HCM 1985
Arterial HCM methodology (auto)	• HCM 1985 for deficiency purposes • HCM 2000 for informational purposes (segments)	• HCM 2000 (intersections) • Testing in 2014 - HCM 2010 (intersections)	• Historically: CCTALOS (planning method based on Circular 212) • Currently testing HCM 2010 (HCM 2000 used at intersections where configuration does not allow use of HCM 2010)	• Currently: HCM 1985 • Proposed: maintain HCM 1985 • Proposed: apply HCM 1985 and HCM 2000 for Tier 2 arterials

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HCM 2010 Auto LOS Methodology LOS Monitoring

- Issues:
  - *Current and possible future data collection methods based on speed – would not work for HCM 2010 freeway methods*
  - *Would lose ability to track prior LOS results and deficiency including deficiency plan progress if HCM 2010 is adopted – impacts both freeways and arterials Tier 1 network*
  - *Would lose simplicity/ease of understanding of speed-based LOS*
- Recommendations:
  - *Maintain HCM 1985 for freeways and Tier 1 arterials*
  - *Apply HCM 1985 and HCM 2000 for Tier 2 arterials since same speed based LOS is used with only difference being the arterial classification*
    - No new data needed
    - Apply to 2012 and 2014 LOS results for Tier 2 arterials
    - Provides opportunity to compare LOS results using the two different methodologies, and identify whether and where it makes a difference, and determine future applications

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HCM 2010 Auto LOS Methodology Land Use Analysis Program

- Considerations:
  - *Data requirements are generally not much greater than what is already collected for Traffic Impact Analyses (TIA)*
  - *TIAs typically conduct simultaneous local and CMP analysis; may be select cases in which analysts need to use consistent methodologies for both purposes*

Recommendation:

- *Encourage use of HCM 2010 as methodology for studying auto impacts on roadway segments in CMP Land Use Analysis Program*
- *Provide flexibility to use same HCM methodology as local jurisdiction requires if absolutely needed*

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HCM 2010 Multimodal Level of Service Overview

- New in HCM 2010
- "User-based" perspective of LOS for transit, bicycles, and pedestrians
- Integrates numerous inputs to assign a composite score for each mode (and associated letter grade)
- Weighting of different inputs based on surveys

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HCM 2010 Multimodal Level of Service Methodology Assessment

- Activities undertaken:
  - *Literature review*
  - *Consultation with other CMAs*
  - *Sensitivity testing*
- Findings:
  - *Application of HCM 2010 MMLOS requires significant data inputs – many inputs require field data collection*
  - *Methodology shows tradeoffs among modes between different design options (changes to geometry and signal timing)*
  - *LOS scores do not respond greatly to changes in operational factors – e.g. travel speed for transit, auto volumes for bike/ped*
  - *Difficult to explain why certain inputs cause certain LOS scores – black box*
  - *Other CMAs – many have not adopted MMLOS, some even after significant pilot testing*

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HCM 2010 Multimodal Level of Service Methodology: LOS Monitoring

- Considerations:
  - *There is a need to provide comparable LOS monitoring-type performance monitoring for alternative modes*
  - *HCM 2010 MMLOS not appropriate for illustrating year-to-year changes as mostly responds to changes in roadway geometry*
- Recommendation:
  - *Explore options for alternative multimodal monitoring methodologies based on the Countywide Multimodal Arterial Corridor Plan and Countywide Transit Plan, including identifying facilities to be monitored and measures to be followed*

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HCM 2010 Multimodal Level of Service Methodology: Land Use Analysis Program

- Considerations:
  - *Current guidance on multimodal impacts in TIAs is flexible; other CMAs have TIA guidelines that name specific types of multimodal impacts to evaluate*
  - *HCM 2010 MMLOS is not appropriate tool to show when new project auto traffic causes impacts on other modes*
  - *Many TIAs propose mitigations that change roadway geometry(e.g. widening or turn pocket) – HCM 2010 MMLOS is suitable for evaluating these changes*
- Recommendations:
  - *Adopt more robust language describing the types of impacts to transit, bicycles, and pedestrians that TIAs should consider*
  - *Encourage use of HCM 2010 MMLOS to assess multimodal tradeoffs from mitigation measures that change roadway geometry*

