A Brief Evaluation of Level of Service Alternatives

February 2018

This page intentionally left blank.

Acknowledgments

This report was developed under the guidance of the City of La Crosse Planning and Development Department.

Funding for the project was provided by the City of La Crosse.

Sponsor

Staff Team

Jason Gilman, AICP, *Director of Planning and Development*

Sara Olson, *Planning Department*

Consultant Team

Belinda Judelman

Ian Lockwood, P.E.

Kevin Luecke

Rob Burchfield, P.E.

Prepared by

Toole Design Group

16 North Carroll Street, Suite 200

Madison, WI 53703

Contents

Figures

Introduction

There are two primary transportation paradigms that guide transportation decisions today: the traditional paradigm, which emphasizes mobility and accessibility, and the conventional paradigm, which emphasizes motor vehicle throughput. The traditional paradigm is the older of the two, and has recently seen a revival because it is often in alignment with community values and it attempts to incorporate the needs of a variety of road users. Most departments of transportation (DOTs) have a "conventional" transportation paradigm. Level of Service (LOS) is central to the conventional paradigm which was developed during the first half of the twentieth century. This paper calls into question this conventional paradigm, and presents strategies that cities like La Crosse can pursue to evaluate transportation system performance. These alternative will help La Crosse improve its transportation network so that future decisions are reflective of local values and support multi-modalism.

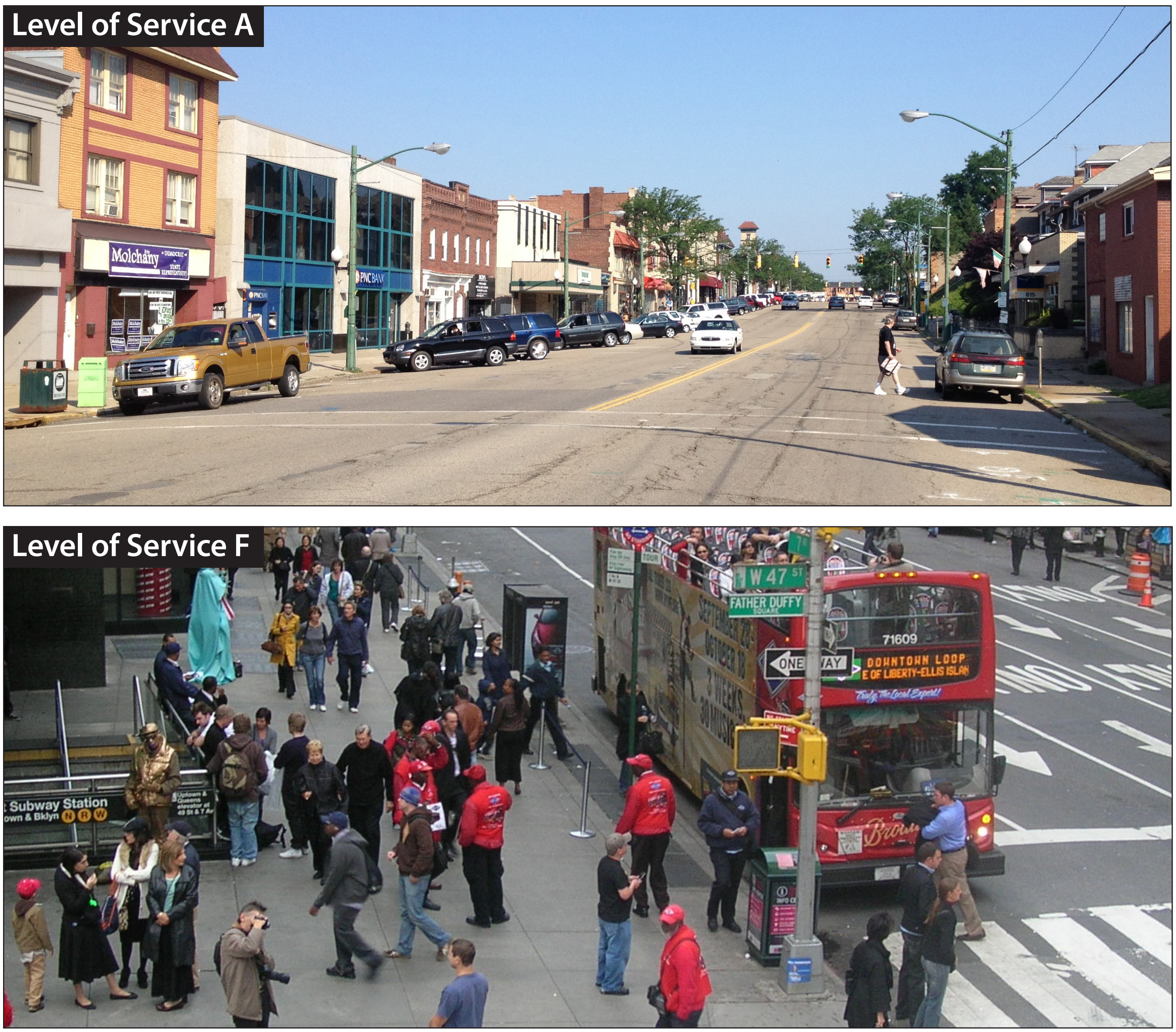
This paper is divided into two main sections. The first section describes LOS, including its history, use, and implications. The second section discusses alternatives to LOS from cities and counties across the nation. These alternatives include both individual performance measures and comprehensive approaches to evaluating the impact of a project that can also be used to evaluate the effectiveness of a community's transportation system as a whole.

What is Level-of-Service?

LOS is a model that transportation professionals use to measure traffic conditions and evaluate the impacts of proposed development projects and roadway changes. LOS measures the change in travel time (conventionally referred to as delay) at a specific location, by relating road capacity to vehicle traffic volume. It is a measure of congestion intensity during peak travel periods (i.e. rush hour) that corresponds to a ranking of A to F. A rating of A indicates the least change in travel time (no congestion) and F indicates the greatest change in travel time (heavy congestion) (see Figure 1).

One of the most critical elements of the LOS model is that it only measures change in travel time for motorists. In many communities, this measurement of congestion intensity is used to evaluate transportation performance. However, LOS only evaluates one need of one group of people – how fast motorists can move through a location during the most congested time of day. There is no incorporation of pedestrian, bicyclist, or transit user needs, or accessibility, safety, connectivity, or reliability – all critical components of a community's transportation network and individual road segments.

