
PEDESTRIAN LEVEL OF SERVICE AND QUALITY OF OPERATIONS ASSESSMENT METHODS

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Abstract

The Level of Service (LOS) concept has been traditionally used to assess quality of operations of transportation facilities. The 2000 Highway Capacity Manual (2000 HCM) offers level of service criteria for pedestrian facilities based on speed, density, and flow threshold values. However, the pedestrian environment is multi-dimensional, and it takes a set of several additional factors to properly describe LOS. Most of these factors are qualitative and subjective and are not easy to measure. Defining and establishing LOS standards for pedestrians is a difficult but important process.

This paper reviews and compares existing methodologies for assessing quality of operations of pedestrian facilities. A detailed description of the 2000 HCM methods for estimating LOS for pedestrian facilities is offered, along with methods that apply multiple quantitative and qualitative criteria to assess quality of operations. Moreover, recent attempts to model pedestrian LOS mathematically are described. Remaining issues and recommendations for future research are also offered to assist researchers and practitioners in developing and/or selecting proper methods for evaluating the quality of operations of pedestrian environments.

INTRODUCTION

For a long time, transportation engineers and planners in the United States have paid attention primarily on the motorized transportation system. Still until today the motorized transportation system receives an overwhelming priority over systems that serve the needs of non-motorized users such as pedestrians and bicyclists. However, in the recent years, multi-modal approaches have begun to be emphasized in the field of transportation planning in order to meet the challenges of congestion, air quality, infrastructure concurrency, and quality of life.

Many communities started promoting walkability concepts through education and infrastructure improvements. The latter created the necessity of measuring the performance of

facilities that serve pedestrian traffic in order to determine quality of operations, existing deficiencies, needs for improvements and priority setting. (4) One of the most common approaches used to assess transportation facilities is the concept of Level of Service (LOS). However, Level of Service measures for pedestrian and bicycle facilities were non-existent until recently. It is generally recognized that the value of having such standards is the contribution they would make to understanding and quantifying the street design elements that are conducive to the needs of pedestrians and bicyclists. (5) The scope of this paper is limited to pedestrians.

The principles used by the 2000 HCM to determine the pedestrian LOS are similar to those for vehicles. The emphasis is almost exclusively on the flow-speed-density relationship.(7) The threshold to determine the six level of service criteria is based on the space available to each pedestrian and speed. A fundamental question remains as whether the HCM really addresses quality of service based on the user's perspective. Recent research on pedestrian and bicycle quality of service indicates that the most important determining factors are lateral separation of the mode from motorized vehicles, and motorized vehicle volume, speed, and type.(12) Also it is probably safe to assume that pedestrians rarely make route choice decisions based on pedestrian flows and densities. Rather, pedestrian route choice is based on a myriad number of other factors, including safety, attractiveness, and distance. Indeed, pedestrians may well seek system attributes that are the opposite of those sought by the motorists. For instance relatively crowded pedestrian spaces may be a desirable attribute for the pedestrian, not an undesirable one. (16)

METHODOLOGY

In order to draw an integrated picture of level of service for the pedestrian facilities it is necessary to review, compare and contrast various methods in the literature that assess quality of service for nonmotorized facilities. The following sections summarize efforts so far to develop LOS and quality of service standards for pedestrians.

Highway Capacity Manual (HCM 2000) Procedures (8)

The pedestrian level of service methodology in the 2000 HCM is essentially based on how crowded the respective modal facilities are. (6) The methodology is based on the fundamental relationships among the characteristics of pedestrian traffic: speed, flow, and density. Not only the characteristics, but also the relationships among these factors are similar to those of vehicles. Based on these relationships, thresholds of LOS of different facilities are determined, including the following.

- 1) Uninterrupted-Flow Facilities
 - a) Walkways and Sidewalks
 - b) Queuing Areas
 - c) Shared Pedestrian-Bicycle Facilities
- 2) Interrupted-Flow Facilities
 - a) Signalized Intersections
 - b) Unsignalized Intersections
 - c) Pedestrian Sidewalks on Urban Streets

More specifically, Table 1 lists the LOS criteria for walkways and sidewalks. It includes the service measure of space and the supplementary criteria of unit flow rate, speed, and volume / capacity (v/c) ratio (where a capacity value of 23 p/min/ft is assumed). The LOS thresholds summarized in Table 1 do not account for platoon flow, but instead assume average flow

throughout the effective width.

