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Christopher Calfee, Senior Counsel (CEQA.Guidelines@ceres.ca.gov)
Governor's Office of Planning and Research
1400 Tenth Street, Sacramento, CA 95814
10 February 2014
Re: LOS Alternatives

Dear Mr. Calfee,
I am writing in response the Governor's Office of Planning and Research request for input concerning development of alternatives to LOS, described in the December 2013 document, *Preliminary Evaluation of Alternative Methods of Transportation Analysis*.

I am a transportation policy analyst who specializes in transport system performance evaluation. I am an active member of professional organizations include the Institute of Transportation Engineers and the Transport Research Board, of which I chair the Sustainable Transportation Indicators Subcommittee (ADD40[1]). I have published extensively in professional journals on these subjects. Although I currently live in British Columbia, I was born and raised in Southern California and continue to work there in various capacities.

This is an important and timely opportunity. As described below, current planning practices, particularly reliance on roadway level-of-service as a primary transport system performance indicator, tends to bias planning decisions to favor automobile travel over other modes and dispersed, automobile-dependent development over more compact, multi-modal development. Experts have long recommended reforms that would result in more comprehensive and multi-modal evaluation practices, but these tend to face obstacles, including inadequate interagency coordination, inadequate data, ignorance and general inertia. The California Governor's Office of Planning and Research can help create a vision, and provide leadership to help develop better transportation performance evaluation methods.

Below are my comments and suggestions. I call this, *Beyond Roadway Level-of-Service: Improving Transport System Impact Evaluation*.

Sincerely,

Todd Litman

Beyond Roadway Level-of-Service: Improving Transport System Impact Evaluation

11 February 2014
By Todd Litman, Victoria Transport Policy Institute

Reasons For Change

Transportation planning decisions have many direct and indirect impacts, including accessibility (people's overall ability to reach services and activities), financial costs and affordability, safety and health, and environmental quality. It is important that the planning process account for these diverse impacts, so transportation planning decisions can align with larger community goals.

An efficient and equitable transportation system must be multi-modal so users can choose the most appropriate mode for each trip. For example, most neighborhood trips are most efficiently made by walking and cycling; public transit is most efficient for travel on major urban corridors, and some trips are most efficiently made by private automobile or taxi. Space-efficient modes (walking, cycling and public transport) are particularly important in urban areas, where there is insufficient space for roads and parking to allow all trips to be made by automobile. Walking, cycling and public transport are important to accommodate the 20-40% of the population (depending on how they are counted) who cannot or should not drive due to age, disability, low incomes, or legal constraints. Increased transport system diversity helps achieve various planning objectives including road and parking infrastructure savings, consumer savings and affordability, increased safety and public health, energy conservation and pollution emission

However, conventional transportation planning tends to be automobile-oriented: it evaluates transportation system performance primarily based on the ease of driving, and tends to overlook and undervalue many benefits of improving alternative modes. Many biases favoring automobile travel are subtle and technical, embedded in the way transport problems are defined and potential solutions evaluated. One such bias is the use of congestion intensity indicators such as roadway level-of-service (LOS) and the travel time index (TTI) as dominant indicator of overall transport system performance. Such indicators only reflect one impact on one mode: motor vehicle traffic delay; they indicate nothing about other accessibility factors (the quality of alternative modes, transport network connectivity, land use accessibility) or about other transport impacts (safety, affordability, mobility for non-drivers, environmental quality).

Roadway LOS only measures automobile congestion *intensity*, that is, the reduction in travel speeds during peak periods at a particular location. It does not account for congestion *exposure* (the amount that people must drive during peak periods, taking into account their travel options and trip distances) and so does not reflect total congestion costs (total per capita congestion delay). More compact, multi-modal neighborhoods and urban regions tend to have relatively intense congestion (automobile travel speeds decline significantly during peak periods), but relatively low per capita congestion costs due to low automobile mode shares and shorter travel distances. In contrasts, automobile dependent, sprawled areas tend to have less intense congestion but higher per capita congestion costs because people are forced to drive more during peak periods (Cortright 2010; Litman 2014).

This is not to suggest that automobile travel is unimportant or to deny that traffic congestion is a problem. However, planning decisions often involve trade-offs between automobile traffic speed and other accessibility factors, and other planning objectives. For example:

- Expanding roads can increase traffic speeds but tends to reduce walking and cycling access (called the *barrier effect*), and therefore public transit access since most transit trips involve walking links.
- The allocation of road space between sidewalks, vehicle parking, bike lanes, bus lanes and general traffic lanes involves trade-offs between access by different modes.
- A hierarchical road network, with many minor roads connecting to a few major arterials, increases traffic speeds but reduces roadway connectivity and local accessibility.
- Infill development may increase local traffic congestion but improve access by other modes, and land use proximity.
- Wider roads and higher traffic speeds tend to increase crash severity, particularly for vulnerable road users (pedestrians, cyclists and motorcyclists).
- Planning that favors automobile travel over walking, cycling and public transit tends to reduce transportation affordability and non-drivers accessibility.