Proposed approach to evaluating multimodal impacts in LUAP

1. Identifying impacts:
   - *Specify categories of transit, bike, and pedestrian impacts to be considered*
   - *Modify NOP response for the TIAs to include multimodal impact analysis*
   - *Qualitative analysis sufficient*
2. Evaluating mitigation measures:
   - *Require assessment of multi-modal tradeoffs from mitigations that change physical (roadway geometry)*
   - *Encourage use of HCM 2010 MMLOS to evaluate tradeoffs*

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Summary of Recommendations

	Auto LOS Methodology	Multimodal LOS Methodology
LOS Monitoring	• Maintain HCM 1985 and speed-based LOS assignment for freeways and Tier 1 network • Apply HCM 1985 and HCM 2000 for Tier 2 network arterials to compare the LOS results and determine future approach in next CMP update	• Leverage modal plans to identify network and performance metrics for better monitoring of alternative modes
Land Use Analysis Program	• Encourage HCM 2010 for evaluating auto impacts; provide flexibility to use HCM 2000 if needed to conform to local requirements	• In the NOP response, clarify types of impacts for alternative modes and provide flexibility in methodology for analysis of those impacts • Encourage HCM 2010 MMLOS to study tradeoffs from mitigation measures

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Action Requested

- Provide input on the analysis and proposed recommendations regarding use of HCM 2010 for auto based LOS and multimodal LOS methodologies in LOS Monitoring and Land Use Analysis Program elements of the CMP

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QUESTIONS?

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2013 Congestion Management Program Update:

Draft Modifications to the Level of Service Monitoring and Land Use Analysis Program

Background

- Alameda CTC, as a Congestion Management Agency (CMA), must prepare a Congestion Management Program biennially
- Two required CMP elements – LOS monitoring and Land Use Analysis Program - use Highway Capacity Manual methodologies

Overview of current CMP practice

	Auto	Other modes
LOS Monitoring	Track LOS on CMP network using HCM 1985	Limited study of transit travel times and bicycle counts
Land Use Analysis Program	Require study of roadway segments using HCM 2000 in Transportation Impact Analyses (TIAs)	Require analysis of impacts on transit operators in TIAs

What is new in the HCM 2010?

- Updated auto LOS methodologies
- Multimodal LOS (MMLOS) – ability to assign LOS letter grades for transit, bicyclists, and pedestrians, based on quality of user experience.

Why investigate HCM 2010 adoption?

The 2011 CMP recommended investigating use of HCM 2010 as a key next step. This recommendation was motivated by three considerations:

- *Legislative mandate* – the CMP statute advises CMAs to use the most recent HCM in LOS monitoring activities
- *Regional guidance* – MTC's CMP guidance encourages use of the 2010 HCM
- *Increasing multimodal focus* – interest in whether HCM 2010's MMLOS techniques were suitable for CMP applications

Assessment activities

Staff conducted a technical evaluation of the HCM 2010 including:

- Comparing the inputs required to assign auto LOS in the HCMs 1985, 2000, and 2010.
- Sensitivity testing of how HCM 2010 MMLOS grades respond to key inputs using a spreadsheet model
- Consultation with other CMAs regarding plans for use of HCM 2010 (both auto LOS and MMLOS)

Findings of assessment

Auto LOS

- Cannot assign freeway segment LOS based on speed post-HCM 1985
- Arterial segment free flow speed classifications change after HCM 1985
- New data needed for arterials in HCM 2010 - okay for project-level application, but excessive for larger scale use

HCM 2010 MMLOS

- Strong at illustrating effects of roadway design changes
- Grades not strongly sensitive to operational changes (e.g. speed for transit or vehicle volumes for bike/ped)
- Can be difficult to tell why scores change
- Very data-intensive

Considerations for recommendations

- *Current and future data availability (auto LOS):* can the methodology be applied with data available? Is it cost-effective/feasible to collect the data? What about future data collection methods?
- *Ability to track trends (auto LOS):* would the new methodology enable results to be compared to previous years (e.g. to assess CMP conformance in LOS).
- *Suitability (MMLOS):* does the methodology respond to the appropriate parameters (will it show change from year-to-year or from no project-to-project)?

