# BICYCLE LEVEL OF SERVICE

## Applied Model

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**BACKGROUND**

The statistically-calibrated mathematical equation entitled the *Bicycle Level of Service*[1] *Model (Version 2.0)* is the most accurate method of evaluating the bicycling conditions of shared roadway environments. It uses the same measurable traffic and roadway factors that transportation planners and engineers use for other travel modes. With statistical precision, the *Model* clearly reflects the effect on bicycling suitability or "compatibility" due to factors such as roadway width, bike lane widths and striping combinations, traffic volume, pavement surface conditions, motor vehicles speed and type, and on-street parking.

The *Bicycle LOS Model* is based on the proven research documented in *Transportation Research Record 1578* published by the Transportation Research Board of the National Academy of Sciences. It was developed with a background of over 250,000 miles of evaluated urban, suburban, and rural roads and streets across North America. It has been adopted by the Florida Department of Transportation as the recommended standard methodology for determining existing and anticipated bicycling conditions throughout Florida. Many urbanized area planning agencies and state highway departments are using this established method of evaluating their roadway networks. These include metropolitan areas across North America such as Baltimore MD, Birmingham AL, Philadelphia PA, San Antonio TX, Houston TX, Buffalo NY, Anchorage AK, Lexington KY, and Tampa FL as well as state departments of transportation such as, Delaware Department of Transportation (DelDOT), New York State Department of Transportation (NYDOT), Maine Department of Transportation (MeDOT) and others.

[1] Landis, Bruce W. "Real-Time Human Perceptions: Toward a Bicycle Level of Service" *Transportation Research Record 1578*, Transportation Research Board, Washington DC 1997 (see Appendix A).

Widespread application of the original form of the *Bicycle LOS Model* has provided several refinements. Application of the *Bicycle LOS Model* in the metropolitan area of Philadelphia resulted in the final definition of the three effective width cases for evaluating roadways with on-street parking. Application of the *Bicycle LOS Model* in the rural areas surrounding the greater Buffalo region resulted in refinements to the "low traffic volume roadway width adjustment". A 1997 statistical enhancement to the *Model* (during statewide application in Delaware) resulted in better quantification of the effects of high-speed truck traffic [see the $SP_t(1+10.38HV)^2$ term]. As a result, *Version 2.0* has the highest correlation coefficient ($R^2$ = 0.77) of any form of the *Bicycle LOS Model*.

Version 2.0 of the *Bicycle LOS Model* was employed to evaluate the roads and streets within the Indian River County MPO area. Its form is shown below:

$$\text{Bicycle LOS} = a_1 \ln(Vol_{15}/L_n) + a_2 SP_t(1+10.38HV)^2 + a_3(1/PR_5)^2 + a_4(W_e)^2 + C$$

Where:

$Vol_{15}$ = Volume of directional traffic in 15 minute time period

$$Vol_{15} = (ADT \times D \times K_d) / (4 \times PHF)$$

where:
ADT = Average Daily Traffic on the segment or link
D = Directional Factor
$K_d$ = Peak to Daily Factor
PHF = Peak Hour Factor

$L_n$ = Total number of directional *through* lanes
$SP_t$ = Effective speed limit

$$SP_t = 1.1199 \ln(SP_p - 20) + 0.8103$$

where:
$SP_p$ = Posted speed limit (a surrogate for average running speed)

HV = percentage of heavy vehicles (as defined in the 1994 Highway Capacity Manual)
$PR_5$ = FHWA's five point pavement surface condition rating
$W_e$ = Average effective width of outside through lane:

where:
$W_e = W_v - (10 \text{ ft} \times \% \text{ OSPA})$ and $W_l = 0$
$W_e = W_v + W_l (1 - 2 \times \% \text{ OSPA})$ and $W_l > 0$ & $W_{ps} = 0$
$W_e = W_v + W_l - 2 (10 \times \% \text{ OSPA})$ and $W_l > 0$ & $W_{ps} > 0$ and a bikelane exists

where:
$W_t$ = total width of outside lane (and shoulder) pavement
OSPA = percentage of segment with occupied on-street parking
$W_l$ = width of paving between the outside lane stripe and the edge of pavement
$W_{ps}$ = width of pavement striped for on-street parking
$W_v$ = Effective width as a function of traffic volume

and:
$W_v = W_t$ if ADT > 4,000veh/day
$W_v = W_t(2-0.00025 \times \text{ADT})$ if ADT $\leq$ 4,000veh/day, and if the street/ road is undivided and unstriped

$a_1$: 0.507 $a_2$: 0.199 $a_3$: 7.066 $a_4$: - 0.005 C: 0.760

($a_1$ - $a_4$) are coefficients established by multi-variate regression analysis.