If platooning or other traffic patterns occur that alter the underlying assumption of average flow in the LOS calculation, then the LOS criteria for walkways and sidewalks shall be adjusted as shown in Table 2. As Pushkarev et al. showed in 1975 (15), the impeded pedestrian flow starts at 530 ft²/p, which is equivalent to 0.5 p/min/ft and the jammed flow in platoons starts at 11 ft²/p (18 p/min/ft). These values are used as the thresholds for LOS A and F respectively.

The average space available to pedestrians also apply as the walkway service measure for queuing or waiting areas in the 2000 HCM. The LOS thresholds listed in Table 3 are related to the average space available to each pedestrian and to the degree of mobility allowed in queuing areas.

On shared pedestrian facilities, bicycles can have a negative effect on pedestrian capacity and LOS. However, it is difficult to establish a bicycle-pedestrian equivalent because the relationship between the two differs depending on their respective flows, directional paths, and other factors. LOS for shared paths is based on hindrance. The LOS for a pedestrian on a shared path depends on the frequency that the average pedestrian is overtaken by a bicycle. Assuming a default average pedestrian speed of 5.0 ft/s and a bicycle speed of 20.0 ft/s LOS thresholds for two-way paths have been established and are summarized in Table 4.

The LOS criteria for pedestrians at signalized intersections are based on pedestrian delay (see Table 5). Table 5 also includes a guide for the likelihood of pedestrians noncompliance (i.e., disregard for signal indication) under low to moderate conflicting vehicle volumes. It should be noted that, even though delay has an impact on the travel time of pedestrians, it does not reflect the functions of street corners and crosswalks, where the circulation of pedestrians and the space for pedestrian queuing to cross are important. Specific procedures are offered in the HCM 2000 for the analysis of such areas.

Table 6 lists LOS criteria for pedestrians at unsignalized intersections, based again on pedestrian delay. Pedestrians expect and tolerate smaller delays at unsignalized intersections than at signalized intersections. Table 6 also includes a likelihood of pedestrian risk-taking behavior related to LOS.

For LOS assessment of pedestrian sidewalks on urban streets the average pedestrian travel speed over the entire section should be computed and then compared to the threshold values in Table 7. The criteria resemble the urban street LOS criteria for motor vehicles; and the thresholds are set at similar percentages of the base speed. (18)

Methodologies Considering the Pedestrian Environment

One of the first pedestrian environment studies was carried out in Finland by Lautso and Murole in 1974. (11) Their purpose was to study pedestrian perceptions about the environment and how elements of the environment influence pedestrian assessments of quality of service. Interviews of approximately 1000 subjects revealed the following four factors:

- 1) City factor: elements such as neon lights, shop windows, shops, young people.
- 2) Traffic disturbance factor: traffic noise, the difficulty of moving with children and perambulators.
- 3) Traffic arrangement factor: traffic management elements as the location and the adequacy of pedestrian crossings.
- 4) The social factor: the influence of other people as to environmental attractiveness.

The study results showed clearly that primary attention must be paid to the traffic arrangement factors when improving the pedestrian role in traffic. This pioneer study threw some

light in this field and was further expanded by later researchers, who tried to set up other broad categories to accommodate all the important factors/standards which should be considered to measure the performance of the pedestrian facility.

As an example, McLeod in Florida (10), (12) defined three general performance measures describing the roadside pedestrian environment:

- 1) Sidewalk capacity,
- 2) Quality of the walking environment, and
- 3) The pedestrian's perception of safety (or comfort) with respect to motor vehicle traffic.

Wetmore (7) in Australia proposed assessing quality of service for pedestrian facilities based on three broad areas, by developing a separate index for each:

- 1) Walking along the street
 - a) Continuity
 - b) Capacity
 - c) Comfort
- 2) Crossing the street
 - a) Safety, comfort, and convenience
 - b) Is there sufficient queuing space?
 - c) Delay
 - d) Deviation
- 3) Some place to walk to
 - a) How well do sidewalks and crossing work as a system?
 - b) Do destinations exist?
 - c) More involved analysis of the mix of destinations within a given walking time or distance.