Recommendations

	Auto	Other modes
LOS Monitoring	• Continue to use HCM 1985 for deficiency purpose • Apply HCM 2000 and 1985 to Tier 2 arterials to make determination on future application in 2015 CMP	• Leverage modal plans to develop networks and metrics for enhanced multi-modal monitoring
Land Use Analysis Program	• Encourage use of HCM 2010 to study segment impacts; permit flexibility if analysts need to conform to local requirements	• Adopt more robust language describing types of impacts to transit, bicyclists, and pedestrians to be considered • Encourage use of MMLOS to evaluate multi-modal tradeoffs from mitigation measures

2013 Congestion Management Program Update:

Draft Modifications to the Level of Service Monitoring and Land Use Analysis Program

	Auto		Other modes	
	Recommendation	**Reasons for recommendation**	**Recommendation**	**Reasons for recommendation**
LOS Monitoring	1) Continue to use HCM 1985 for deficiency purposes	• Change of methodology would result in loss of ability to track trends (and CMP conformance) • Post-1985 HCM freeway segment methodology not compatible with current (GPS-floating car) and possible future (commercially collected) data collection methods which provide speed data (LOS methodology based on density).	4) Leverage modal plans outcome to develop networks and metrics for enhanced multimodal monitoring	• Modal plans provide opportunity to look at ways to monitor critical network and metrics for non-auto modes (e.g. speed and reliability of key lines for transit) • HCM 2010 MMLOS mostly responds to changes in schedule (for transit) or roadway design (for bike and ped) but these do not change greatly from year-to-year • Would not be clear why HCM 2010 MMLOS grades change if multiple input variables change at the same time (black box)
	2) Apply HCM 1985 and 2000 to Tier 2 arterials and make a determination on future application in the 2015 CMP update	• No new data needed • New CMP roadways and no LOS estimated yet, so can be applied to 2012 and 2014 Monitoring results • Monitored only for informational purposes, so no conformity issue • Provides opportunity to compare results based on different methodologies, and determine future application		
Land Use Analysis Program	3) Encourage use of HCM 2010 to study segment impacts; permit flexibility if analysts need to conform to local requirements	• No change in data needs for freeway segments; additional data needs for arterials within scope of what is generally collected for TIAs	5) Adopt more robust language describing types of impacts to transit, bicyclists, and pedestrians to be considered	• HCM 2010 MMLOS is not strong at illustrating how transit, bicyclists, or pedestrians are affected by operational changes. For many projects, the primary impact to these modes is via increased project vehicle traffic.
			6) Encourage use of HCM 2010 MMLOS to evaluate multi-modal tradeoffs from mitigation measures	• HCM 2010 MMLOS is strong at illustrating modal tradeoffs from design changes (e.g. adding a turn pocket or retiming a signal) • Most TIAs propose mitigation measures for only a few segments,

				so scope of application would be limited.

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ATTACHMENT B: APPROACH TO USE OF HCM 2010 AND MMLOS AT OTHER CMAS

This attachment presents detailed information on other comparable Bay Area CMAs' (San Francisco County Transportation Authority, Valley Transportation Authority, and Contra Costa Transportation Authority) current and future plans for use of HCM methodologies in their CMPs. Specifically, information is provided on:

- Use of HCM 2010 for the auto based roadway LOS methodology
    - As part of LOS monitoring activities since adoption of HCM 2010 is related to current and future plans for data collection
    - As a required methodology to study auto impacts in Transportation Impact Analyses reviewed for Land Use Analysis element
- Use of MMLOS methodologies
    - To provide increased monitoring for alternative modes in the LOS monitoring
    - As part of the guidelines for Transportation Impact Analysis reviewed for Land Use Analysis element.