Figure 1: Level-of-Service A and F



Context

LOS is central to the conventional transportation paradigm, which emerged during the modernist era, in the first few decades of the 20th century. Fifty years ago, LOS-based thinking would have been consistent with the conventional societal values of that time. Modernism allowed highways into cities based on an assumption that connecting distant objects in the landscape with high-speed highways was inherently important. However, in the 21st century, with 20-20 hindsight, automobile-centric design and highway expansion in cities is increasingly seen as a bad idea. As a result, there has been a shift towards the older, "traditional" paradigm. The "traditional" paradigm has been in use since people first began living in villages and towns. It is based on the ideas of proximity, access, exchange, networks, walkability, convenience, and connectedness – all of which support designing communities for the movement of people, not vehicles. This shift back to the "traditional" paradigm is evident in recent policy changes, the removal of highways from cities, the slowing of motorists, and the reprioritizing of what is important to city life – vibrancy, mobility, and accessibility.

Figure 2 shows examples of how elements of transportation planning are viewed differently in the two transportation paradigms. The traditional paradigm clearly shows a shift towards a planning philosophy that is focused on human needs and inclusive of a variety of roadway user groups.

Implications

In communities that only use LOS models to evaluate the impact of roadway projects, streets are built that make it faster and easier to drive. While this can temporarily improve the motorist environment, this results in negative impacts on a community's economic and active transportation environments. The information presented below explains some of the primary reasons a community should reconsider the use of LOS. This is especially pertinent for jurisdictions seeking to improve their walking and bicycling mode share, create vibrant

Figure 2. Transportation Planning Paradigms[1]

	Conventional Paradigm	Traditional Paradigm
Definition of Transportation	Mobility (physical travel).	Accessibility (people's overall ability to reach services and activities).
Modes considered	Mainly automobile.	Multimodal; walking, cycling, transit, automobile, telecommunications, and delivery services.
Planning objectives	Congestion reduction; road cost savings; vehicle cost savings; and reduced crash and emission rates per vehicle-mile.	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; congestion delays; vehicle operating costs; crash and emission rates.	A variety of environmental, economic, and social impacts, including indirect impacts.
Performance indicators	Vehicle traffic speeds; road level-of-service; distance-based crash and emission rates.	Multimodal 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; mode accessible land development.
Planning scope	Limited. Transportation planning is separated from other planning scopes.	Planning is integrated so individual, short-term decisions support strategic, long-term goals.

streets and neighborhoods, and encourage slower vehicle speeds to promote roadway safety.

Figure 3 provides a summary of the trade-offs between prioritizing LOS and promoting vehicle traffic speed over accessibility and mobility objectives. Some of the key trade-offs include reduced affordability, mobility, and accessibility of transportation for non-drivers. A more in-depth discussion about the negative impacts associated with relying on LOS is provided below.

The use of LOS does not reduce congestion. LOS models generally indicate that increasing roadway capacity (through the addition of vehicle lanes) will lead to a reduction in congestion and a reduction in travel time. In reality, this rarely occurs. An analysis of data from over 70 metropolitan areas over 15 years by the Surface Transportation Policy Project found that, "Metropolitan areas that invested heavily in road capacity expansion fared no better in easing congestion than metropolitan areas that did not."[3] This is due in part to the induced demand that adding lanes causes. Induced demand (also called induced travel or induced traffic) is an economic term often used to explain one of the outcomes of expanding a roadway. The impact of adding a new lane, or increasing the supply of roadway, creates an increase in demand. More people want to travel because there is more space (or capacity) for them to do so. In addition, people who might otherwise have traveled by foot, bicycle, or transit switch modes and choose to travel by car because the option to drive has become more appealing due to the assumption that there will be less congestion. This induced demand diminishes the reduction in congestion that might have otherwise occurred.[4, 5]

The use of LOS can result in traffic projections that are unreliable. LOS is a very simple model that relies on a set of very specific assumptions, and with assumptions comes room for error. Traffic models frequently predict increased traffic, and often, local trends do not match these predictions. This may be in part because these models do not consider changes in economic and social contexts or changes in mode share and active transportation infrastructure.

The use of LOS prioritizes the speedy movement of motor vehicles above the safety of users. A better LOS score occurs when vehicles can move faster. Under the LOS model, the faster movement of a greater volume of vehicles is good, and slow movements are bad. Given what we know about the relationship between higher speeds and crash severity for all road users, it is difficult to understand how a jurisdiction can strive for a "better" LOS rating and expect to see safety improvements amongst road users, especially among pedestrians and

Figure 3. Impacts Considred and Overlooked when Prioritizing Conventional Level-of-Service[2]

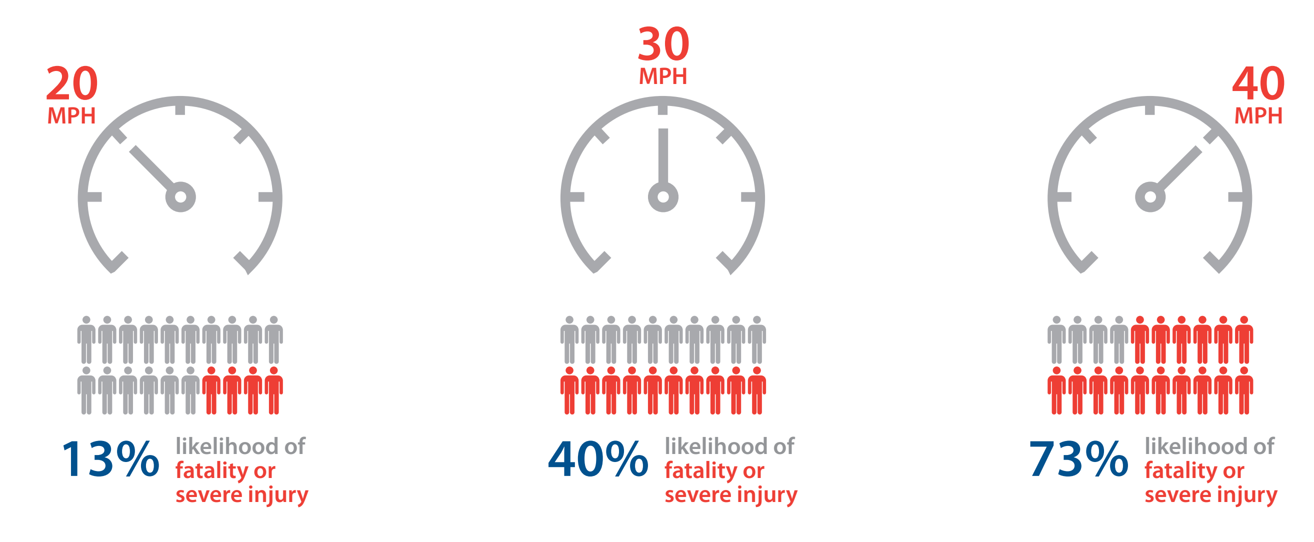
Usually Considered	Often Overlooked	
• Financial costs to governments • Vehicle operating costs (fuel, tolls, tire wear) • Travel time (reduced congestion) • Per-mile crash risk • Project construction environmental impacts	• Downstream congestions impacts • Impacts on non-motorized travel • Parking costs • Vehicle ownership and mileage-based description costs • Project construction traffic delays • Generated traffic impacts • Indirect environmental impacts • Strategic land use impacts	• Transportation diversity value (e.g., mobility for non-drivers) • Equity impacts • Per-capita crash risk • Impacts on physical activity and public health • Travelers' preferences (e.g., for walking and cycling)