In such cases, planning that relies primarily on roadway LOS as a performance indicator tends to create more automobile-dependent and sprawled communities than is overall optimal, considering all impacts and planning objectives. This is a timely issue because current demographic and economic trends are causing automobile travel to peak, while demand for alternative modes is growing, while the scope of issues to consider in the planning process is expanding (Polzin, Chu and McGuckin 2011); more comprehensive and multi-modal planning is needed in response to these changing demands.

A Challenge To the Profession

Many transportation planning practitioners have criticized over-reliance on roadway LOS (LaPlante 2010; Litman 2003; Poorman 2005), and there is progress developing more comprehensive methods. In 2008, NCHRP Report 616, *Multimodal Level Of Service Analysis For Urban Streets* (Dowling, et al. 2008), described methods for multi-modal LOS analysis, which were incorporated into the most recent *Highway Capacity Manual* (TRB 2010). Simultaneously, various researchers and modelers have been developing more comprehensive methods for evaluating accessibility (Access to Destinations; CTS 2008; HTAI 2013; Litman 2008) and impacts such as affordability, environment and health impacts (Johnston 2008).

Evaluating transportation system performance primarily based on roadway LOS reflects an older planning paradigm, which assumed that "transportation" primarily means automobile travel, so "transportation problem" means slow or costly automobile travel, and "transportation improvement" means faster and cheaper automobile travel. Advocates of this paradigm point to high automobile mode shares in many North American communities which they claim proves the dominance of this mode. However, such claims reflect various biases: they are based on statistics that significantly undercount travel by alternative modes (particularly walking trips), and they reflect expressed demand (the travel activity that occurs), ignoring latent demand (the additional walking, cycling and public transit that people would like to make by these modes if they were improved). Where walking, cycling and public transit conditions are improved, these modes often represent 20-60% of trips within urban neighborhoods and on major urban corridors.

Table 1 **Changing Transport Planning Paradigm** (Litman 2013)

	Old Paradigm	New Paradigm
Definition of *Transportation*	*Mobility* (physical travel).	*Accessibility* (people's overall ability to reach services and activities).
Modes considered	Mainly automobile.	Multi-modal: Walking, cycling, public transport, automobile, telecommunications and delivery services.
Planning objectives	Congestion reduction; roadway cost savings; vehicle cost savings; and reduced crash and emission rates per vehicle-kilometer.	Congestion reduction; road and parking cost savings; consumer savings and affordability; improved access for non-drivers; reduced per capita crash, energy consumption and emission rates; improved public fitness and health; strategic development objectives.
Impacts considered	Travel speeds and congestion delays, vehicle operating costs and fares, crash and emission rates.	A variety of economic, social and environmental impacts, including indirect impacts.
Performance indicators	Vehicle traffic speeds, roadway Level-of-Service (LOS), distance-based crash and emission rates.	Multi-modal level-of-service and accessibility modeling which calculates the time and other costs required to access services and activities.
Favored transport improvement options	Roadway capacity expansion.	Improve transport options (walking, cycling, public transit, etc.). Transportation demand management. Pricing reforms. More accessible land development.
Planning scope	Limited. Transport planning is separated from other planning issues.	Planning is integrated so individual, short-term decisions can support strategic, long-term goals.

The new paradigm expands the range of modes, objectives, impacts and options considered in planning.

The new paradigm emphasizes more comprehensive and multi-modal evaluation (ADB 2009; Litman 2013). This new paradigm recognizes other accessibility factors, including the quality of other modes, roadway connectivity and land use proximity, and recognizes other planning objectives such as infrastructure cost efficiency, safety, affordability, the quality of mobility for non-drivers, and environmental objectives, as summarized in tables 1 and 2.

For example, roadway LOS analysis favors siting new schools on major arterials at the urban fringe, since that maximizes automobile access and minimizes local, short-term traffic congestion problems. However, more comprehensive analysis tends to favor siting schools toward the center of a community, since the reduction in automobile travel access is offset by improved access by other modes (more convenient walking and cycling) which helps achieve other planning objectives including road and parking facility cost savings, consumer savings, improved accessibility for non-drivers (which reduces motorists' chauffeuring burdens), improved public fitness and health, reduced total traffic accident risk, energy conservation and pollution emission reductions.