HCM 2010 Application for Auto based Roadway LOS

Table B1: Other CMA approaches to applying HCM auto based roadway LOS methodology for LOS monitoring data collection

	SFCTA	VTA	CCTA	Alameda CTC
Data collection	• Historically: GPS-based floating car runs • 2013 onwards: private, commercially available data (speed)	• Historically: Aerial photography • Testing in 2014: Private, commercially available data (speed) & PeMS data (flow)	• Historically: GPS-based floating car runs, PeMS • 2013 onwards: PeMS, private, commercially available (Bluetooth™) data (speed)	• Currently: GPS-based floating car runs • Interest in testing private, commercially available data (speed)
Freeway HCM methodology (auto)	• HCM 1985 (decided in 2011 CMP to continue to use speed as the LOS measure based on 1985 HCM to maintain historical comparisons, monitor exempt segments and identify potential deficiencies)	• HCM 2000 (since density data was collected historically, it was easy to move to using HCM 2000) • Testing in 2014 - use of HCM 2010.	• Historically: HCM 1985 • Currently testing HCM 2010	• Currently: HCM 1985 • Proposed: maintain HCM 1985
Arterial HCM methodology (auto)	• HCM 1985 for deficiency purposes • HCM 2000 for informational purposes (segments)	• HCM 2000 (intersections) • Testing in 2014 - HCM 2010 (intersections)	• Historically: CCTALOS (planning method based on Circular 212) • Currently testing HCM 2010 (HCM 2000 used at intersections where configuration does not allow use of HCM 2010)	• Currently: HCM 1985 • Proposed: maintain HCM 1985

Table B2: Other CMA approaches to applying HCM auto based roadway LOS methodology for Land Use Analysis Program data collection related to Transportation Impact Analysis

	San Francisco Planning Department*	VTA	CCTA	Alameda CTC
Freeway	• HCM 2000	• Current: HCM 2000 • Under consideration: HCM 2010	• HCM 2010	• Currently: HCM 2000 • Proposed: HCM 2010 encouraged
Non-Freeway	• HCM 2000 (intersections)	• Current: HCM 2000 (intersections) • Under consideration: HCM 2010 (intersections)	• HCM 2010 (intersections)	• Currently: HCM 2000 (segments) • Proposed: HCM 2010 encouraged

Notes:
* San Francisco's Planning Department reviews Traffic Impact Analyses on behalf of the CMA, however considerations may be different as this review serves as both City- and CMA-level review.

Table B3: Other CMA approaches to applying HCM 2010 MMLOS for LOS Monitoring

	SFCTA	VTA	CCTA	Alameda CTC
Overall	• No plans to adopt MMLOS	• Pilot analysis of MMLOS bike/ped methodologies.	• Exploring applying multimodal LOS measures that may not be HCM 2010 MMLOS as part of Action Plan update	• Currently: limited multimodal reporting in LOS monitoring. Extensive countywide multimodal reporting in Performance Report.
Transit	• Report on transit travel time; exploring reporting on transit reliability measures. Utilize data obtained from SFMTA APC and AVL units.	• No facility specific reporting. • Exploring use of big data approach to study transit speed, reliability, and causes of delay on key corridors.	As above	• Proposed: use countywide modal studies to identify monitoring network, metrics, and data sources
Bike/Ped	• No facility specific reporting. • Report on bike/ped counts, network build-out (miles built), and collisions.	• No facility specific reporting. • Report bike/ped counts biannually.	As above	• Current: annual bike/ped count program • Proposed: use countywide modal studies to identify monitoring network, metrics, and data sources

Notes:
APC = Automated Passenger Counter, AVL = Automatic Vehicle Locater (i.e. GPS)

Table B4: Other CMA approaches to applying HCM 2010 MMLOS in Land Use Analysis Program related to Transportation Impact Analysis