bicyclists (see Figure 4).[6, 7, 8, 9, 10] The increased crossing distances that result from roadway expansions also create unsafe environments for pedestrians and bicyclists because the larger crossing distances leave these vulnerable users exposed to the impact of vehicles for a longer time period.

The use of LOS promotes faster, longer vehicle trips, above all other trips and modes. A key function of cities and metro areas is to promote social and economic exchange—a portion of these exchanges requires people to travel to access other people, employment, food, etc. The total number of trips is a function of the social and economic activity in an area; the more trips, the more activity. A long trip and a short trip for the same purpose have the same value to the economy/society but they have different costs. For example, a dentist going from her home to her office by driving four blocks has the same value to society as another dentist who drives 16 miles to her office. However, the latter costs more in public infrastructure and reflects an inefficient use of land and energy consumption. Using the example of the two dentists, many more short trips can be accommodated with the same expenditure on infrastructure as the single long trip and provide much more value to society. Trip lengths are affected by transportation infrastructure, density, and land use mix. The more urban the street network, the higher the density, and the more mixed the land uses are, the shorter the average trip-length. The shorter the trip, the more likely the trip will be made on foot or by bicycle.

The use of LOS promotes policies that appeal to individual motorist interests over public interest. Every motorist, acting rationally and in their own self-interest, wants to drive faster rather than slower. However, a public policy that encourages this individual desire is not good public policy. It is analogous to the proverbial "tragedy of the commons." Acting rationally and in one's self-interest, a fisher would prefer to catch and sell more fish and a logger would prefer to cut and sell more timber. However, if everyone were to act in their own self-interest, then fish would go extinct and the forests would disappear. LOS relies heavily on individual values of wanting to drive to places faster, and can result in a "tragedy of the commons." If we designed all roadways so that all motorists could travel faster, then entire communities could be highly damaged.

Figure 4: Pedestrian injury risk by motor vehicle speed[6]



Source: Tefft, B. C. Impact speed and a pedestrian's risk of severe injury or death. Accident Analysis & Prevention. 50. 2013.

The use of LOS reduces mobility and discourages active transportation and transit ridership. There are many populations in a community, including children, elderly, mobility impaired, low income, pedestrians, bicyclists, transit users, and students. All of these populations have mobility needs that are not reflected in conventional LOS models. A population's capabilities and strategies to move are dependent on its physical ability to move (e.g. walk or bicycle), privately and publicly provided mode choices, and its adaptations to changes in its environment. As an area becomes more automobile dependent or prioritizes vehicles on roadways (i.e., wider roads and faster travel speeds), barriers to traveling by other modes of transportation increase (referred to as the barrier effect).

On a large scale, land uses disperse over greater distances due to roadways rewarding longer trips. This reduces infill development, and the mobility and accessibility of the non-motorist populations diminishes relative to that of the motorists. On a smaller scale, the prioritization of roadway space for vehicles can increase the barrier effect because the green time at intersections is reallocated to favor the additional traffic on the large streets, and the available gaps for the pedestrians, bicyclists, and transit users leaving the smaller streets are fewer and shorter. Wider streets with faster speeds can also mean smaller waiting areas for transit stops, lower comfort levels for children, elderly, or mobility impaired populations crossing streets, and the potential for bicyclists, street trees, and on-street parking are reduced. In sum, the mobility of the pedestrians, bicyclists, and transit users will drop because those modes and short trips will be disadvantaged.

Summary

The use of LOS is a pro-automobile, pro-speed practice that has yet to successfully reduce congestion. It can result in the devaluing of the area around higher speed streets via reduced access, and add value to land far away because motorists assume they can travel faster across the city. All of this undermines the needs of pedestrians, bicyclists, and transit users and makes it more difficult to walk, bicycle, drive, or take transit locally. These negative impacts associated with LOS work against the City's vision which supports shorter trips lengths, less automobile dependency, connectivity, and multi-modalism. By focusing on mobility holistically, it is feasible to increase mobility while reducing traffic volumes, even with growing populations and growing economies. Cities like La Crosse can increase mobility by mixing land uses and designing and prioritizing roadways and development projects that support active transportation and make multimodal travel more feasible and comfortable.

Alternatives to Level-of-Service

Cities, counties, and regions across the nation are exploring and implementing alternative methods to evaluate the impacts of transportation and development projects in response to the many issues associated with the use of LOS. This section presents a discussion of alternative metrics that city, county, and state DOTs are adopting to supplement or replace their use of conventional LOS. These metrics include:

- Person Delay
- Multimodal Level-of-Service
- Trip Generation
- Vehicle Miles Traveled
- Total Travel Time
- Level-of-Traffic-Stress
- Multimodal Transportation "System Completeness"

