

CE474: Traffic Systems Design-Fall 2004

Class 3 – Traffic flow models at intersections
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Design Project 1 – Project Requirements

- ◆ Design report 1 is due at the beginning of class on September 14th
- ◆ The report must be no longer than 20 pages, including all text, figures, and tables.
- ◆ The report should clearly describe the design alternatives that you considered (the range of values that you considered for each parameter), the results of the analysis of the alternatives, your final design parameters, and why you selected your final design parameters.
- ◆ The report should also include all supporting information including figures, tables, and computations.

Project Requirements (cont.)

- You will be responsible for developing the optimal signal timing for the intersection given a set of future (projected) traffic volumes. You should clearly define what you mean by an "optimal" signal timing plan.
- You may consider changes to lane configuration or alignment as long as your design remains within the existing curb-to-curb right of way.
- The signal timing design will include the following parameters: (1) phasing plan, (2) cycle length, (3) green splits, (4) pedestrian phase lengths, (5) yellow time, (6) all-red time.

Project Requirements (cont.)

- ◆ You should define a set of phasing plans and a range of timing parameters that are appropriate to be considered as alternatives for your intersection.
- ◆ You should conduct your analysis of the design alternatives using the Highway Capacity Software and the CORSIM simulation model.
- ◆ Average control delay per vehicle, volume/capacity ratio, and queue length should be used as your measures of effectiveness in optimizing your design.

What happens if one or more design parameters were not designed appropriately?

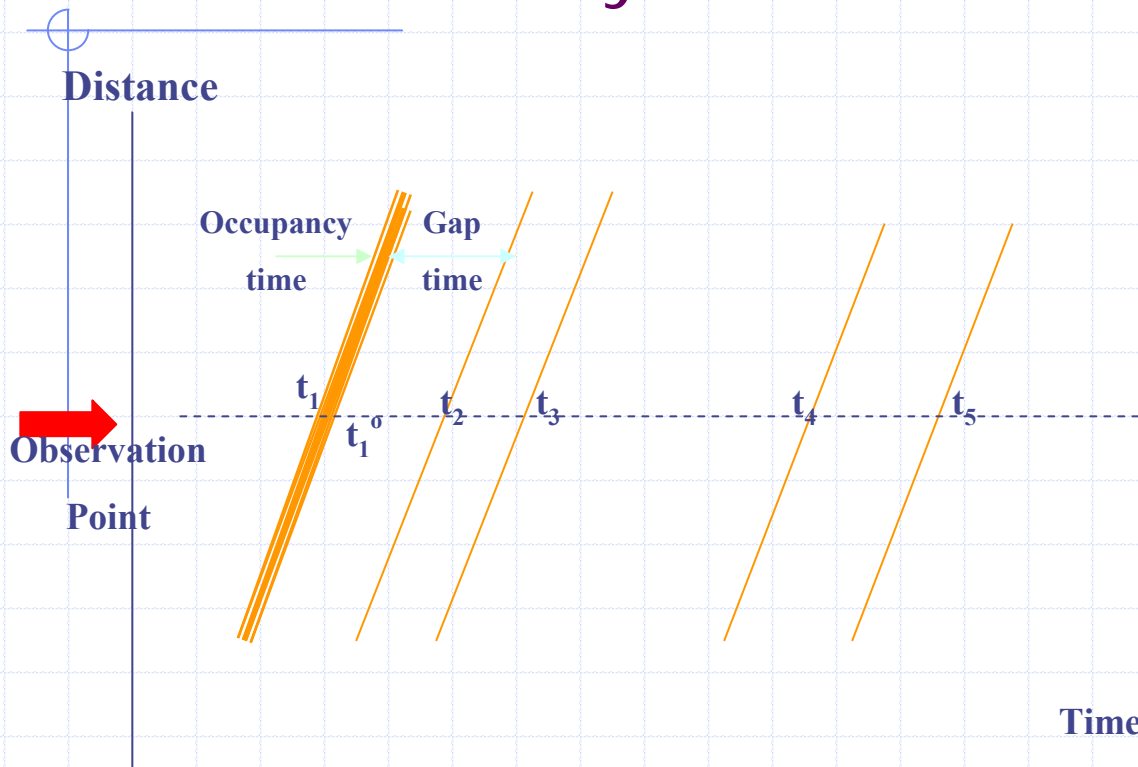


Today's objectives

- ◆ Apply principal traffic flow theories at signalized intersections
- ◆ Interrupted Flow Applications
 - Signalized intersections
 - Unsignalized intersections
 - Stop-an-go operation
- ◆ Traffic Flow Theories
 - Arrival/departure Headway distribution
 - Deterministic/stochastic queuing theories
 - Queue forming Polygons