The *Bicycle LOS* score resulting from the final equation is stratified into service categories "A, B, C, D, E, and F" (according to the ranges shown in Table 1) to reflect users' perception of the road segment's level of service for bicycle travel.

**TABLE 1 Bicycle Level-of-Service Categories**

| LEVEL-OF-SERVICE | BLOS SCORE |
|---|---|
| A | $\leq$ 1.5 |
| B | $>$ 1.5 and $\leq$ 2.5 |
| C | $>$ 2.5 and $\leq$ 3.5 |
| D | $>$ 3.5 and $\leq$ 4.5 |
| E | $>$ 4.5 and $\leq$ 5.5 |
| F | $>$ 5.5 |

This stratification is in accordance with the linear scale established during the referenced research (i.e., the research project bicycle participants' aggregate response to roadway and traffic stimuli). The *Model* is particularly responsive to the factors that are statistically significant. An example of its sensitivity to various roadway and traffic conditions is shown in Figure 1.

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Bicycle LOS = $a_1 \ln (Vol_{15}/L_n) + a_2 SP_t(1+10.38HV)^2 + a_3(1/PR_5)^2 + a_4 (W_e)^2 + C$

$a_1$: 0.507 $a_2$: 0.199 $a_3$: 7.066 $a_4$: -0.005 C: 0.760

Baseline inputs:

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ADT | = | 12,000 vpd | % HV | = | 1 | L | = | 2 lanes |
| $SP_p$ | = | 40 mph | $W_e$ | = | 12 ft | $PR_5$ | = | 4 (good pavement) |

| | BLOS | % Change |
|---|---|---|
| Baseline Bicycle LOS Score | 3.98 | N/A |

Lane Width and Lane striping changes (T-statistic = 9.844)

| | | | | |
|---|---|---|---|---|
| $W_t$ | = | 10 ft | 4.20 | 6% increase |
| $W_t$ | = | 11 ft | 4.09 | 3% increase |
| $W_t$ | = | 12 ft - - (baseline) - - - - - - - - - - - - - | 3.98 - - - - | no change |
| $W_t$ | = | 13 ft | 3.85 | 3% reduction |
| $W_t$ | = | 14 ft | 3.72 | 7% reduction |
| $W_t$ | = | 15 ft ( $W_l$ = 3 ft ) | 3.57 (3.08) | 10%(23%) reduction |
| $W_t$ | = | 16 ft ( $W_l$ = 4 ft ) | 3.42 (2.70) | 14%(32%) reduction |
| $W_t$ | = | 17 ft ( $W_l$ = 5 ft ) | 3.25 (2.28) | 18%(43%) reduction |

Traffic Volume (ADT) variations (T-statistic = 5.689)

| | | | | | |
|---|---|---|---|---|---|
| ADT | = | 1,000 | Very Low | 2.75 | 31% decrease |
| ADT | = | 5,000 | Low | 3.54 | 11% decrease |
| ADT | = | 12,000 | Average (baseline) - - - - - - - - | 3.98 - - - - - - | no change |
| ADT | = | 15,000 | High | 4.09 | 3% increase |
| ADT | = | 25,000 | Very High 4.35 | 9% increase | |

Pavement Surface conditions (T-statistic = 4.902)

| | | | | | |
|---|---|---|---|---|---|
| $PR_5$ | = | 2 | Poor | 5.30 | 33% increase |
| $PR_5$ | = | 3 | Fair | 4.32 | 9% reduction |
| $PR_5$ | = | 4 | - - Good - (baselinE) - - - - - | 3.98 - - - - | no change |
| $PR_5$ | = | 5 | Very Good | 3.82 | 4% reduction |

Heavy Vehicles in percentages (Combined speed and heavy vehicles T-statistic = 3.844)

| | | | | | |
|---|---|---|---|---|---|
| HV | = | 0 | No Volume | 3.80 | 5% decrease |
| HV | = | 1 - - - | Very Low - (baseline) - - - - - - | 3.98 - - - - - | no change |
| HV | = | 2 | Low | 4.18 | 5% increase |
| HV | = | 5 | Moderate | 4.88 | 23% increase[a] |
| HV | = | 10 | High | 6.42 | 61% increase[a] |
| HV | = | 15 | Very High | 8.39 | 111% increase[a] |

[a]Outside the variable's range (see Reference *(1)*)

**Figure 1: Bicycle LOS Model Sensitivity Analysis**

## Data Collection / Inventory Guidelines

Following is the list of data required for computation of the *Bicycle LOS* scores as well as the associated guidelines for their collection and compilation into a programmed database.