Qualitative Evaluation

In 1993 Sarkar (17) developed a qualitative evaluation method to determine the pedestrian LOS. The seven respects considered in this research are: safety, security, comfort and convenience, continuity, system coherence, and attractiveness. The criteria are summarized in Table 8. Because it is a qualitative method, the standard for each performance measurement in this method is not easy to control, which is viewed as a shortcoming of the method.

Points Scale

To provide a quantitative measure (a shortcoming of Sarkar's method), a points scale method was proposed by Khisty (9) in 1994. Khisty continued to use the performance measures suggested by Sarkar, but instead of using the qualitative evaluation he quantified these measures and set up a 5-point scale method to assess the pedestrian environment LOS. A summary of the procedure developed and applied is offered in Tables 9 through 11.

In 1995, Dixon (4) presented a method utilized by the city of Gainesville, Florida in TRR which also used a point scale system. The method is applicable for corridor evaluations on arterial and collector roadways in urban or suburban areas. It considers the type of pedestrian facility, existing conflicts, presence of pedestrian amenities, motor vehicle traffic conditions, maintenance conditions and Traffic Demand Management (TDM) presence. Table 12 illustrates this method and Table 13 shows the corresponding standard of LOS.

In 2000, Miller et al. from Virginia also set up a scale method for pedestrian LOS

assessment. (14) This study attempted to calibrate the proposed model by using 3-D visualization. In this method alternatives to improve the existing facility are considered and the corresponding change in points is shown. The research design involved interviews of pedestrians who were provided by computer-aided models consisting of still shots and animations. The given scores from the pedestrians were compared to the computed rating of the facility based on a LOS scale method. By doing so, different performance measures were calibrated and the most effective alternative to improve the facility was discovered. Table 14 shows one example of their work.

In 1993 Bradshaw (1) presented his rating system for neighborhood walkability that revolved around four basic characteristics:

- 1) A “foot friendly”, man-made, physical micro-environment that involved wide, level sidewalks, small intersections, narrow streets, lots of litter containers, good lighting, and an absence of obstructions.
- 2) A full range of useful, active destinations within walking distance such as shops, services, employment, professional offices, recreation, libraries, etc.
- 3) A natural environment that moderates the extremes of weather – wind, rain, sunlight – while providing the refreshment of the absence of man’s overuse with no excessive noise, air pollution, or the dirt, stains, and grime of motor traffic.
- 4) A local culture that is social and diverse. This increases contact between people and the conditions for social and economic commerce.

His scale method is shown on Table 15 where the lowest score is best. It should be noted that this method is only applicable in a small community and requires a number of surveys to be carried out, a fact that may restrict its applicability. Moreover, clear guidelines on how to analyze the survey data and how to determine different levels of service are missing from this work.

Mathematical Model

A mathematical model was proposed by Bruce Landis etc in 2000 (6), (10) in research work that focused on the perceived safety or comfort (with respect to the presence of motor vehicle traffic). The model is calibrated, transferable and applicable at the roadway segment, and ultimately, when combined with an intersection level of service measure, applicable at the facility corridor and network levels. It evaluates roadside walking conditions regardless of the presence of a sidewalk. The model is designed to evaluate a roadway segment; and it does not include intersections.

The factors that significantly affect pedestrians’ sense of safety or comfort based on this research are limited to the roadway environment (i.e., excluding intersection conditions), and include:

- 1) Presence of a sidewalk;
- 2) Lateral separation from motor vehicle traffic;
- 3) Barriers and buffers between pedestrians and motor vehicle traffic;
- 4) Motor vehicle volume and composition;
- 5) Effects of motor vehicle traffic speed, and
- 6) Driveway frequency and access volume, among other factors.

The design of the research involved placement of people in actual traffic and roadway conditions to obtain real time feedback. The participants represented a broad cross section of age, gender, experience level, and geographic origin. The experiment procedure can be summarized in three steps:

- 1) Create a special event that places a significant number on a walking course consisting of typical roadways in a typical US metropolitan area
- 2) Obtain the real time response to the roadway environment stimuli, and
- 3) Create and test a mathematical relationship of measurable factors to reflect the study participants' reactions.