Person Delay

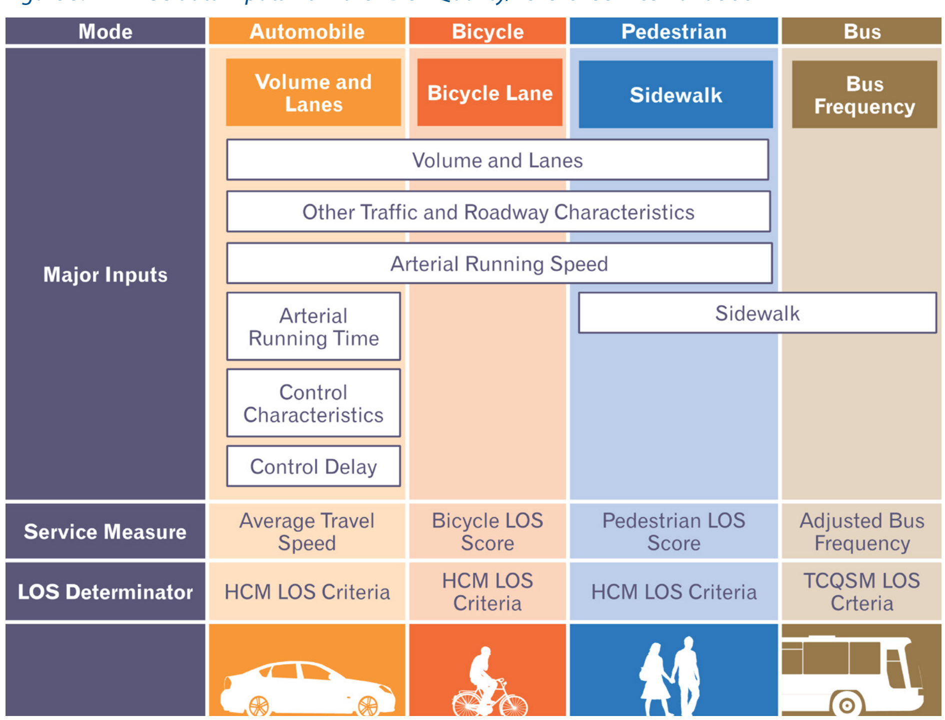
Person delay (also called person throughput) evaluates vehicle and signal operations to determine delay per person for each mode of travel at an intersection. Some uses of this method combine the delay for each person to create an overall person delay for the intersection. Since the measure is the same for all modes, it allows for an easy comparison of impact across modes. This measure is an improvement from traditional LOS because it incorporates the delay associated with a variety of users, not just drivers. However, this performance measure uses only one measurement – delay – to evaluate a project, and delay may not the best measurement for evaluating impacts to pedestrians and bicyclists. It is also possible that the use of this measurement will always yield results favoring vehicles or transit in cases where shared occupant vehicle traffic is common.[11]

Multimodal Level of Service

Multimodal LOS (MM-LOS) measures the change in travel time experienced by pedestrians, bicyclists and transit users that would occur as the result of a roadway project. There are many existing guidebooks that describe the standard methodology for calculating MM-LOS, most notably the 2010 Highway Capacity Manual (HCM), NCHRP Report 616, and the Florida Department of Transportation's (FDOT) Level of Service Handbook.[12, 13] Figure 5 shows the inputs for evaluating LOS by mode, following the methodology prescribed by FDOT.

The use of the standard MM-LOS proposed by the HCM or FDOT provides a more complete assessment than relying on LOS alone, however, there is still room for improvement and many communities continue to criticize the MM-LOS methodology proposed by the HCM. The use of MM-LOS measures change in travel time, which assumes that pedestrians, bicyclists, and transit users have the same primary need as motorists, and that their top priority is to travel as fast as possible.[14] However, a street with minimal delay may not be a great street for bicyclists, pedestrians or transit users, and measuring immediate travel conditions does not account for other accessibility, network, reliability, or safety factors – all of which are important to most non-motorists. The MM-LOS model proposed in NCHRP Report 616 provides a more comprehensive assessment of LOS through the incorporation of variables accounting for facility design, facility control, transit service characteristics, and the volume of vehicle traffic on the facility. The methodology also prescribes a way to measure the interaction between modes. A disadvantage of this method is that it requires many data inputs and can be complicated to calculate. In

Figure 5: MM-LOS data inputs from the FDOT Quality/Level of Service Handbook



addition, if a community is still using the conventional LOS, then the addition of MM-LOS, alone, may not mitigate the negative impacts of using LOS.

The City of Burien, WA, a city with a similar population size to that of La Crosse, developed a set of MM-LOS standards for different priority areas as part of the 2012 Transportation Master Plan. Figure 6 shows the Pedestrian LOS standards for the three different priority areas. A green circle indicates the preferred city standard, a yellow circle denotes acceptable short-term conditions, and a red circle is considered unacceptable.[15]

Figure 6: Pedestrian Level-of-Service, Burien, WA[17]

Pedestrian Priority Area LOS – Sidewalk Requirements

LOS	Along Transit Priority Corridors	Pedestrian Activity Centers	Downtown Burien
	Sidewalk and Buffer	Arterial/Collector – Sidewalk on Both Sides	Meets Downtown Standards
	Sidewalk	Wide Shoulder	Sub-standard Sidewalk
	No Sidewalk	Congested Roadway	No Sidewalk

Pedestrian Non-Priority Area LOS – Sidewalk Requirements

LOS	Other Roadway Segments
	Arterial – Sidewalk on Both Sides
	Arterial – Sidewalk on One Side
	Arterial – No Sidewalk

Crossing Requirements

LOS	Pedestrian Priority Areas	Other Areas
	Appropriately designed crossing every 300 feet in pedestrian activity area[a] or downtown	Appropriately designed crossings at existing marked crosswalks
	Crosswalks present every 600 feet	Crosswalks present
	No crosswalks present	No crossings within 600 feet

[a] Pedestrian activity areas are those areas within a quarter mile of schools, an eighth mile of neighborhood parks, or within a quarter mile of food banks.

Trip Generation

Trip generation models are already widely used for traffic planning. Trip generation models typically measure the number of new daily peak hour trips added by a proposed project. Most communities using this metric follow the Institute of Transportation Engineers' Trip Generation Manual, 9th Edition to calculate vehicle trip generation. Some jurisdictions have considered using trip generation because it can be estimated for all modes, however the models for bicycle and pedestrian trips are often considered unreliable. This metric is typically more applicable when measuring the impact of an individual development project, rather than for system-wide or corridor impact evaluations. In addition, trip generation does not incorporate a measurement of trip length or facility or service accessibility or quality for motorists or multimodal road users.

Vehicle Miles Traveled

Vehicle miles traveled (VMT) is a widely-used performance metric in transportation and environmental planning. Use of VMT assumes that projects that generate fewer trips or vehicle-miles tend to impose lower traffic and environmental costs. Some studies show that VMT is strongly related to measures of accessibility to destinations and secondarily to street network design variables.[16] One of the reasons VMT has become so popular is because it is easier to calculate than LOS and numerous models to calculate it already exist. Calculating VMT requires estimates of trip generation rates and trip lengths. Since this metric incorporates both number of trips and trip length, it is a more comprehensive measure than trip generation alone. However, the use of VMT does not incorporate needs of multimodal users, except to indicate whether there may be increases or decreases in vehicle mode share. Communities must also keep in mind that any metric based on a model (e.g., VMT, trip generation, or LOS) is subject to errors from inaccurate assumptions that provide the basis for these types of models.