	SF Planning Department	VTA	CCTA	Alameda CTC
Overall	• TIA guideline document • No plans to adopt MMLOS	• TIA guideline document • Pilot analysis of MMLOS bike/ped methodologies. • Continuing to study to determine role in TIAs.	• TIA guideline document • MMLOS encouraged but not required	• Current: no TIA guideline document. Flexible NOP response • Proposed: TIA guidelines with expanded list of multimodal impacts. Encourage MMLOS for evaluating mitigation measures.
Transit Impact Requirements	• Custom methodology for studying transit impacts that looks at capacity. • Consideration of access to transit and delays to transit from site-related activities also required.	• TIA guidelines include list of specific effects on transit that should be considered. • List includes capacity, congestion that affects transit services, and access/egress.	• No language in TIA Guidelines about how to study transit, impacts	• Proposed: require study of effects on transit operations, capacity, and access/egress; no required methodology and qualitative analysis sufficient
Bicycle/ Pedestrian Impact Requirements	• TIA guidelines state that impacts on pedestrians and bicycles should be analyzed qualitatively or quantitatively depending on project size and circumstances. • HCM 2000 used if quantitative analysis required. • Planning Dept. determines required analysis on case-by-case basis.	• TIA guidelines name specific effects on bicycles and pedestrians that should be considered • List includes effects of vehicle trips on existing bike and pedestrian conditions, consistency with adopted plans, and if project or mitigations would impede current connections.	• No language in TIA Guidelines about how to study bike or pedestrian impacts	• Proposed: require study of effects on bikes and peds including _____no required methodology and qualitative analysis sufficient

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ATTACHMENT C: OVERVIEW OF MMLOS AND SENSITIVITY TESTING

Overview of MMLOS

The HCM 2010 introduced a series of new methodologies for assigning LOS scores for transit, bicycles, and pedestrians. Consistent with LOS for autos, these methodologies focus on the quality of experience for a user of a facility. However, unlike auto LOS for which a single variable (speed or density) determines LOS, transit, bicycle, and pedestrian LOS scores are composites based on a series of variables. For instance, transit LOS takes into account the frequency of vehicle arrivals, the on-time percentage, the travel time, the presence of covered shelters, and crowding, among other factors.

A key aspect of the research to develop MMLOS is the calibration of the various inputs – the determination of how much one factor should influence the overall modal LOS score, relative to other factors. The calibration was based on user surveys. For pedestrian and bicycle modes, participants in video labs in four cities watched footage of street segments and rated conditions on a 1-6 scale. For transit, national traveler response data to changes in transit service quality were used.

The MMLOS models can be applied at different scales, illustrated in Figure C1. Pedestrian and cyclist LOS can be assessed at the link, signalized intersection, segment, or facility scale; transit LOS can be assessed at the segment or facility scale. The Alameda CTC applications of HCM methodologies involve application at a segment scale, the MMLOS scores for segments are based on scores for the link and intersection that comprise that segment.

Figure C1: Scales of application of MMLOS

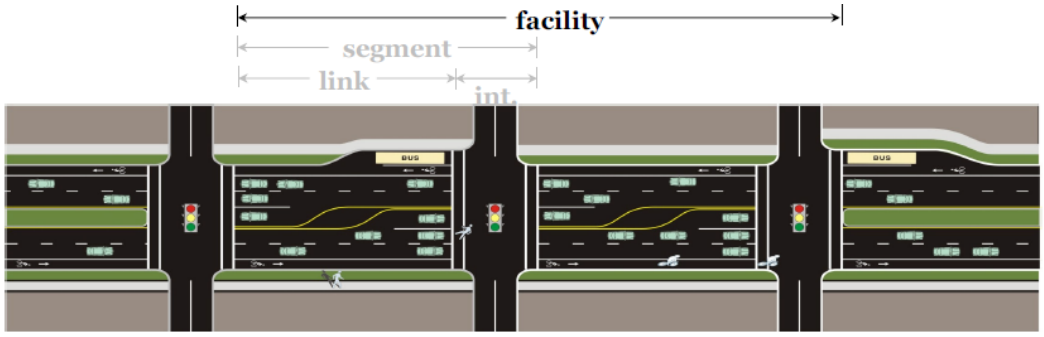

Table C1 summarizes all of the different factors that the MMLOS model takes into account in its computation of a modal LOS score at a given scale. The plus or minus signs indicate whether this factor positively or negatively influences the LOS. It is difficult to generalize about the magnitude of influence of different factors on an LOS score. As the table indicates, larger scale applications (e.g. segment or facility) tend to make use of the LOS score from component units (e.g. the segment LOS combines the link and intersection LOS, plus a few additional factors).