It should be noted that the research was designed to elicit responses from participants walking individually, not in pairs or groups. Several Pearson Correlation analyses were run using the SAS program on a variety of traffic and roadway variables. The researchers conducted step-wise regression analyses using 1,315 real time observations. Based on the 95 percent level of statistical significance of the coefficients, the model was developed as shown below.

$$\text{Ped LOS} = -1.2021 \ln (W_{ol} + W_1 + f_p \times \%OSP + f_b \times W_b + f_{sw} \times W_s) + 0.253 \ln (\text{Vol}_{15} / L) + 0.0005\text{SPD}^2 + 5.3876$$

Where:

- W_{ol} = Width of outside lane (feet)
- W_1 = Width of shoulder or bike lane (feet)
- f_p = On-street parking effect coefficient (= 0.20)
- $\%OSP$ = Percent of segment with on-street parking
- f_b = Buffer area barrier coefficient (=5.37 for trees spaced 20 feet on center)
- W_b = Buffer width (distance between edge of pavement and sidewalk, feet)
- f_{sw} = Sidewalk presence coefficient = $6 - 0.3W_s$
- W_s = Width of sidewalk (feet)
- Vol_{15} = average traffic during a fifteen minutes period
- L = total number of (through) lanes (for road or street)
- SPD = Average running speed of motor vehicle traffic (mi/hr).

Table 16 shows the standard for different LOS values based on Landis method.

Although this model offers a good quantitative method to determine LOS a question still remains on whether or not it is applicable to roadways other than “a typical roadway in a typical US metropolitan area”. Moreover, factors other than the environment are not represented in the model. Also the research was designed to elicit responses from participants walking individually, and thus an interest remains on analysis of effects of the platooning pedestrians.

DISCUSSION

Even though significant progress has occurred in the recent years toward properly addressing LOS and quality of service issues for pedestrian facilities, a number of related issues still remain unresolved. These issues include, but are not limited to the following:

1. Effect of platooning pedestrians

Both the HCM methodology and other researchers (3), (13) recognize that the platooning of pedestrians has an effect on the LOS of facilities. However, this effect is not stated explicitly in most of the methodologies that consider the environmental factors. The trade off between the increase of the sense of security and potential inconvenience to users due to platooning should be addressed in future research.

2. Consideration of a variety of pedestrian user groups

Just as there are many different types of motor vehicles (trucks, buses, RV's), there are many types of pedestrian users. Pedestrian users may include school children, the elderly, walking-aid users, scooter and wheelchair users, prosthesis users, people with vision and hearing impairments, dog guide users etc. There is a need to study the different characteristics and needs of the various pedestrian user groups and address them in the methodologies that estimate capacity and LOS of pedestrian facilities.

3. The need for classification of pedestrian facilities

In 2000 HCM, the LOS thresholds of different pedestrian facilities (such as transportation terminals, intersections, corridors (multimode), midblock crossings), are different. When compared to the HCM method, other assessment methods are either too general or do not apply to all facility types. Furthermore, most of these methods require the presence of a sidewalk to be applicable. (10) The question can be raised of whether or not the pedestrian quality of service measures should address the type of facility (sidewalk, pedestrian mall, off-road paths, etc.).

Moreover, different methods or different performance measurements may be applied to different facilities. For example, in Steven Kaiser's work (7) a delay-based measure was proposed for signalized intersections, rather than a congestion-based one. A research in Hong Kong on the pedestrian route choices between escalator and stairway in MTR stations (2) found that the pedestrians chose their routes by considering the delay of using different facilities such as escalator and stairway. It seems that the next best single measure for basing pedestrian LOS is considered to be average delay per pedestrian along a link or through a node. The quantitative relationship between delay and pedestrian LOS requires further research. (10)

4. Requirement for calibration of the scale methodologies

The points scale methodologies have offered some innovative ideas, but unfortunately, the results of these scales are not always easy to interpret. (14) Five types of errors are possible with the scale methods:

- 1) Specific geometric attributes may not be aligned perfectly with the factors identified in the original survey.
- 2) The factors may overlap.
- 3) The survey sample may be too small.
- 4) The sphere of influence of these factors may differ.
- 5) Performance may be nonlinear.

Therefore, specific calibration work for these methodologies is needed.

5. Combination of different methodologies

Generally speaking, the LOS concept represented by the HCM is a dynamic standard, while most of the environmental factors are static, i.e., the LOS of the facility has been determined and fixed once its design was set. This is somewhat unreasonable. Therefore, the HCM approach to estimating LOS remains a robust design tool and measure for areas where local capacity is the key design issue. (7) However, a full and far broader consideration of all factors determining a LOS for pedestrians is necessary and thus recommended for future research.