After much debate, California, and eventually San Francisco, switched from using LOS to VMT as one of the standards for assessing a project's impact. This switch marked a realignment of public policy with City and State environmental and public health goals. La Crosse is already tracking VMT as prescribed in the City's 2012 Bicycle and Pedestrian Master Plan.

Total Travel Time

Total travel time is a simple way to measure accessibility in an area for multiple transportation modes. This type of analysis does not incorporate the number of trips occurring, instead, it measures trip length and travel time. Measurements of total travel time evaluate accessibility by counting the number of services and activities that can be reached within a given time period. A few existing models of this approach include WalkScore, BikeScore, and TransitScore. Communities choosing to use this performance metric must evaluate total travel time for all modes and note that like VMT, trip generation, LOS, and person delay, total travel time does not provide a measure of the quality or level of comfort of a roadway or intersection.

Figure 7 compares the scope of accessibility factors and impacts considered by each performance measure. LOS (referred to as Roadway LOS in Figure 7) considers only one impact for one mode: peak period travel delay. Multi-modal LOS considers delay to active and public transport modes. Vehicle trip generation and VMT models can reflect additional impacts, including fuel consumption and emissions, parking, and accident costs. Multi-modal accessibility models consider some of the effects of roadway connectivity and land use proximity on the time and costs required to reach various destinations, and therefore incorporate the largest range of impacts.[17] Note that level of comfort and network completion are missing from all of these metrics.

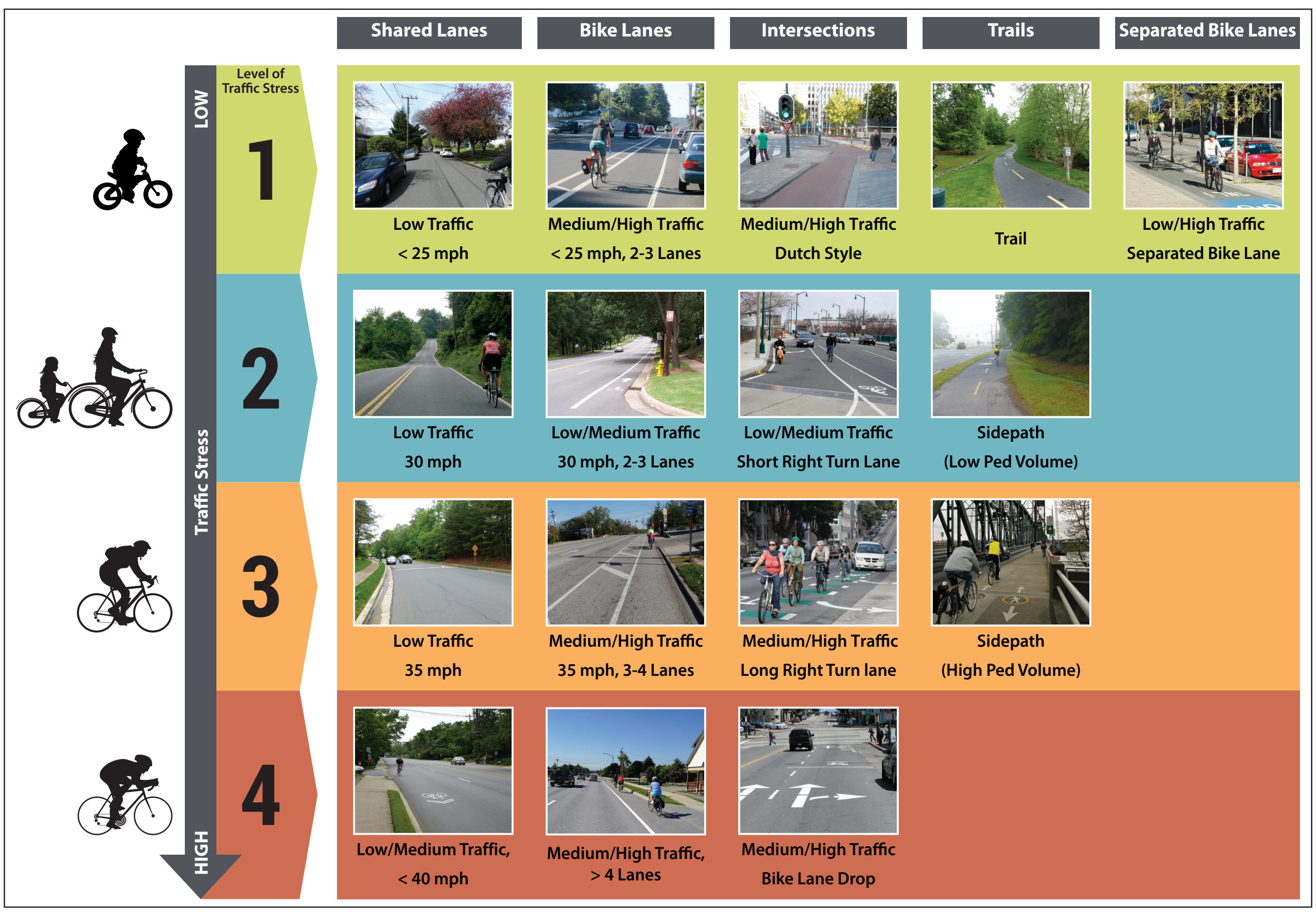
Figure 7: Level of Service Performance Measures and Impacts Considered[19]

	Accessibility Factors ➔				
	Automobile Travel	Active Transport	Public Transport	Roadway Connectivity	Land Use Proximity
➔ Impacts: Traffic Delay	Roadway LOS	Multimodal LOS			
User financial costs					
Energy consumption	Vehicle Trip, Travel and Fuel Consumption Models				
Pollution emissions					
Traffic safety					
Accessibility for non-drivers					
Physical fitness and health	Multimodal Accessibility Models				
Land Use Impacts					

Level of Traffic Stress

Level of Traffic Stress (LTS) is a performance measure that can be used to indicate user comfort. LTS scores can be calculated for facilities or roadway types, and typically provide a score from one (low stress) to four (high stress) (see Figure 8). For roadways or corridors that contain a variety of facility types, the overall LTS score of the corridor is associated with the highest category of stress found along the corridor. LTS scores can also provide a measure of segment or network completeness and quality for bicycling based on facility type, topography, directness, street width, operating space, vehicle travel speed, or level of separation or integration between vehicle traffic and bicycle traffic. The primary advantage of LTS is that it incorporates comfort levels of different types of cyclists, from children or inexperienced cyclists - who may prefer more separation between vehicle traffic and bicycle traffic, to advanced cyclists - who may be comfortable riding on a shoulder or painted bike lane next to vehicles traveling at high speeds.[18] Although this methodology is most often used to evaluate bicycle level of comfort, it can also be used for other modes.