Microscopic Flow Characteristics

Time Headway - Definition

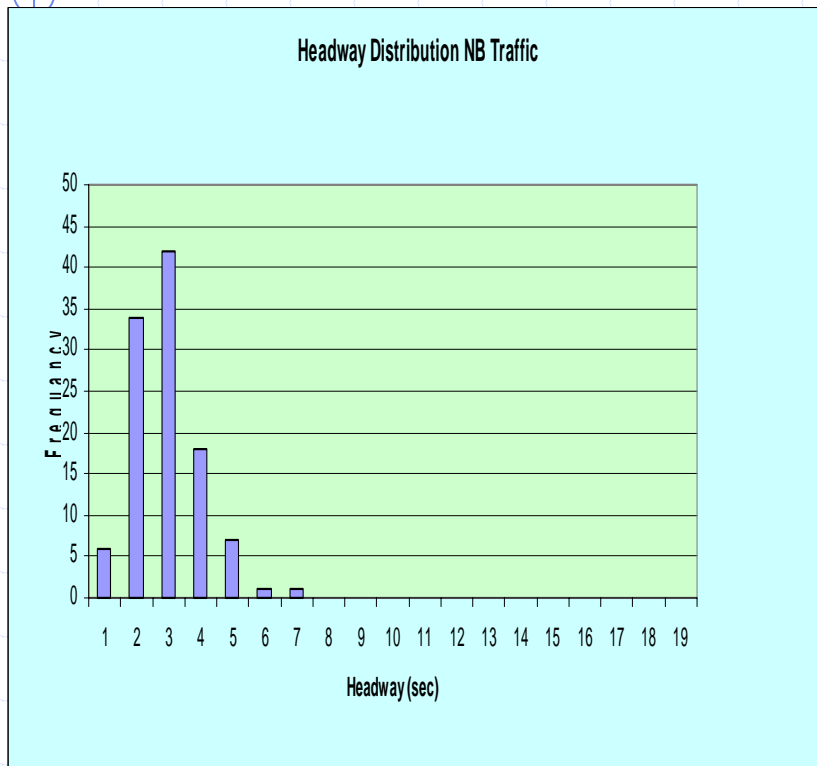


$T_1^0 - T_1 = \text{occupancy time for vehicle (1)}$

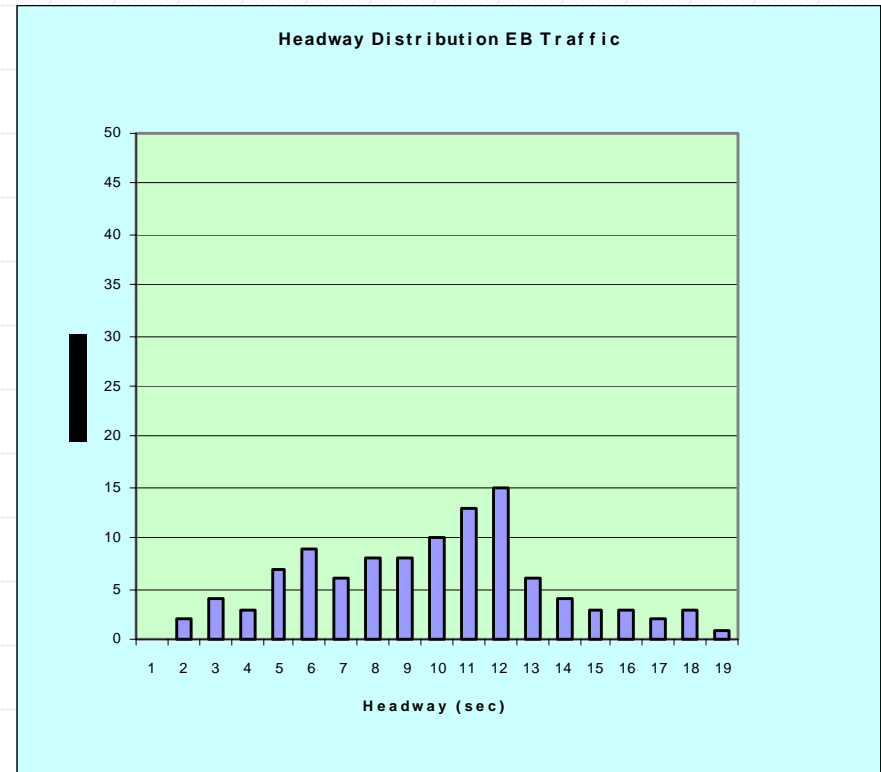
$(h)_{1-2} = t_2 - t_1, \quad (h)_{2-3} = t_3 - t_2, \quad (h)_{3-4} = T_4 - T_3, \text{ etc}$