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TABLE 1: Average Flow LOS Criteria for Walkways and Sideways

LOS	Space (ft ² /p)	Flow Rate (p/min/ft)	Speed (ft/s)	v/c Ratio
A	>60	≤5	>4.25	≤0.21
B	>40-60	>5-7	>4.17-4.25	>0.21-0.31
C	>24-40	>7-10	>4.00-4.17	>0.31-0.44
D	>15-24	>10-15	>3.75-4.00	>0.44-0.65
E	>8-15	>15-23	>2.50-3.75	>0.65-1.0
F	≤8	variable	≤2.50	variable

TABLE 2: Platoon – Adjusted LOS Criteria for Walkways and Sidewalks

LOS	Space (ft ² /p)	Flow Rate ^a (p/min/ft)
A	>530	≤0.5
B	>90-530	>0.5-3
C	>40-90	>3-6
D	>23-40	>6-11
E	>11-23	>11-18
F	≤11	>18

^aRates in the Table represent average flow rates over a 5- to 6-min period

TABLE 3: LOS Criteria for Pedestrian Queuing Areas

LOS	Space (ft ² /p)
A	>13
B	>10-13
C	>6-10
D	>3-6
E	>2-3
F	≤2

TABLE 4: Pedestrian LOS Criteria for Shared Two – Way Paths ^a

Pedestrian LOS	Number of Events/h^b	Corresponding Bicycle Service Volume per Direction^c (bicycles/h)
A	≤38	≤28
B	>38-60	>28-44
C	>60-103	>44-75
D	>103-144	>75-105
E	>144-180	>105-131
F	>180	>131

^aPath 8.0 ft wide^bAn event is a bicycle meeting or passing pedestrians^cAssuming 50/50 directional split of bicycles**TABLE 5: LOS Criteria for Pedestrians at Signalized Intersection**

Pedestrian LOS	Pedestrian Delay (s/p)	Likelihood of Noncompliance
A	>10	Low
B	>10-20	
C	>20-30	Moderate
D	>30-40	
E	>40-60	High
F	>60	Very High

TABLE 6: LOS Criteria for Pedestrians at Unsignalized Intersection

LOS	Average Delay/Pedestrian (s)	Likelihood of Risk-Taking Behavior
A	>5	Low
B	>5-10	
C	>10-20	Moderate
D	>20-30	
E	>30-45	High
F	>45	Very High

TABLE 7: LOS Criteria for Pedestrian Sidewalks on Urban Streets

LOS	Travel Speed (ft/s)
A	>4.36
B	>3.84-4.36
C	>3.28-3.84
D	>2.72-3.28
E	>1.90-2.72
F	<1.90

TABLE 8: SARKAR'S CRITERIA

LOS	A	B	C	D	E	F
Safety	Complete space separation between vehicles and pedestrians. Bicycles are allowed under restricted conditions. No pedestrian-vehicle conflict.	Either horizontal or vertical separation among the modes exists to avoid bimodal conflict.	Physical separation is still ensured, but bidirectional flows may constitute a far greater number of obstacles for some users.	Physical separation reduces the risk of pedestrian-vehicle conflict, but the streetscape design increases the odds of pedestrian-bicycle conflicts	All groups of pedestrians feel threatened by the prospect of probably vehicular conflict.	This is the worse scenario. All the preference is given only to vehicular traffic. The safety of pedestrian has been overlooked. The pedestrians feel totally disoriented, confused, and thoroughly inconvenienced.
Security	The security is ensured by the presence of people and police cars	The street and sidewalk configurations allow vigilance by pedestrians and patrolling police cars.	The street and sidewalk configuration provides clear lines of sight for patrolling police cars.	The vigilance from the street may be inhibited. Some locations at night may be dangerous for pedestrians.	The proximity to moving vehicles may increase the number of drive-by crimes and pedestrians may have very few avenues to escape.	
Comfort and Convenience	The modification facilities free pedestrian movement. Underground transit is easily accessible. And the precincts offer sanctuary from street level noise and air pollution.	The grade-separated pedestrian network with considerable effective walk width. There is excellent intermodal connectivity.	The walkways are unable to cope with bidirectional peak hour flow. Captive users find these walkways uncomfortable and inconvenient.	Pedestrians are inconvenienced because the environment is far from user-friendly. There is poor intermodal connectivity.	There is no facility to afford comfort and convenience. Walking is no longer comfortable and pleasurable.	
Continuity	The pedestrian corridor and the major public open spaces appear as a single entity.	There are continuous stretches of physically separated, well-landscaped networks.	Continuous stretches of sidewalk exists, but have variable widths and poor design standards.	The pedestrian corridors are not well connected and continued stretches of sidewalk are no longer guaranteed.	The prevailing design standards prepare pedestrians for the possibility of several breaks in the continuity.	
System Coherence	There is excellent connectivity and system coherence brought about by full utilization of the urban space.	Excellent system coherence with clear visual statements on the transit facilities, streets, etc.	The perception of urban space becomes less coherent. Pedestrians feel uncomfortable with the visual guidance.	There are confusing directional signs and other visual statement.	Pedestrians' perceptions of urban space falter, and they may devote sensory awareness entirely to the task of restrained locomotion.	
Attractiveness	The pedestrian environment is aesthetically designed and visually pleasing.	Aesthetic components are not as profusive as A, but stil much visual variety can be introduced.	Mediocre design standards prevail.	The designers have ignored pedestrian's need for visual and psychological interaction with the millieu.	The walkway ceases to be an aesthetic component of the streetscape, offering nothing in the form of diversity and variety.	

