CIVL - 7904/8904

TRAFFIC FLOW THEORY

LECTURE -3

Agenda for Today

- Last lecture review
- Fundamentals on headway
- Single and multi regime models
- In class discussion
- Text Book Example

Example

- For the following data on speed and density, determine the parameters of the Greenshields' model. Also find the maximum flow and density corresponding to a speed of 30 km/hr.

k	v
171	5
129	15
20	40
70	25

Model Calibration (1)

x(k)	y(v)	$x_i - \bar{x}$	$y_i - \bar{y}$	$x_i - \bar{x} * y_i - \bar{y}$	$x_i - \bar{x}^2$
171	5	73.5	-16.3	-1198.1	5402.3
129	15	31.5	-6.3	-198.5	992.3
20	40	-77.5	18.7	-1449.3	6006.3
70	25	-27.5	3.7	-101.8	756.3
390	85			-2947.7	13157.2

$$u = 40.8 - 0.2k$$

$$\overline{x} = \frac{390}{4} = 97.5$$

$$\overline{y} = \frac{85}{4} = 21.3$$

b= -2947.7/13157.2 = -0.2

a = y-bx = 40.8

Model Calibration (2)

$$u_f = 40.8\ kph;\ k_j = \frac{40.8}{0.2} = 204\ veh/km$$

$$q_{max} = \frac{40.8 * 204}{4} = 2080.8$$

k @ 30kph; k=(40.8-30)/0.2 = 54veh/km

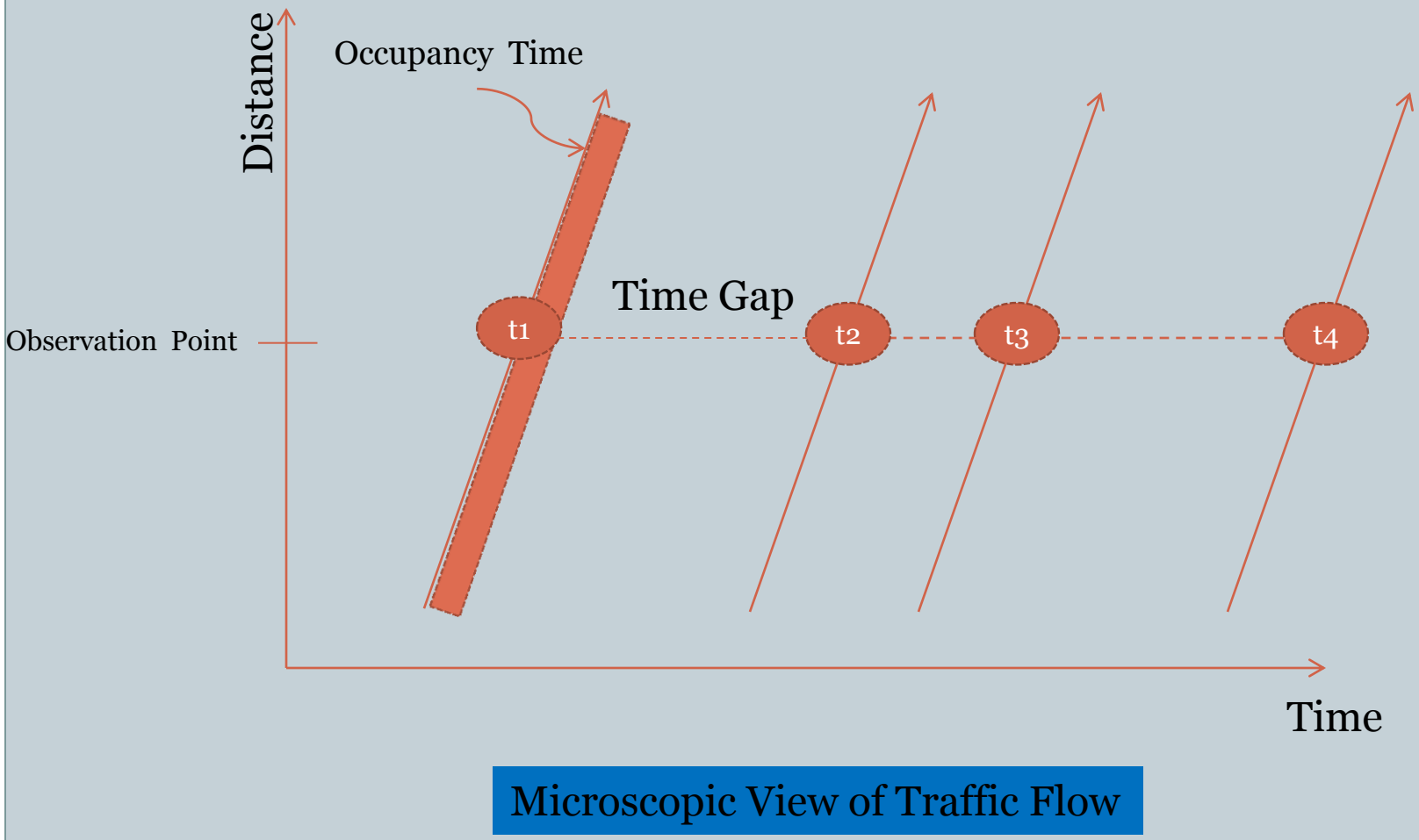
Microscopic Flow Characteristics

- Time headway between vehicles in crucial as it affects
  - Driver behavior
  - Level of service
  - Capacity
  - Safety
- A minimum time headway must be present to provide safety in the event that the lead vehicle suddenly decelerates

Microscopic Flow Characteristics

- The percentage of time that the following vehicle must follow the lead vehicle is an indication of level of service.
- The capacity of the system is governed by
  - minimum time headway and
  - its distribution
- For these reasons it is imperative that designer and operational manager have theoretical knowledge of
  - time headway and
  - its distribution

Time Headways



Microscopic View of Traffic Flow

Time Headways

- Time headway can be represented as
- $h_{1-2} = t_2 - t_1$
- $h_{2-3} = t_3 - t_2$
- ….
- Headway consists of two intervals
- Occupancy time
  - The physical vehicle to pass the observation point
- Time Gap
  - Rear end of the lead vehicle and front end of the following vehicle

Time Headways

- In theory an individual time headway does not necessarily have to be the elapsed time
  - From the passage of the leading edges of two consecutive vehicles
  - But only the elapsed time between passage of identical points on two consecutive vehicles
- However, in practice the leading edges are used whether the measurements are taken automatically by detectors or manually by observers

Time Headway Distributions

- An observer could continue to record individual time headways at a specific location for periods of time representing different flow situations.