Table C1: Variables Used in MMLOS

Mode	Link	Signalized Intersection	Segment	Facility
Pedestrian	Outside travel lane width (+) Bicycle lane/ shoulder width (+) Buffer presence (e.g., on-street parking, street trees) (+) Sidewalk presence and width (+) Volume and speed of motor vehicle traffic in outside travel lane (–)	Permitted left turn and right-turn-on-red volumes (–) Cross-street motor vehicle volumes and speeds (–) Crossing length (–) Average pedestrian delay (–) Right-turn channelizing island presence (+)	Pedestrian link LOS (+) Pedestrian intersection LOS (+) Street-crossing difficulty (–/+) Delay diverting to signalized crossing Delay crossing street at legal unsignalized location	Length weighted average of component segment LOS
Bicycle	Volume and speed of traffic in outside travel lane (–) Heavy vehicle percent (–) PCI (+) Bicycle lane presence (+) Bicycle lane, shoulder, and outside lane widths (+) On-street parking use (–)	Width of outside through lane and bicycle lane (+) Cross-street width (–) Motor vehicle traffic volume in the outside lane (–)	Bicycle link LOS (+) Bicycle intersection LOS, if signalized (+) Number of access points on right side (–)	Length weighted average of component segment LOS
Transit (mixed flow vehicles)	N/A	N/A	Access to transit (uses pedestrian link LOS) Wait for transit (frequency) Actual bus travel speed (+) Stop amenities (+) Excess wait time due to late bus/train arrival (–) Crowding (–)	Length weighted average of component segment LOS

Source: Kittelson Associates, Inc. (2012) HCM 2010: Urban Street Concepts: Pedestrian, Bicycle, and Transit. Presentation to MTC Arterial Operations Committee. March 21, 2012.

Sensitivity Testing

Alameda CTC staff performed sensitivity testing of the MMLOS methodologies by implementing the MMLOS equations in a spreadsheet model, and then observing how the MMLOS score changed when key variables were allowed to change within reasonable ranges.[1] Sensitivity testing is performed for the following applications:

Table C2: Variables Considered for MMLOS Sensitivity Testing

Methodology	Variables Tested
Transit (Segment)	On-time percentage Bus speed (including delays) Frequency of Bus Arrivals
Bicycle (Link)	Automobile volumes Automobile speeds On-street parking occupancy Outside lane effective width
Pedestrian (Link)	Automobile volumes Automobile speeds Effective walkway width

General findings of sensitivity testing for (mixed flow) transit include the following:

- Transit LOS is highly sensitive to the frequency of bus arrivals (headway), though this sensitivity diminishes when headways reach 10 min or less.
- Transit LOS is not highly sensitive to on-time percentage. On-time percentage can decline by 20-30 percent without dropping an LOS grade. A substantial body of research[2] shows that poor reliability is a common reason why transit riders stop riding transit, so this attribute may be undervalued in the MMLOS transit score.
- Transit LOS is not highly sensitive to commercial speed[3] (i.e. speed that a transit vehicle actually achieves, when factoring in delays from boarding, signals, etc.). The commercial speed can drop by 5 mph or more without dropping an LOS grade. Many AC Transit routes operate at commercial speeds between 10 mph and 15 mph, so a 5 mph change in commercial speed is quite significant.

General findings of sensitivity testing for bicycles and pedestrian include the following:

- Bicycle and pedestrian LOS are both most sensitive to roadway space allocation. For bicycles, adding effective width to the outer lane – either through a wider lane or a bike lane – improves LOS by at least a letter grade. For pedestrians, adding on-street parking or items that provide a physical barrier from autos (e.g. trees, street furniture) greatly increase LOS.

[1] This spreadsheet model uses the equations from the HCM 2010 MMLOS methodologies and computes the MMLOS "score" (which is used to determine letter grade) for a given set of inputs.
[2] Carrell, A., A. Halvorsen, J. Walker (2012). Passengers Perceptions of and Behavioral Adaptation to Unreliability in Public Transportation. Submitted for presentation at the 92nd Transportation Research Board Annual Meeting.
[3] When elasticity of demand to travel time set at its default value for urban areas.