TABLE 9: Khisty's LOS Thresholds

LOS	Standard	Score (points)
A	$\geq 85\%$ satisfied	5
B	$\geq 60\%$ satisfied	4
C	$\geq 45\%$ satisfied	3
D	$\geq 30\%$ satisfied	2
E	$\geq 15\%$ satisfied	1
F	$< 15\%$ satisfied	0

TABLE 10: Illustration of Performance Measurement of Khisty's Method

Rank	Performance Measure (PM)	Mean	Std Dev	% Wt
1	Security	0.354	0.120	35
2	Safety	0.241	0.108	24
3	Comfort	0.101	0.032	10
4	Convenience	0.092	0.049	9
5	Attractiveness	0.080	0.048	8
6	System Coherence	0.071	0.029	7
7	System Continuity	0.061	0.027	6
		1.000		100

TABLE 11: Illustration of The Calculation Measurement of Khisty's Method

Performance Measure	% Satisfied	LOS	Points	Wt	Total
Attractiveness	21	E	1	0.08	0.08
Comfort	22	E	1	0.10	0.10
Convenience	33	D	2	0.09	0.18
Safety	16	E	1	0.24	0.24
Security	61	B	4	0.35	1.40
System Coherence	42	D	2	0.07	0.14
System Continuity	48	C	3	0.06	0.18
Grand Total					2.32

The overall environment LOS is slightly better than D.

TABLE 12: Illustration of Dixon's Method

CATEGORY	CRITERION	POINTS
PEDESTRIAN FACILITY PROVIDED (Max Value = 10)	Not Continuous or Non-existent	0
	Continuous on One Side	4
	Continuous on Both Sides	6
	Min. 1.53 m (5') Wide & Barrier Free	2
	Sidewalk Width > 1.53 m (5')	1
	Off-Street/Parallel Alternative Facility	1
CONFLICTS (Max Value = 4)	Driveways & Sidestreets	1
	Ped Signal Delay 40 Sec. Or Less	0.5
	Reduced Turn Conflict Implementation	0.5
	Crossing Width 18.3 (60') or Less	0.5
	Posted Speed	0.5
	Medians Present	1
AMENITIES (Max Value = 2)	Buffer Not Less Than 1 m (3.5')	1
	Benches or Pedestrian Scale Lighting	0.5
	Shade Trees	0.5
MOTOR VEHICLE LOSS (Max Value = 2)	LOS = E, F, OR 6 or More Travel Lanes	0
	LOS = D and < 6 Travel Lanes	1
	LOS = A, B, C and < 6 Travel Lanes	2
MAINTENANCE (Max Value = 2)	Major or Frequent Problems	-1
	Minor or Infrequent Problems	0
	No Problems	2
TDM/MULTIMODAL (Max Value = 1)	No Support	0
	Support Exists	1

TABLE 13: LOS Thresholds for Dixon's Method

LOS	RATING DEFINITION (SUM)
A	$\leq 21 \text{ \& } > 17$
B	$\leq 17 \text{ \& } > 14$
C	$\leq 14 \text{ \& } > 11$
D	$\leq 11 \text{ \& } > 7$
E	$\leq 7 \text{ \& } > 3$
F	< 3

