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.

<table>
<thead>
<tr>
<th>k</th>
<th>v</th>
</tr>
</thead>
<tbody>
<tr>
<td>171</td>
<td>5</td>
</tr>
<tr>
<td>129</td>
<td>15</td>
</tr>
<tr>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>70</td>
<td>25</td>
</tr>
</tbody>
</table>
Model Calibration (1)

<table>
<thead>
<tr>
<th>x(k)</th>
<th>y(v)</th>
<th>$x_i - \bar{x}$</th>
<th>$y_i - \bar{y}$</th>
<th>$x_i - \bar{x}*y_i - \bar{y}$</th>
<th>$x_i - \bar{x}^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>171</td>
<td>5</td>
<td>73.5</td>
<td>-16.3</td>
<td>-1198.1</td>
<td>5402.3</td>
</tr>
<tr>
<td>129</td>
<td>15</td>
<td>31.5</td>
<td>-6.3</td>
<td>-198.5</td>
<td>992.3</td>
</tr>
<tr>
<td>20</td>
<td>40</td>
<td>-77.5</td>
<td>18.7</td>
<td>-1449.3</td>
<td>6006.3</td>
</tr>
<tr>
<td>70</td>
<td>25</td>
<td>-27.5</td>
<td>3.7</td>
<td>-101.8</td>
<td>756.3</td>
</tr>
<tr>
<td>390</td>
<td>85</td>
<td></td>
<td></td>
<td>-2947.7</td>
<td>13157.2</td>
</tr>
</tbody>
</table>

\[ u = 40.8 - 0.2k \]

\[ \bar{x} = \frac{390}{4} = 97.5 \]

\[ \bar{y} = \frac{85}{4} = 21.3 \]

\[ b = \frac{-2947.7}{13157.2} = -0.2 \]

\[ a = y - bx = 40.8 \]
Model Calibration (2)

\[ u_f = 40.8 \text{ kph}; \quad k_j = \frac{40.8}{0.2} = 204 \text{ veh/km} \]

\[ q_{max} = \frac{40.8 \times 204}{4} = 2080.8 \]

\[ k \text{ @ 30kph}; \quad k = \frac{(40.8-30)}{0.2} = 54 \text{ veh/km} \]
Microscopic Flow Characteristics

- Time headway between vehicles is 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
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
• **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 exponential 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?