- Bicycle and pedestrian LOS are not very sensitive to auto flow rates or speeds. For instance, flow rates can increase by several hundred veh/hr without seeing a change in bicycle or pedestrian LOS. Similarly, speeds can increase by 10 mph or more without registering a change in bicycle or pedestrian LOS. The lack of emphasis on traffic volumes and speeds in bicycle and pedestrian LOS seems contrary to some research on why people choose to use active transportation modes (e.g. a 2010 Alameda CTC survey found that safety concerns were the second most common reason why residents chose not to bicycle).[4]
- Bicycle LOS is highly sensitive to pavement quality.

Illustration of Sensitivity Testing

Figure C2 and Table C3 below provides an illustration of the sensitivity testing Alameda CTC staff performed of MMLOS. Similar graphs were produced for the variables in Table B2, and are available on request.

Figure C2 illustrates how bicycle LOS score changes in response to variations in the automobile flow rate, when all other inputs are set to the typical values indicated in Table C3. The figure shows that at auto flow rates less than 100 vehicles per hour per lane (vphpl), bicycle LOS is A, from 100 vphpl to roughly 400 vphpl, bicycle LOS is at B, and above 400 vphpl bicycle LOS is at C. While most users would expect cyclist conditions to degrade if a facility handles hundreds of additional vehicle trips per hour (e.g. goes from 600 vphpl to 1100 vphpl), this analysis indicates that bicycle LOS can remain at C, even with significant added vehicle traffic.

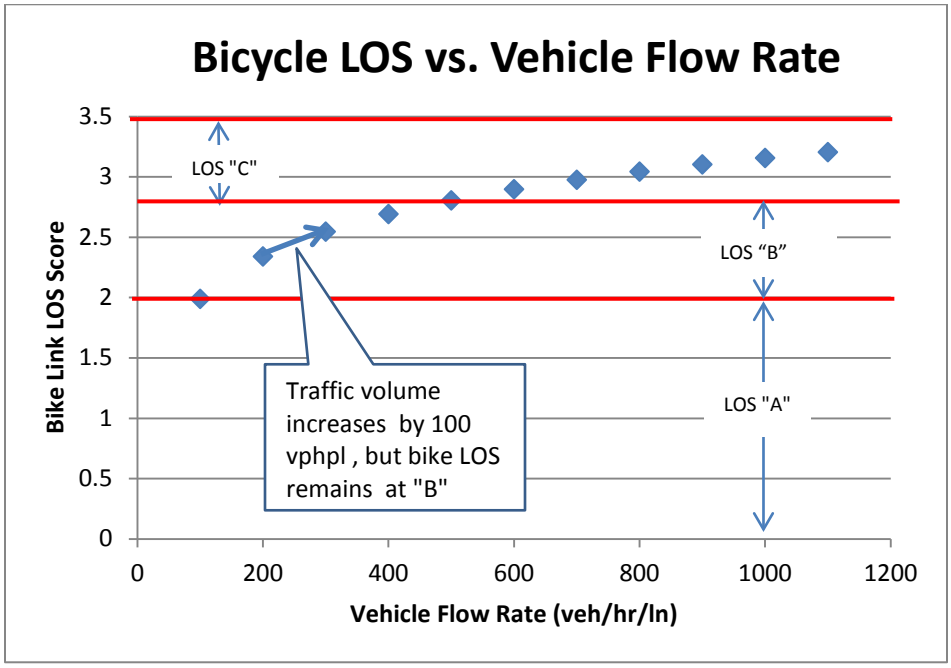

Figure C2: Illustration of MMLOS sensitivity testing

[4] Alameda CTC (2012). Bike to Work Day and Get Rolling Advertisement: Assessment Report. Prepared by EMC Research, February 2012.