- Then the individual time headways for each flow situations could be sorted into time headway distributions for four traffic levels
  - 10-14 veh/min
  - 15-19 veh/min
  - 20-24 veh/min
  - 25-29 veh/min

- See Fig. 2.2 in text

Headway Distribution-Observation

- Vertical scale
  - Minute flow rate on vertical scale
  - Four measured time headway distributions are positioned in this scale at their average minute flow rate values
- Horizontal scale
  - Time headway in seconds
  - Each of the four distributions is plotted on this scale based on 0.5 sec time headway intervals

- The height of the shaded areas represent the proportion of observed headway between each 0.5 sec headway interval.
- There are two sets of contour lines superimposed on top of the headway distributions which represents the mean time headway and cumulative percentage headways for (percentages)
  - 1
  - 15
  - 33
  - 50
  - 67
  - 85
  - 99
- The data set contains a 14,570 individual measured time headways

Important Observations

- Individual time headways are rarely less than 0.5 sec
- Individual time headways are rarely over 10 sec unless the minute flow rate is below 15 veh/min
- The time headway
  - mode <median<mean
  - They tend to converge as minute flow rate increases toward capacity

Important Observations

- The mean time headway always tracks the 67 cumulative percentile curve for the entire minute flow range
- The ratio of std dev/mean
  - approaches 1 under low flow conditions
  - But decreases as the minute flow rate increases

Type of Headway Distributions

- Random: Very low flow conditions
- Constant: Saturated conditions
- Intermediate: Transitional flow conditions

Random Headway State

- -ve exponential distribution represents the distribution of random intervals such as time headways
- Two conditions must be met
  - Vehicle can arrive at any point
  - Arrival of any vehicle at any point does not depend on arrival of any other vehicle
- -ve expontial distribution can be derived from poisson
  - -ve exponential is an interval distribution
  - Poisson is a count data distribution

Poisson Distribution Model

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

- *P(x)*-> probability of exacting x vehicle arriving in a time interval t
- *m*-> average number of vehicles arriving at time interval t
- *e*-> Napier's constant
- *t*-> selected time interval
- *x*-> number of vehicles arriving in a time interval being investigated

Poisson Distribution

- How do we know the form?
- How is it related to negative exponential distribution