*Average Daily Traffic (ADT)*

ADT is the average daily traffic volume on the segment or link. The programmed database will convert these volumes to $Vol_{15}$ (volume of directional traffic every fifteen minutes) using the Directional Factor (D), Peak to Daily Factor ($K_d$) and Peak Hour Factor (PHF) for the road segment.

*Percent Heavy Vehicles (HV)*

Percent HV is the percentage of heavy vehicles (as defined in the *2000 Highway Capacity Manual*).

*Number of lanes of traffic (L)*

L reflects the total number of *through* traffic lanes of the road segment and its configuration. (e.g., D = Divided, U = Undivided, OW = One-Way, S = Center Turning Lane). The programmed database will convert these lanes into directional lanes. The presence of continuous right-turn lanes should be noted in the comments field. In the other direction it will be noted in the comments if there is a different number of through lanes.

*Posted Speed Limit ($S_p$)*

$S_p$ is recorded as posted.

*$W_t$ total width of pavement*

$W_t$ is measured from the center of the road, yellow stripe, or (in the case of a multilane configuration) the lane separation striping to the edge of pavement or to the gutter pan of the curb. When there is angled parking adjacent to the outside lane, $W_t$ is measured to the traffic-side end of the parking stall stripes.

*Width of pavement is the pavement striped for on-street parking ($W_{ps}$)*

$W_{ps}$ is recorded only if there is parking to the right of a striped bike lane. If there is parking on two sides on a one-way, single lane street, $W_{ps}$ is reported as the combined width of the striped parking.

*Width of paving between the outside lane stripe and the edge of pavement ($W_l$)*

$W_l$ is measured from the outside lane stripe to the edge of pavement or to the gutter pan of the curb. When there is angled parking adjacent to the outside lane, $W_l$ is measured from the outside lane stripe to the traffic-side end of the parking stall stripes.

*OSPA %*

OSPA% is the estimated percentage of the segment (excluding driveways) along which there is occupied on-street parking at the time of survey. Record each side separately. If the parking is allowed only during off-peak periods and parking restrictions change widths and laneage, indicate the geometric changes in the comments field. Note: Indicate any “angled parking” in the comments field.

*Pavement Condition (PC)*

PC is the pavement condition of the motor vehicle travel lane according to the FHWA’s five-point pavement surface condition rating shown below in Figure 2.

*Designated Bike Lane*

A “Y” is coded if there is a bike lane on the segment, otherwise “N” is entered.

*Comments*

If there is any noticeable difference in the above parameters between two directions (north/south or east/west) on a roadway segment, the data will be recorded for the other direction in the comments field along with the direction. All special conditions and assumptions made during the data collection on the segment will be reported in the comments field.

| RATING | PAVEMENT CONDITION |
|---|---|
| 5.0 (Very Good) | Only new or nearly new pavements are likely to be smooth enough and free of cracks and patches to qualify for this category. |
| 4.0 (Good) | Pavement, although not as smooth as described above, gives a first class ride and exhibits signs of surface deterioration |
| 3.0 (Fair) | Riding qualities are noticeably inferior to those above; may be barely tolerable for high-speed traffic. Defects may include rutting, map cracking, and extensive patching. |
| 2.0 (Poor) | Pavements have deteriorated to such an extent that they affect the speed of free-flow traffic. Flexible pavement has distress over 50 percent or more of the surface. Rigid pavement distress includes joint spalling, patching, etc. |
| 1.0 (Very Poor) | Pavements that are in an extremely deteriorated condition. Distress occurs over 75 percent or more of the surface. |

Source: U.S. Department of Transportation. Highway Performance Monitoring System-Field Manual. Federal Highway Administration. Washington, DC, 1987.

**Figure 2: Pavement Condition Description**