Figure 8: Bicycle Level-of-Traffic-Stress



Multimodal Transportation System Completeness

Many cities dedicated to increasing bicycling and walking are evaluating the completeness of their transportation system. System completeness is a measurement of network completeness for each roadway user type. A 'system' includes segments, crossings, and existing facilities. While relatively straightforward in theory, this performance measure requires a significant amount of data and time to complete and maintain. However, communities with detailed master plans, or those interested in conducting existing conditions inventories are in a good position to implement this measure. Cities and counties throughout Oregon and Washington have begun prioritizing this performance measure.

Portland, OR

In December of 2016, the City of Portland incorporated a system completeness performance measure for pedestrian, bicycle, and transit networks into its Transportation System Plan after determining that its use of conventional LOS was not in alignment with local policy goals of expanding transportation choices, reducing VMT, and growing transit, bicycle, and pedestrian mode shares. The City has stated that because of its focus on LOS, the pedestrian and bicycle networks were incomplete and transit access was limited. The City of Portland used existing transportation planning documents to define 'system completeness' for each mode. Next, existing conditions inventories for pedestrian, bicycle, and transit networks were developed; these included evaluations of existing and proposed crossings, roadways, and other facilities. Refer to the City of Portland's Multimodal System Completeness for a detailed explanation of the methodology used to measure system completeness for pedestrians, bicycles, and transit.

Cities and counties of varying sizes throughout the pacific northwest have adopted system completeness performance measures, often in conjunction with other performance measures.

Comprehensive Approaches

Increasingly, communities across the nation are adopting comprehensive approaches to measure the impact of transportation and development projects. These comprehensive approaches incorporate a variety of performance measures to ensure that the needs of people walking, bicycling, riding transit, and driving are incorporated into decisions making processes and that the methodologies use to evaluate decisions are in alignment with community goals.

Washington County, OR

Washington County, Oregon is exploring the incorporation of a collection of performance measures into its corridor project assessments and transportation system plan. After reviewing the ease of application, understandability, data cost, usefulness for prioritization and comparisons, and reflectiveness of user experiences for more than 100 potential performance measures, Washington County chose the performance measures listed in Figure 9 to assess corridor projects. Note that Washington County's proposed approach incorporates many of the performance measures discussed above.

Yolo County, CA

Yolo County, California took a simplified approach to focus on the goals of accessibility and safety, in addition to vehicle and multimodal LOS. Yolo County uses the methodology presented in NCRP Report 616 to calculate multimodal LOS. Accessibility is measured by activity connectedness via travel time for each mode between a potential project site and surrounding land

Figure 9. Multi-modal Performance Measures and Standards, Washington County, OR[19]

Performance Measure	Standard
Sidewalk completeness	Baseline numbers should be developed and reported annually. Could report completeness in each of three ways: • % sidewalk coverage of full arterial/collector network • % of existing sidewalks that meet ADA standards • % sidewalk coverage of full arterial/collector network that is to standard (ADA and width)
Crossings completeness	100% of corridor has crossings connecting essential destinations; four complete crossings at four-leg intersections; crossings present within reasonable distance of all transit stops (collectors and arterials); crossings present at trail connections
Bicycle facility completeness	100% coverage of arterial/collector network with bicycle facilities meeting TSP designation along all collectors and arterials complete connections to neighborhood greenways
Intersection completeness	Includes all elements of intersection completeness, providing safe multi-modal access to all intersections New projects should meet 100% standard
Predicted crash rate	Lower predicted crash rate than existing condition
Pedestrian delay	Evaluate impacts of each alternative
Pedestrian crossing distance	
Pedestrian MMLOS	
Bicycle MMLOS	
Bicycle LTS	
Travel time	
Travel time reliability – buffer index	
Volume-to-capacity ratio	

uses. The County prioritizes the safety of its road users through a speed management strategy. The County states that desired travel speeds for each mode must be evaluated when new transportation facilities are constructed. In urban areas, the County set a standard for roadways to be designed for 35 mph or less in order to reduce crash severity and minimize barriers to people walking and bicycling.[20]

Two Australian authors explored a similar approach to Yolo County, and, after an extensive review, proposed a set of performance measures for different elements of a transportation network, including mobility, safety, access, information, and amenity needs for each road user type (see Figure 10).

The Victoria Transport Policy Institute developed a list of metrics that when used all together, provide a

Figure 10. Level-of-Service Framework[21]

Road User	LOS Needs	LOS Measure
Motorist	Mobility	Congestion, travel time reliability, travel speed
	Safety	Crash risk
	Access	Ability to park close to destination, access roadside land, or depart an intersection
	Information	Traveler information available
	Amenity	Aesthetics, driving stress, pavement ride quality
Transit User	Mobility	Service schedule reliability, operating speed
	Safety	Crash risk of transit vehicle and of transit users while accessing/egressing transit vehicle
	Access	Service availability, disability access, access to stops from key origins and destinations
	Information	Traveler information available
	Amenity	Pedestrian environment, on-board congestion, seat availability, security, comfort and convenience features, aesthetics, ride quality
Pedestrian	Mobility	Footpath congestion, grade of path, crossing delay or detour
	Safety	Exposure to vehicles at mid-blocks; Exposure to vehicles at crossings; trip hazards
	Access	Crossing opportunities, level of disability access
	Information	Traveler information available including signposting
	Amenity	Footpath pavement conditions, comfort and convenience features, security, aesthetics
Cyclist	Mobility	Travel speed, congestion, grades
	Safety	Risk of cycle-to-cycle/pedestrian crash Risk of crash caused by surface unevenness or slippage Risk of crash with stationary hazards Risk of cycle-to-motor vehicle crash at mid-blocks Risk of cycle-to-motor vehicle crash at intersections and/or driveways
	Access	Access to and ability to park close to destination, cycle restrictions
	Information	Traveler information available, including signposting
	Amenity	Aesthetics, comfort and convenience, security, pavement ride quality
Freight	Mobility	Congestion, travel time reliability, travel speed
	Safety	Crash risk
	Access	Level of freight vehicle type access
	Information	Traveler information
	Amenity	Pavement ride quality, driving stress

comprehensive assessment of bicycle and pedestrian mobility in a community (see Figure 11). The measures may be more or less relevant to different communities based on size, density, and existing and planned pedestrian and bicycle mode share.