Table 2 **Scope of Impacts Considered**

Conventional Evaluation	Comprehensive Evaluation
Travel speed (congestion delays)	Downstream congestion
Vehicle operating costs (fuel, tolls, tire wear)	Traffic delay to non-motorized travel (the *barrier effect*)
Per-mile crash risk	Parking costs
Roadway costs	Vehicle ownership costs
Road construction environmental impacts	Mobility for non-drivers
	Social equity objectives
	Indirect environmental impacts
	Strategic land use impacts (compact development)
	Public fitness and health

Conventional transportation planning tends to focus on a limited set of impacts.

Alternatives of Roadway Level-Of-Service

This section evaluates various alternatives to roadway LOS.

Multi-Modal Level-of-Service (LOS) and Quality of Service (QOS)

Description: Multi-modal level-of-service analysis measures travel delay experienced by pedestrians, cyclists and public transport passengers, for example, by wider roads, heavy traffic, inadequate crosswalks, and transit delays, and therefore the potential benefits of transport system changes that reduce such delays. As previously mentioned, the latest *Highway Capacity Manual* (TRB 2010) provides guidance for multi-modal LOS analysis, and models are now available for automating this analysis (Dowling Associates 2010).

Multi-modal quality of service (QOS) analysis can account for factors other than travel speed, related to convenience, comfort, safety and affordability (FDOT 2012; Fehr & Peers 2012). Since pedestrians, cyclists and transit users are particularly affected by planning decisions (a motorist can purchase a more comfortable vehicle, but pedestrian, cycling and transit comfort depends on planning decisions, such as the sidewalk, road and transit vehicle design and maintenance), these qualitative factors tend to be important.

Potential Criticisms: Multi-modal LOS and QOS only considers travel conditions, they do not account for other accessibility factors such as transport network connectivity, and land use proximity. These indicators require new data on sidewalks, crosswalks, traffic conditions and transit service, which is costly to collect.

Implementation strategies: These models already exist and can be improved with targeted research. Data collection costs can be minimized if jurisdictions establish strategic plans which begin collecting the needed data during regular field work (for example, during regular land, road and utility line surveys).

Trip Generation, Vehicle Travel and Fuel Consumption Models

Description: Trip generation models are widely used for traffic planning, and are a key input into roadway LOS analysis. Variations also calculate vehicle miles travel (VMT) and fuel consumption. Such models are widely used for transport, energy and emission modeling, and can be used for traffic and environmental impact analysis, assuming that projects which generate fewer trips, vehicle-miles, or less fuel consumption tend to impose lower traffic and environmental costs.

Potential criticisms: Trip generation, vehicle travel, fuel consumption, and roadway LOS impact models are all subject to uncertainties, particularly when evaluating the impacts of innovative transportation and land use changes for which there is limited experience, such as qualitative improvements in alternative modes, pricing reforms, transit-oriented development, and commute trip reduction programs (Arrington and Sloop 2010; SPACK Consulting 2010). Expanding and improving these models will require investments in research and data collection. Another possible criticism is that vehicle travel reduction targets could contradict other planning objectives, for example, by imposing restrictions that harm consumers and businesses, or by limiting development.

Implementation strategies: These models already exist and can be improved, particularly with research which identifies how various transportation demand management and smart growth strategies affect travel activity, and how these affect other planning objectives such as infrastructure costs, affordability, safety and health, and residents' satisfaction.

Multi-Modal Accessibility Modeling

Description: New models evaluate accessibility based on the number of services (shops, schools, parks, etc.) and activities (such as jobs) that can be reached within a given time period and financial cost by various travel modes (Levine, et al 2012; Levinson 2013). Simplified versions include WalkScore, BikeScore, TransitScore, Transit Connectivity Index and a Transit Access Shed Indicator and Google Maps Commute Travel Time (HTAI 2013); although these tools only reflect single modes, they can be aggregated for multi-modal accessibility.

Potential Criticisms: Multi-modal accessibility models are a new approach to transport system performance evaluation. They require new data, and most only consider a limited set of accessibility factors, so it is important that people who apply these models and their results understand their limitations.

Implementation strategies: These models are developing rapidly; they are already suitable for many planning applications (for example, even relatively crude methods such as WalkScore and Google Maps commute time applications are widely used by consumers, businesses and researchers to quantify accessibility) and their availability and utility is increasing rapidly. It should be possible to standardize these methods so they can be used in transport system performance evaluation.