TABLE 14: Illustration For Virginia's 3-D Calibration Method

Characteristic and Points Awarded for Each	Maximum Points Possible	Do Nothing (Base Case)	Add Level Cross-walk	Add Colored Cross-walk	Widen Median, Remove Lane	Widen and Raise Median, Remove Lane	Add Curb Cuts	Make all Geo-metric Changes	Reduce Traffic
Medians Raised Curb Median (6) Delineated Road Level Median (3) Two-Way Left-Turn Lane (2) No Median (1)	6	4 (narrow, raised median)	4	4	5	6	4	6	4
Vehicle Traffic Control Signalized Intersection, Adequate Crossing Time (6) Signalized Intersection, Inadequate Crossing Time (1-3) Unsignalized intersection (0-2)	6	2 (LOS D too little crossing time)	2	2	2	2	2	2	3
Pedestrian Warning Devices Blinking Pedestrian Crossing Signal (3) Non-Blinking Pedestrian Crossing Sign (1) No Warning Device (0)	3	0	0	0	0	0	0	0	0
Crosswalks Raised or Colored Crosswalk (15) Level Crosswalk (10) No Crosswalk (0)	15	0	10	15	0	0	15	15	0
Security Lighting Adequate Lighting (10) Some but Inadequate Lighting (5) No Lighting (0) Significant Business and/or Police Activity (5)	15	2 (no light, no police, some retail)	2	2	2	2	2	2	2
Handicapped Access Ramps Present (15) No Ramps Present (5)	15	5 (no ramps)	5	5	5	5	15	15	5
Speed Limit of Road Crossing ≤ 20 mph (15) 25 or 30 mph (12) 35 or 40 mph (8) ≥ 45 mph (5)	15	5	5	5	5	5	5	5	15
Total Score	75 (A)	18 (D)	28 (D)	33 (C)	19 (D)	20 (D)	28 (D)	41 (C)	29 (D)

Scoring Range: LOS A ≥ 61; LOS B ≥ 46; LOS C ≥ 31; LOS D ≥ 16; LOS E < 16

TABLE 15: Performance Measurements For Community Walkability

Catalog	Condition	Score
Density (persons per square acre, up to centre-line of bordering features)	Over 15	1
	0-15	2
	5-10	3
	fewer than 5	4
Parking places off-street per household (unrestricted street access)	Less than 1	1
	1-2	2
	2-3	3
	more than 3	4
Number of sitting spots on benches per household (include seating in front yards)	More than 0.75	1
	0.5 to 0.75	2
	0.25 to 0.5	3
	0.25 or fewer	4
Chances of meeting someone you now while walking (survey)	10 or more per mile	1
	3-10 per mile	2
	fewer than 3 per mile	3
	“Are you kidding?!”	4
Age at which a child is allowed to walk alone (survey)	Age 6 or younger	1
	Ages 7-9	2
	Ages 10-13	3
	Age 12 or older	4
Women’s rating of neighborhood safety (survey)	“I walk alone anywhere anytime”	1
	“I walk alone, but am careful of routes”	2
	“I must walk with someone at night”	3
	“I never walk, except to car visible from entrance”	4
Responsiveness of transit service	Within ten minutes	1
	10-20 minutes	2
	more than 20 minutes	3
	no service	4
Number of neighborhood “places of significance” (significant to the respondent) named by average respondent (survey)	10 or more	1
	5-10	2
	3-5	3
	fewer than 3	4
Parkland (measurement)	> 50 acres/square mile and average residence	1
	and 50 acres/square mile and average residence	2
	and > 1,500-foot walk	3
	1,500-foot walk	4
Sidewalk (single point each)	Not on both sides of 90% of streets	1
	Dips at each driveway	2
	Widths less than 5 feet on residential streets; 8 feet on shopping streets	3
	More than discontinuity (1” or more) per clock	4

TABLE 16: LOS THRESHOLDS FOR LANDIS'S METHOD

Level of Service	Model Score
A	≤ 1.5
B	$> 1.5 \ \& \ \leq 2.5$
C	$> 2.5 \ \& \ \leq 3.5$
D	$> 3.5 \ \& \ \leq 4.5$
E	$> 4.5 \ \& \ \leq 5.5$
F	> 5.5