Figure 11. Nonmotorized Level-Of-Service Rating Factors, Victoria Transport Policy Institute[22]

Feature	Definition	Indicators
Network continuity	Whether sidewalks and paths exist, and connect throughout an area.	• Portion of streets with nonmotorized facilities. • Length of path per capita. • Network connectivity and density (km of sidewalks and paths per km2).
Network quality	Whether sidewalks and paths are properly designed and maintained.	• Sidewalk and path functional width. • Portion of sidewalks and paths that meet current design standards. • Portion of sidewalks and paths in good repair.
Road crossing	Safety and speed of road crossings.	• Road crossing widths. • Motor vehicle traffic volumes and speeds. • Average pedestrian crossing time. • Quantity and quality of crosswalks, signals and crossing guards.
Traffic protection	Separation of nonmotorized traffic from motorized traffic, particularly high traffic volumes and speeds.	• Distance between traffic lanes and sidewalks or paths. • Presence of physical separators, such as trees and bollards. • Speed control.
Congestion and user conflicts	Whether sidewalks and paths are crowded or experience other conflicts.	• Functional width of sidewalk and paths. • Peak-period density (people per square meter). • Clearance from hazards, such as street furniture within the right-of-way. • Number of reported conflicts among users. • Facility management to minimize user conflicts.
Topography	Presence of steep inclines.	• Portion of sidewalks and paths with steep inclines.
Sense of Security	Perceived threats of accidents, assault, or abuse.	• Reported security incidents. • Quality of visibility and lighting.
Wayfinding	Guidance for navigating within the station and to nearby destinations.	• Availability and quality of signs, maps and visitor information services.
Weather protection	User protected from sun and rain.	• Presence of shade trees and awnings.
Cleanliness	Cleanliness of facilities and nearby areas.	• Litter, particularly potentially dangerous objects. • Graffiti on facilities and nearby areas. • Effectiveness of sidewalk and path cleaning programs.
Attractiveness	The attractiveness of the facility, nearby areas and destinations.	• Quality of facility design. • Quality of nearby buildings and landscaping. • Air and noise pollution experienced by cyclists and pedestrians. • Community cohesion. • Parks/recreational areas accessible by nonmotorized facilities.
Marketing	Effectiveness of efforts to encourage nonmotorized transportation.	• Quality of nonmotorized education and promotion programs. • Nonmotorized transport included in Commute Trip Reduction programs.

Bellingham, WA

In December of 2008, Bellingham's City Council adopted its Multi-modal Transportation Concurrency Program and began to officially incorporate multimodal needs into its transportation and land use planning processes. This resolution emerged after a multi-year effort which originally sought to change the city policy to allow a lower LOS (F) standard during the evening peak hour for certain arterials as a way to adhere with state law and support high-density, mixed-use developments which were supported by local city planning documents.[23]

The City of Bellingham successfully combined multimodal LOS standards with a system completeness strategy which helps them achieve local comprehensive plan goals to prioritize urban infill and multimodal transportation. Bellingham's adopted LOS standard is "person trips available by concurrency service area" based on arterial and transit capacity for motorized modes and on the degree of network completeness for pedestrian and bicycle modes, as listed below. In Bellingham's methodology, bicycle or pedestrian facilities must be a minimum of 50 percent complete in a concurrency service area to be credited with person trips available. Refer to Moving Beyond the Automobile for additional details about Bellingham's story and methodology.

Figure 12. Performance Measurement by Mode, City of Bellingham, WA[24]

Mode	Measurement
Motorized	
Automobiles	Arterial volume-to-capacity measured during weekday p.m. peak hour based on data collected at designated concurrency measurement points in concurrency service areas
Public Transit	Seated capacity based on bus size and route frequency and ridership based on annual transit surveys measured during weekday p.m. peak hour based on data collected at designated concurrency measurement points for each concurrency service area
Non-Motorized	
Bicycle	Credit person trips according to degree of bicycle network completeness for designated system facilities/routes for each concurrency service area
Pedestrian	Credit person trips according to degree of pedestrian network completeness for designated system facilities/routes for each concurrency service area
Trail Use	Credit person trips according to degree of trail network completeness, where trails serve a clear transportation function for a concurrency service area

Conclusion

There is no one-size-fits-all approach for transportation planning, however, the use of conventional LOS and the prioritization of vehicles is not recommended for communities that seek to promote multi-modalism. State DOTs may continue to advocate for LOS, and in some cases, such as low-density rural areas, its use may be appropriate. However, adhering to the conventional transportation paradigm, which promotes roadway expansion, fast travel speeds, longer trips, and more VMT, results in incomplete and unsafe travel environments for people walking and bicycling, and land use patterns that do not value and promote accessibility and mobility for all community members.

This paper presented a variety of performance measures that communities can use as alternatives, or in conjunction with, conventional LOS. There are advantages and disadvantages to each performance measure. As such, a comprehensive approach that incorporates a selection of the aforementioned performance measures is advised. La Crosse should consider its transportation goals and local transportation and land use context before considering which performance measures to use. It is important for La Crosse to select a manageable number of performance measures, which may require a deeper level of analysis. Based on the lessons learned from other communities, La Crosse must choose performance measures that directly support and track progress towards local goals. By doing this, La Crosse will take a critical step towards creating a city with a vibrant transportation system that promotes mobility, reliability, accessibility, safety, and multimodal network infrastructure.