Table 3 compares the scope of accessibility factors and impacts considered by these various evaluation methods. Roadway LOS (white square) considers just one impact for one mode: peak-period travel delay. It may measure fuel consumption and pollution emission rates per vehicle-mile, but because it does not account for per capita mileage, it cannot measure total per capita fuel consumption or pollution emissions. Multi-modal LOS (light blue) also considers delay to active (walking and cycling) and public transport modes. Vehicle trip generation, travel and fuel consumption models (medium blue) can reflect additional impacts, including fuel consumption and emissions, parking and accident costs. Multi-modal accessibility models (darkest blue) also consider the effects of roadway connectivity and land use proximity on the time and costs required to reach various destinations, and therefore accounts for the largest range of impacts.

Table 3 **Scope of Accessibility Factors and Impacts Considered**

Impacts ↓	Accessibility Factors → Automobile Travel	Active Transport	Public Transport	Roadway Connectivity	Land Use Proximity
Traffic delay	Roadway LOS	Multi-modal LOS			
User financial costs	Vehicle Trip, Travel and Fuel Consumption Models				
Energy consumption					
Pollution emissions					
Traffic safety					
Accessibility for non-drivers	Multi-Modal Accessibility Models				
Physical fitness and health					
Land use impacts					

Roadway LOS (white square) only considers one impact (delay) for one mode (automobile). Multi-modal LOS (light blue) considers delay for additional modes. Vehicle trip, travel and fuel consumption models (medium blue) indicate additional impacts. Multi-modal accessibility models consider the widest range of accessibility factors and impacts, and so are the most comprehensive and multi-modal.

Conclusions and Recommendations

Transportation planning decisions have many direct and indirect impacts so it is important to use comprehensive and multi-modal analysis when evaluating policies and projects. Current practices, which rely primarily on congestion intensity indicators, such as roadway level-of-service (LOS), overlook important accessibility factors and impacts. Many experts recommend replacing roadway LOS with more comprehensive and multi-modal indicators, particularly when evaluating urban infill developments that may increase local congestion but improve overall accessibility (SSTI 2014).

Roadway LOS is particularly inappropriate for environmental impact analysis. People often assume that traffic congestion increases fuel consumption and pollution emissions, but per mile fuel consumption and emission rates are minimized at 40-50 miles-per-hour, so moderate congestion (LOS C or D) tends to reduce fuel consumption and emissions compared with freeflow speeds, and roadway expansions often increase per capita fuel consumption and emissions by inducing additional vehicle travel (Barth and Boriboonsomin 2009).

Models are available for predicting how a particular policy or project will affect vehicle *trips, travel* and *fuel consumption*, which are useful indicators since reduced trips/travel/fuel consumption generally indicate lower traffic and environmental impacts. Like all models, they have various degrees of uncertainty, but can be improved with targeted research and data collection programs. In recent years, transportation professional organizations have developed *multi-modal level-of-service* and *quality of service* evaluation models. These can be useful in some situations, but they do not account for connectivity or proximity and so do not indicate overall accessibility.

Of currently available methods, the most comprehensive and multi-modal is *multi-modal accessibility modeling* which measures the time and other costs to reach services and activities by various modes, taking into account travel speed, network connectivity and geographic proximity. These range from relatively simple indicators such as WalkScore and TransitScore, to sophisticated integrated models that account for numerous accessibility factors. More work is needed to improve and standardize these methods so they can be used to evaluate specific projects, but they could be operational within a few years.

Critics argue that these alternative evaluation methods are difficult and costly to implement, and their results are unreliable. This only seems true because roadway LOS methods and information resources have had decades of development, so they seem convenient and affordable, and their results are not particularly accurate. Alternative evaluation methods are developing rapidly, and with targeted research and data collection, supported by state agencies and professional organizations, could be operational within a few years.

Below are specific recommendations for improving transport system performance evaluation:

- Use vehicle travel generation models as an interim method for evaluating transportation and environmental impacts of specific projects. For example, assume that a development in an accessible, multi-modal location that incorporates transportation demand management strategies such as efficient parking management, and so generates low per capita VMT imposes lower infrastructure and environmental costs than the same amount of development in automobile-dependent locations and lacking TDM strategies.
- Establish a strategic vision for comprehensive and multi-modal transport system performance evaluation. Identify how the system should operate within three to five years, and what is needed to make this happen.
- Identify short- and mid-term actions to facilitate this development, including targeted research, new data collection and professional development programs. Work with professional and academic organizations such as the Institute of Transportation Engineers, the American Planning Association, and University Transportation Centers to implement these actions.
- Identify the scope of impacts that should be considered in transport planning analysis, which will probably include traffic congestion, road and parking infrastructure costs, consumer costs and affordability, traffic safety, public fitness and health, accessibility for non-drivers, energy consumption and pollution emissions, and consistency with strategic development objectives.

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