Microscopic Flow Characteristics

Time Headway - Distribution



**Headway Distribution
Northbound Traffic**



**Headway Distribution
Eastbound Traffic**

Time Headway Distribution Studies

◆ Capacity:

- Gap acceptance at unsignalized intersection
- Permitted left-turn movements

◆ Safety

- Human factors and gap acceptance

◆ What happens if a headway was misjudged?

Microscopic Flow Characteristics

Time Headway - Classification

◆ Random Headway State

(Negative Exponential-Poisson count Distribution)

◆ Constant Headway State

(Normal Distribution)

◆ Intermediate Headway State

(Pearson type II, Gamma, Erlang, Negative Exponential ,
shifted Negative Exponential)

Microscopic Flow Characteristics

Random Headway State-Poisson Distribution

$$P(x) = \frac{m^x e^{-m}}{x!}$$

$P(x)$ = Probability that exactly x number of events occur [time interval (t)]

m = Average number of events [time interval (t)]

e = Napierian base of logarithms ($e=2.71828$)

Examples of using Poisson Distribution

- On an intersection approach with a left turn volume of 120 vph. (Poisson), what is the probability of skipping the green phase for the left turn traffic if you have an actuated signal and a 90 seconds cycle?

m = Average number of left turn vehicles per Cycle

number of cycles per hour = $3600/90 = 40$

m = $120 \text{ vph} / 40 = 3 \text{ vehicles/cycle}$

$$P(x) = \frac{m^x e^{-m}}{x!}$$

Probability of $x = 0$

$P(0) = 0.049787 = 4.9 \% (1.96 \text{ cycles/hours})$

Examples of using Poisson Distribution

An intersection is controlled by a fixed time signal having a cycle length of 55 seconds. From the northbound, there is a permitted left turn movement of 175 vph. If two vehicles can turn each cycle without causing delay, on what percent of the cycles will delay occur?

$m =$ Average number of left turn vehicles per Cycle

number of cycles per hour = $3600/55 = 65.46$

$m = 175 \text{ vph} / 65.46 = 2.67 \text{ LT vehicles/cycle}$

Probability of $x > 2$

$$P(x) = \frac{m^x e^{-m}}{x!}$$

$$P(x > 2) = 1 - [P(0) + P(1) + P(2)]$$

$$= 1 - [0.069 + 0.185 + 0.247] = 49.9\% [32.67 \text{ Cycles/hour}]$$

Constant Headway State-Normal Distribution

Mean time headway (h) = $3600/V$

Normal distribution with mean (μ) and standard deviation s

95% confidence interval in the range ($\mu \pm 2s$)

Minimum headway (α) = $\mu - 2s$ or = $\bar{t} - 2s$

Then $s = (h - \alpha)/2$

Constant Headway State-Normal Distribution

Normal Distribution:

To get the probability $P (A \leq X < B)$

$$Z = (B - A)$$

From the table using the value (Z/S)

Constant Headway State-Normal Distribution

Example: $V = 2000$ vph

$$\bar{t} = 3600/2000 = 1.8 \text{ seconds}$$

Assuming a minimum headway of 0.6 seconds

$$s = (1.8 - 0.6)/2 = 0.6$$

Constant Headway State-Normal Distribution

To obtain the probability: $P(1.0 \leq h < \bar{t})$

$$Z = 1.8 - 1.0 = 0.8$$

$$Z/s = 0.8 / 0.6 = 1.333$$

$$P(1.0 \leq h < 1.8) = 0.408$$

40.8% of the headway between the mean headway and 1.0 second

Intermediate Headway State

- ◆ Generalized Mathematical Model Approach
- ◆ Composite Model Approach
- ◆ Other Approaches