Table C3: Values used in illustration of MMLOS sensitivity testing

Input Variable	Value	Units
Segment length	500	ft
Bike running speed	13	mi/hr
Bike control delay	10	sec
Number through lanes (direction of travel)	2	#
Pavement condition rating	3	1-6 scale
On-street parking occupancy	50	%
Width outside through lane	10	ft
Width outside shoulder (can be parked in)	8	ft
Width bike lane	6	ft
Percent Heavy Vehicles	3	%
Automobile Flow Rate (direction of travel)	Allowed to vary	veh/hr/ln
Motorized vehicle running speed	25	mi/hr
Curb present?	Y	

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ATTACHMENT D: PROPOSED NEW LANGUAGE ON MULTIMODAL IMPACTS FOR NOTICE OF PREPARATION (NOP) RESPONSE

Transit Impacts

The DEIR should consider how the project may impact transit operators and riders, including:

- Mixed flow transit operations: the DEIR should evaluate if vehicle trips generated by the project will cause congestion that degrades transit vehicle operations. It should not be assumed that transit operational impacts will not exist if a roadway operates at better than automobile LOS F. This analysis may be qualitative and may be based on auto traffic circulation analysis, but should consider that transit vehicles may have unique considerations compared to autos (e.g. pulling into and out of stops, longer gaps needed for left turns).
- Transit capacity: the DEIR should evaluate if transit trips generated by the project will cause ridership to exceed existing transit capacity. Both vehicle and station circulation should be considered. Transit operators should be consulted to see if any routes or stations in the project area require capacity analysis. The Alameda CTC can assist in providing ridership data by line if such analysis is required. If a project will cause transit capacity impacts such that additional service will be required, funding for transit operations cannot be assumed and appropriate mitigations considered.
- Transit access/egress: the DEIR should assess whether pedestrian connections between the project site and transit stops are adequate to support any project trip generation assumed to be served by transit. This assessment should include consideration of the safety of crossing opportunities, as needed.

Bicycle Impacts

The DEIR should consider impacts on facilities in the Countywide Bike Network, including:

- Effects of vehicle traffic on bicyclist conditions: the DEIR should evaluate if vehicle trips generated by the project will present barriers to bicyclists safely crossing roadways or executing turning movements as well as whether project traffic volumes necessitate greater separation between bicyclists and vehicles. This analysis may be qualitative and may be based on auto traffic circulation analysis.
- Site development and roadway improvements: the DEIR should evaluate if the project or its mitigations will reduce or sever existing bicycle access or circulation in the area as well as whether the project could produce conflicting movements between bicyclists and vehicle turning into and out of project driveways.
- Consistency with adopted plans: the DEIR should disclose whether the project is consistent with the Alameda Countywide Bicycle Plan, and should consider opportunities to implement the plan in the project vicinity, either in conjunction with other roadway improvements required by the project or as a mitigation measure for air quality or traffic circulation impacts.
- Other impacts as appropriate for the project

Pedestrian Impacts

The DEIR should consider impacts on pedestrian facilities in the Areas of Significance identified in the Alameda Countywide Pedestrian Plan, including:

- Effects of vehicle traffic on pedestrian conditions: the DEIR should evaluate if vehicle trips generated by the project will present barriers to pedestrians safely crossing roadways at intersections and mid-block crossings. This analysis may be qualitative and may be based on auto traffic circulation analysis.
- Site development and roadway improvements: the DEIR should evaluate if the project or its mitigations will reduce or sever existing pedestrian access or circulation in the area as well as whether the project could produce conflicting movements between pedestrian and vehicle turning into and out of project driveways. The need for new crossing opportunities or circulation given project pedestrian access points and likely access/egress routes should be considered.
- Consistency with adopted plans: the DEIR should disclose whether the project is consistent with the Alameda Countywide Pedestrian Plan, and should consider opportunities to implement the plan in the project vicinity, either in conjunction with other roadway improvements required by the project or as a mitigation measure for air quality or traffic circulation impacts.
- Other impacts as appropriate for the project

Multimodal Tradeoffs Associated with Mitigation Measures

For any mitigation measures that involve changes in roadway geometry, intersection control, or other changes of the transportation network, the DEIR should include a discussion of the multi-modal tradeoffs associated with this change. This analysis should clearly identify whether the mitigation will result in an improvement, degradation, or no change in conditions for automobiles, transit, bicyclists, and pedestrians. The HCM 2010 Multimodal Level of Service methodology is encouraged as a tool to evaluate these tradeoffs.