Traffic Analysis at Signalized Intersections 3

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(based on notes by Henry Liu University of Minnesota)

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)

$$c = s \times g/C$$

Where:

s = adjusted saturation flow rate
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

$$d_A = \frac{\sum_i d_i v_i}{\sum_i v_i} \qquad d_I = \frac{\sum_A d_A v_A}{\sum_A v_A}$$

Eq. 7.27

Eq. 7.28

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,

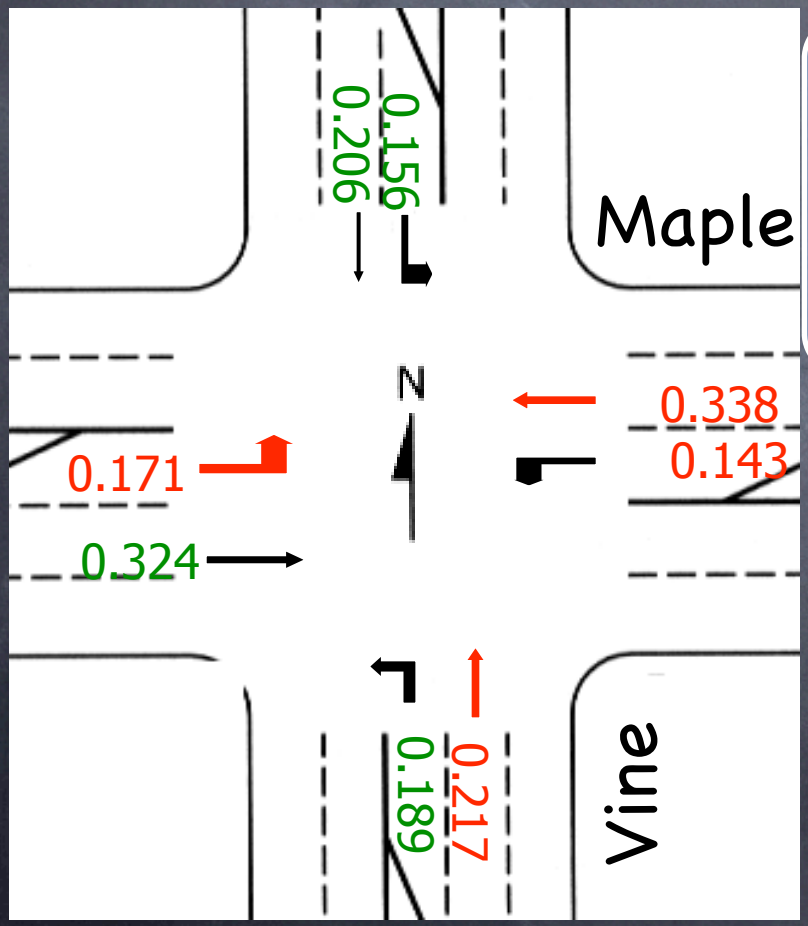
d_A = average delay per vehicle for approach A in seconds, and

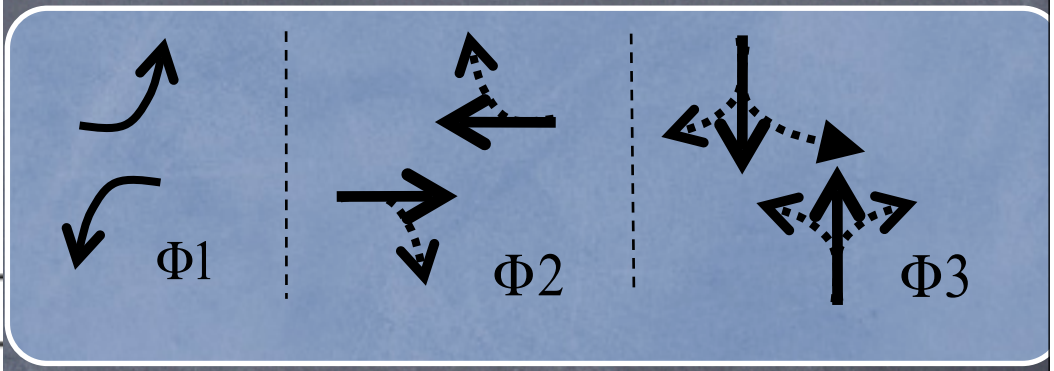
v_A = analysis flow rate for approach A in veh/h.

Level of Service

LOS	Control Delay per Vehicle (s/veh)
A	≤ 10
B	> 10-20
C	> 20-35
D	> 35-55
E	> 55-80
F	> 80

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

g/C = 17/85 = 0.2

c = s × g/C = 1750 × 0.2 = 350 veh/hr (capacity)

X = v/c = 300/350 = 0.8572

Uniform Delay

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

$$d_1 = \frac{0.5(85)(1-0.2)^2}{1-[0.8572\times.2]} = 32.8 \text{ sec}$$

Determine Delays & LOS

Random Delay

With:

T = 0.25 (15 min)

X = 0.857 (from above)

k = 0.5 (pretimed control)

I = 1.0 (isolated mode)

c = 350 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