Traffic Analysis at Signalized Intersections

3

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Signalized Intersection
Level of Service
Introduction

Level of service (LOS) is a qualitative assessment of facility operations based upon a quantitative performance measure.

The performance measure that is used to assess level of service for signalized intersections is average control delay per vehicle.
Introduction

- Analysis Procedure (assuming phasing, cycle length, and effective green times have already been determined)
  - Calculate Capacities
  - Calculate Delay
  - Determine Level of Service (LOS)
Calculate Lane Group Capacities (c)

\[ c = s \times \frac{g}{C} \]

Where:

- \( s \) = adjusted saturation flow rate
- \( \frac{g}{C} \) = eff. green to cycle length ratio
Determining Delay

Average control delay per vehicle

\[ d = (d_1 \times PF) + d_2 + d_3 \]

Where:
\( d \) = average signal delay per vehicle in seconds,
\( d_1 \) = average delay per vehicle due to uniform arrivals in seconds,
PF = progression adjustment factor,
\( d_2 \) = average delay per vehicle due to random arrivals in seconds, and
\( d_3 \) = average delay per vehicle due to initial queue at start of analysis time period, in seconds.
Uniform Delay

\[ d_1 = \frac{0.5C \left( 1 - \frac{g}{C} \right)^2}{1 - \left[ \min(1, X) \frac{g}{C} \right]} \]

Where:
\( d_1 \) = average delay per vehicle due to uniform arrivals in seconds,
\( C \) = cycle length in seconds,
\( g \) = effective green time for lane group in seconds, and
\( X \) = volume/capacity (v/c) ratio for lane group.
Random Delay

\[ d_2 = 900T \left[ (X - 1) + \sqrt{(X - 1)^2 + \frac{8kIX}{cT}} \right] \]

Where:
- \( d_2 \) = average delay per vehicle due to random arrivals in seconds,
- \( T \) = duration of analysis period in h,
- \( X \) = v/c ratio for lane group,
- \( k \) = delay adjustment factor that is dependent on signal controller mode,
- \( I \) = upstream filtering/metering adjustment factor, and
- \( c \) = lane group capacity, in veh/h.
Delay Calculation Assumptions

For problems in class, all intersections are assumed to be isolated, under pretimed control, and have no initial queue at beginning of analysis period; thus:

- $d_3 \rightarrow 0$
- $PF \rightarrow 1.0$
- $k \rightarrow 0.5$
- $I \rightarrow 1.0$
Determining Delay

Aggregating Delays

\[
d_A = \frac{\sum_i d_i v_i}{\sum_i v_i}
\]

\[
d_I = \frac{\sum_A d_A v_A}{\sum_A v_A}
\]

Where:

- \(d_A\) = average delay per vehicle for approach A in seconds,
- \(d_i\) = average delay per vehicle for lane group i (on approach A) in seconds, and
- \(v_i\) = analysis flow rate for lane group i in veh/h.

Where:

- \(d_I\) = average delay per vehicle for the intersection in seconds,
- \(d_A\) = average delay per vehicle for approach A in seconds, and
- \(v_A\) = analysis flow rate for approach A in veh/h.

Eq. 7.27
Eq. 7.28
## Level of Service

<table>
<thead>
<tr>
<th>LOS</th>
<th>Control Delay per Vehicle (s/veh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>≤ 10</td>
</tr>
<tr>
<td>B</td>
<td>&gt; 10-20</td>
</tr>
<tr>
<td>C</td>
<td>&gt; 20-35</td>
</tr>
<tr>
<td>D</td>
<td>&gt; 35-55</td>
</tr>
<tr>
<td>E</td>
<td>&gt; 55-80</td>
</tr>
<tr>
<td>F</td>
<td>&gt; 80</td>
</tr>
</tbody>
</table>
Example

Φ1: Effective Green = 17
Φ2: Effective Green = 34
Φ3: Effective Green = 22

C = 85 s

analysis flow rate $v_{EB-LT} = 300$

Note $300/1750 = .171$
Determine Delays & LOS

Calculate EB approach delay

Left turn lane group

\[ \frac{g}{C} = \frac{17}{85} = 0.2 \]

\[ c = s \times \frac{g}{C} = 1750 \times 0.2 = 350 \text{ veh/hr (capacity)} \]

\[ X = \frac{v}{c} = \frac{300}{350} = 0.8572 \]

Uniform Delay

\[ d_1 = 0.5C\left(1 - \frac{g}{C}\right)^2 \]

\[ d_1 = \frac{0.5(85)(1 - 0.2)^2}{1 - [0.8572 \times 0.2]} = 32.8 \text{ sec} \]
Determine Delays & LOS

Random Delay

With:

\[ T = 0.25 \text{ (15 min)} \]
\[ X = 0.857 \text{ (from above)} \]
\[ k = 0.5 \text{ (pretimed control)} \]
\[ I = 1.0 \text{ (isolated mode)} \]
\[ c = 350 \text{ veh/h (from above)} \]

\[
d_2 = 900T \left[ (X - 1) + \sqrt{(X - 1)^2 + \frac{8kIX}{cT}} \right]
\]

\[
d_2 = 900(0.25) \left[ (0.857 - 1) + \sqrt{(0.857 - 1)^2 + \frac{8(0.5)(1.0)(0.857)}{(350)(0.25)}} \right] = 22.76\text{sec}
\]
Determine Delays & LOS

Total Delay

With PF = 1.0 (for isolated signal)

\[ d = (d_1 \times PF) + d_2 + d_3 \]

\[ d_{EB\_LT} = 32.8 \times 1.0 + 22.76 + 0 = 55.56 \text{ sec} \]

Level of Service: D
Questions

- Questions?
Abbreviations
Key Terms
Variables