Appendix A: Resources

- FDOT (2012), Expanded Transportation Performance Measures to Supplement Level of Service (LOS) for Growth Management and Transportation Impact Analysis, Florida Department of Transportation. www.dot.state.fl.us/researchcenter/Completed_Proj/Summary_PL/FDOT_BDK77_977-14_rpt.pdf.
- Richard Dowling, et al. (2008), Multimodal Level Of Service Analysis For Urban Streets, NCHRP Report 616, Transportation Research Board. https://nacto.org/docs/usdg/nchrp_rpt_616_dowling.pdf User Guide at http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_w128.pdf. This describes ways to evaluate roadway design impacts on various modes (walking, cycling, driving and public transit).
- WalkScore (www.walkscore.com) calculates the walkability of a location based on proximity to public services such as stores, schools and parks. However, it does not consider any other factors, such as the presence or quality of walking and cycling facilities (sidewalks, paths, crosswalks, etc.) or the ease of crossing streets (the presence of crosswalks, road widths, traffic volumes and speeds, etc.), or the quality of the pedestrian environment.
- The Walkability Checklist (www.walkableamerica.org/checklist-walkability.pdf), developed by the Partnership for a Walkable America and the Pedestrian and Bicycle Information Center, provides an easy-to-use form for evaluating neighborhood walkability, taking account factors such as the quality of sidewalks and paths, roadway crossing conditions (crosswalks, and traffic speeds and volumes), the degree of care by motorist, and amenities such as shade trees and street lighting along sidewalks, as perceive by users.
- CDM Research (2014) developed a mid-block level of service (LOS) model for bicycle riders which provides non-technical practitioner with a means to rapidly estimate the LOS of a current link or route and to help estimate the proportion of demand that will use competing facilities. The model is sensitive to facility type; frequency of delay due to interaction with other path/road users; interactions with other path users (cyclists, pedestrians); car and transit volumes; presence of curb side parking and motorized traffic speed limits.
- The Bikeability Checklist (www.walkinginfo.org/cps/checklist.htm) developed by the Pedestrian and Bicycle Information Center includes ratings for road and off-road facilities, driver behavior, cyclist behavior, and barriers, and identifies ways to improve bicycling conditions.
- The 2010 Highway Capacity Manual (the main reference guide for evaluating roadway system performance) created urban roadway LOS ratings for various modes, including walking, cycling, public transit and automobile.
- BikeScore (www.walkscore.com/bike-score-methodology.shtml) evaluates local walking conditions on a scale from 0 - 100 based on four equally weighted components, bike lanes, hills, destinations and road connectivity and bike commuting mode share.
- Neighborhood Bikeability Score (www.ibpi.usp.pdx.edu/neighborhoods.php) is a rating from 0 (worst) to 100 (best) that indicates the number of destinations (stores, schools, parks, etc.) that can be reached within a 20-minute bike ride, taking into account the quality of cycling infrastructure.

References

1. Todd Litman. (2017). The New Transportation Planning Paradigm. ITE Journal (83): p. 26. http://digitaleditions.sheridan.com/publication/?i=161624.

2. Todd Litman. (2017). Introduction to Multi-Modal Transportation Planning. Victoria Transport Policy Institute. http://www.vtpi.org/multimodal_planning.pdf

3. Surface Transportation Policy Project. (1998). An Analysis of the Relationship between Highway Expansion and Congestion in Metropolitan Areas: Lessons from the 15-Year Texas Transportation Institute Study.

4. Vanderbilt, Tom (2008) Traffic: Why We Drive the Way We Do (and What It Says About Us) New York; Knopf. p.154-156.

5. EPA. (2001). Our Built and Natural Environments: A Technical Review of the Interactions between Land Use, Transportation, and Environmental Quality.

6. Brian Tefft. (2013). Impact speed and a pedestrian's risk of severe injury or death. Accident Analysis and Prevention (50): p. 871 – 878.

7. Rosén, E., & Sander, U. (2009). Pedestrian fatality risk as a function of car impact speed. Accident Analysis and Prevention (41): p. 536–542.

8. Joon-Ki, K., Sungyop, K., Gudmundur, U.F., and Porrello, L.A. (2007). Bicyclist Injury Severities in Bicycle-Motor Vehicle Accidents. Accident Analysis and Prevention (39): p. 238-251.

9. Nishimoto, T., Mukaigawa, K., Tominaga, S., Lubbe, N., Kiuchi, T. et al. (2017). Serious Injury Prediction Algorithm on Large-Scale Data and Under-Triage Control. Accident Analysis and Prevention (98): p. 266-276.

10. Goran, Nilsson. (2004). Traffic safety dimensions and the power model to describe the effect of speed on safety. Lund Bulletin 221. Lund Institute of Technology, Lund. https://safelyhome.westerncape.gov.za/sites/safelyhome.westerncape.gov.za/files/assets/Documents/Nilsson%20Academic%20Paper%20on%20Speed.pdf

11. Fehr and Peers. Multi-Modal Level of Service Toolkit. http://asap.fehrandpeers.com/wp-content/uploads/2015/04/MMLOS-Tool-Person-Delay.pdf

12. Dowling, R., Reinke, R., Flannery, A., Ryus, P., Vandehey, M. et al. (2008). Multimodal Level of Service Analysis for Urban Streets (NCHRP Report 616). National Cooperative Highway Research Program Transportation Research Board: Washington D.C. https://nacto.org/docs/usdg/nchrp_rpt_616_dowling.pdf

13. Florida Department of Transportation. (2013). Quality/Level of Service Handbook. p.19. http://www.fdot.gov/planning/systems/programs/SM/los/pdfs/2013%20QLOS%20Handbook.pdf

14. Angie Schmitt. Beyond "Level of Service" – New Methods for Evaluating Streets. Published October 23, 2013. USA Streets Blog. http://usa.streetsblog.org/2013/10/23/the-problem-with-multi-modal-level-of-service/

15. Burien, WA. (2012). Transportation Master Plan. P. 34. http://www.burienwa.gov/DocumentCenter/Home/View/2069

16. Ewing, Reid and Cervero, Robert. (2010). Travel and the Build Environment. Journal of the American Planning Association (76): p. 265-294.

17. Todd Litman. (2014). Beyond Roadway Level-of-Service: Improving Transport System Impact Evaluation. Victoria Transport Policy Institute. http://www.vtpi.org/CGOP_LOS.pdf

18. Mineta Transportation Institute. (2012). Level-of-Traffic-Stress.

19. Washington County, OR. (2014). Multi-modal Performance Measures and Standards. p. 27

20. Yolo County, CA. (2010). Transportation Impact Study Guidelines. http://www.yolocounty.org/home/showdocument?id=11513

21. Green, David and Espada, Ian. (2015). Level of Service Metrics (for Network Operations Planning). https://www.onlinepublications.austroads.com.au/items/AP-R475-15

22. Victoria Transport Policy Institute. Multi-modal Level-of-Service-Indicators. Updated July 19, 2017. http://www.vtpi.org/tdm/tdm129.htm

23. Chris Comeau. (2009). Moving Beyond the Automobile. American Planning Association. http://mrsc.org/Corporate/media/MediaLibrary/SampleDocuments/ArtDocMisc/B45BeyAuto.pdf

24. Chris Comeau. (2009). Moving Beyond the Automobile. American Planning Association. http://mrsc.org/Corporate/media/MediaLibrary/SampleDocuments/ArtDocMisc/B45BeyAuto.pdf

CITY OF LA CROSSE
FOUNDED 1842
WISCONSIN