Assessment of HCM2010 and MMLOS

D.1—Assessment of HCM2010

Background

Alameda CTC, as a Congestion Management Agency (CMA), must prepare a Congestion Management Program biennially.

Two required CMP elements—level of service (LOS) monitoring and the Land Use Analysis Program—use Highway Capacity Manual (HCM) methodologies. These methodologies and measures are anticipated to be changed soon to be in line with the SB 743 related requirements. This assessment is a documentation of analyses and tests performed in applying various versions of HCM methods in order to identify and recommend what works for the implementation of these two CMP elements.

Overview of Current CMP Practice

	Auto	Other Modes
LOS Monitoring	Track LOS on CMP network using HCM1985	Limited study of transit travel times and bicycle counts
Lan Use Analysis Program	Require study of roadway segments using HCM2000 in Transportation Impact Analyses (TIAs)	Require analysis of impacts on transit operators in TIAs

What Is New in the HCM2010?

- 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 HCM2010 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 HCM 2010.
- *Increasing multimodal focus*—There is interest in whether HCM 2010's MMLOS techniques were suitable for CMP applications.

Assessment Activities

Staff conducted a technical evaluation of HCM 2010 including:

- Comparing the inputs required to assign auto LOS in the 1985, 2000, and 2010 HCMs.
- Sensitivity testing of how HCM2010 MMLOS grades respond to key inputs using a spreadsheet model
- Consultation with other CMAs regarding plans for use of HCM2010 (both auto LOS and MMLOS)

Assessment Findings

Auto LOS	HCM2010 MMLOS
• Cannot assign freeway segment LOS based on speed post-HCM1985 • Arterial segment free flow speed classifica-tions change after HCM 1985 • New data needed for arterials in HCM2010—okay for project-level application, but excessive for larger scale use	• 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

- *Ability to track trends (auto LOS)*: Would the new methodology enable results to be compared to pre-vious 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)?

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?

Recommendations

	Auto	Other Modes
LOS Monitoring	• Continue to use HCM1985 for deficiency purpose • Apply HCM 2000 and 1985 to Tier 2 arterials to make determination on future application in the upcoming CMP update cycle	• Leverage modal plans to develop networks and metrics for enhanced multimodal monitoring
Land Use Analysis Program	• Encourage use of HCM 2010 to study segment impacts; permit flexibility if analysts need to con-form 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 multimodal tradeoffs from mitigation measures

Table D.1—Rationale for Recommended Use of HCM2010 for LOS Monitoring

Auto		Other Modes	
Recommendation	**Reasons for recommendation**	**Recommendation**	**Reasons for recommendation**
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 pos-sible future (commercially collected) data collection methods which provide speed data (LOS methodology based on density).	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)
Apply HCM 1985 and 2000 to Tier 2 arterials and make a determination on future application in the upcoming CMP update cycle	• 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 infor-mational purposes, so no conformity issue • Provides opportunity to compare results based on different methodologies, and determine future application		

Table D.2—Rationale for Recommended Use of HCM 2010 for Land Use Analysis Program

Auto		Other Modes	
Recommendation	**Reasons for recommendation**	**Recommendation**	**Reasons for recommendation**
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	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
		Encourage use of HCM 2010 MMLOS to evaluate multimodal 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

D.2—Approach to Use of HCM2010 and MMLOS at Other CMAs

Detailed information follows 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 Analyses reviewed for the land use analysis element

HCM 2010 Application for Auto-Based Roadway LOS

Table D.3—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) and 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 seg-ments 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 D.4—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	• Current: HCM 2000 • Proposed: HCM 2010 encouraged
Non freeway	• HCM 2000 (intersections)	• Current: HCM 2000 (intersections) • Under consideration: HCM 2010 (intersections)	• HCM 2010 (intersections)	• Current: HCM 2000 (segments) • Proposed: HCM 2010 encouraged

* 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 a city- and CMA-level review.

Table D.5—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	• Current: Limited multimodal reporting in LOS monitoring; extensive countywide multimodal reporting in Performance Report
Transit	• Report on transit travel time; exploring report-ing on transit reliability measures; utilizing 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

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

Table D.6—Other CMA Approaches to Applying HCM 2010 MMLOS in Land Use Analysis Program Related to Transportation Impact Analysis

	San Francisco 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 Guide-lines 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 Department 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	• TIA guidelines include list of specific effects on transit that should be considered • List includes capac+A3:E6+A3:E6ity, congestion that affects transit services, and access/egress

D.3—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, as illustrated in Figure D.1. 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.

Table D.7 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).

Figure D.1—Scales of Application of MMLOS

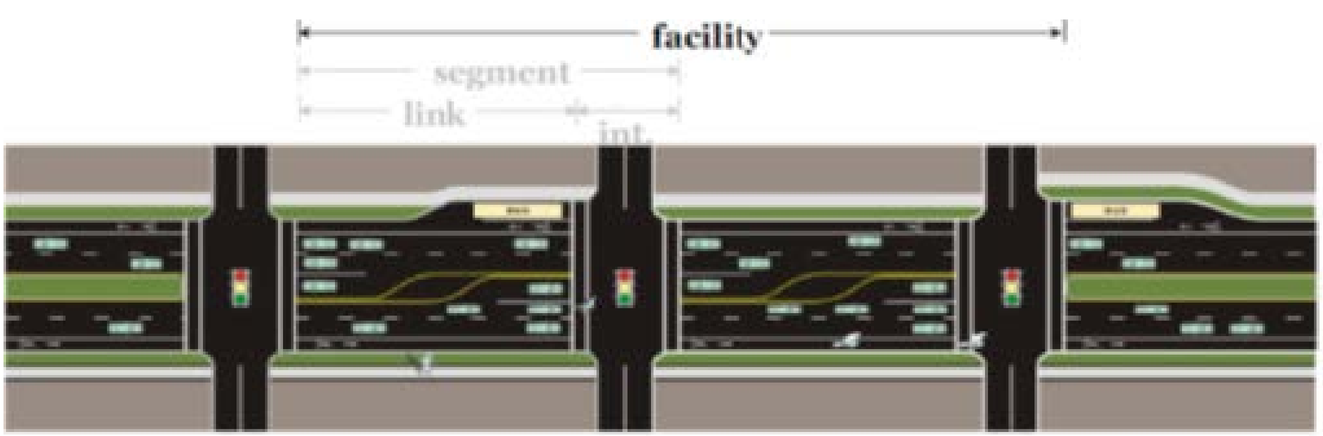

Table D.7—Variables Used in MMLOS

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	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 D.8—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.
- 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.

[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.

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

Illustration of Sensitivity Testing

Figure D.2 and Table D.9, which follows, provide an illustration of the sensitivity testing Alameda CTC staff performed of MMLOS. Similar graphs were produced for the variables in Table D.4, and are available on request.

Figure D.2 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 D.9. 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 D.2—Illustration of MMLOS Sensitivity Testing

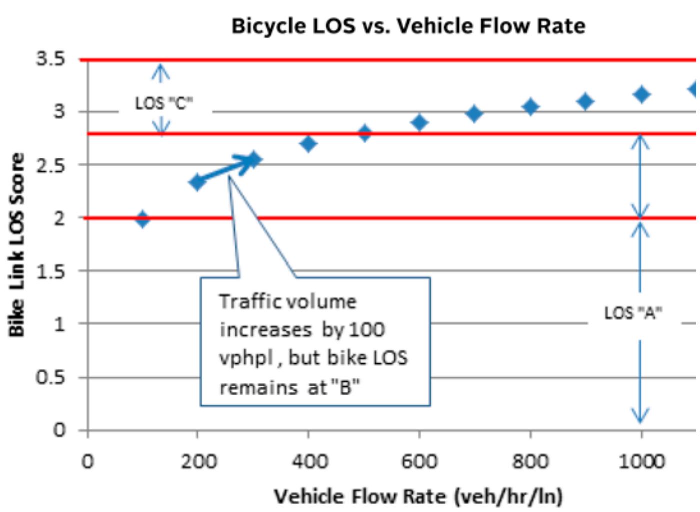

Table D.9—Values Used in Illustration of MMLOS Sensitivity Testing

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	