Fundamental parameters of traffic flow

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Overview

• What is traffic engineering
• How can the traffic be described?
• What are the fundamental parameters of traffic
Introduction

• **Traffic flow**
  – Complex movements
  – Stochastic in nature

• **Traffic Engineering**
  – Mange traffic facilities
  – Means: by modeling
    • Driver, Vehicle,
    • Road, & their interactions
Traffic stream parameters

- Traffic characterization
  - Efforts to describe traffic
  - Measurable parameters from field

- Parameters
  - Quantitative (for modeling)
  - Qualitative (for evaluation)

- Characteristics
  - Macroscopic
  - Microscopic
Traffic stream parameters

• Fundamental parameters
  – Speed
  – Flow
  – Density

• Derived parameters
  – Time headway
  – Space headway
  – Travel time
Speed

• A quality measurement of travel
  – Drivers and passengers perception of journey
  – Rate of motion in distance per unit of time
  – Speed or velocity is given by

\[ v = \frac{d}{t} \]

– where

  • \( v \) is the speed of the vehicle in m/s
  • \( d \) is the distance traveled in meters
  • \( t \) time in seconds
Speed

• Various types
  – Spot speed
  – Running speed
  – Journey speed
  – Time mean speed
  – Space mean speed
• **Spot Speed**
  
  – Instantaneous speed at a point
  
  – Application:
    • Geometrical design
    • Location and size of signs
    • Design of signals
    • Safe speed
    • Speed zoning
    • Accident analysis
    • Congestion analysis
Speed

• **Spot Speed measurement**
  – Enoscope
  – Pressure contact tubes
  – Radar speedometer
  – Time-lapse photography
  – Video image processing
Speed

- **Running speed**
  - Average speed over a stretch of road
  - Does not consider stop time
  - Takes care of variability in traffic and geometric conditions
Speed

• **Journey speed**
  – Effective speed between two points
  – Journey speed < Running speed
    • journey follows a stop-go traffic
  – Journey speed ≈ Running speed
    • comfortable travel conditions.
Time and space mean speeds

- **Time mean speed** $v_t$

- **Space mean speed** $v_s$
Time and space mean speeds

- **Time mean speed** $v_t$
  - Average speed of all the vehicles passing a point on a highway over time period
  - Mean speed of vehicles over a period of time at a point in space
  - Point measurement
Time and space mean speeds

- **Space mean speed** $v_s$
  - Average speed of all the vehicles in a given section of a highway at a given time instant
  - Mean speed over a space at an instant

- **Relationship**
  - $v_t \neq v_s$ normal traffic
  - $v_t = v_s$ if all vehicles have same speed
Flow

• Definition

– Number of vehicles that pass a point on a road during a specific time interval

\[ q = \frac{n_t}{t} \]

– \( n_t \) no. of vehicles passing a road section
– \( t \) time duration in hours
– \( q \) the flow vehicles/hour
Flow

- **Temporal variations**
  - Monthly
  - Weekly
  - Daily
  - Hourly

- **Units**
  - Vehicle/day
  - Vehicle/hour
  - Vehicle/second
Flow

• **Type of averaging**
  – Average Annual Daily Traffic (AADT)
  – Average Annual Weekday Traffic (AAWT)
  – Average Daily Traffic (ADT)
  – Average Weekday Traffic (AWT)
Flow

- **Average Annual Daily Traffic (AADT)**
  - The average 24-hour traffic volume at a given location over a full 365-day year
  - Total number of vehicles passing the site in a year divided by 365
Flow

• **Average Annual Weekday Traffic (AAWT)**
  – The average 24-hour traffic volume occurring on weekdays over a full year
  – It is computed by dividing the total weekday traffic volume for the year by 260
Flow

• **Average Daily Traffic (ADT)**
  – An average 24-hour traffic volume at a given location for a period of time less than a year
    • Six months or a season
    • A month or week
  – ADT is a valid only for the period over which it was measured
Flow

- **Average Weekday Traffic (AWT)**
  - Average 24-hour traffic volume occurring on weekdays for some period of time less than one year
    - Six months or a season
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Flow

- **Measurements**
  - manual counting
  - detector/sensor counting
  - moving-car observer method
Density

- **Definition**
  - Number of vehicles occupying a given stretch of road expressed as vehicles per km
    \[ k = \frac{n_x}{x} \]
  - \( n_x \) number of vehicles in the stretch
  - \( x \) distance in km
  - \( k \) flow vehicles/km
Density

• **Importance**
  – Most perceived parameter by a driver
  – One of the level of service concept
  – Used in most of the traffic flow models
Derived parameters

- **Derived parameters**
  - Time headway or headway
    - related to flow
  - Distance headway or spacing
    - related to density
  - Travel time
    - related to speed
Derived parameters

- **Time headway**
  - Time difference between any two successive vehicles when they cross a given point
  - Adding all headways $\sum_{i=1}^{n_t} h_i = t$

- But flow is defined as
  \[ q = \frac{n_t}{t} = \frac{n_t}{\sum_{i=1}^{n_t} h_i} = \frac{1}{h_{av}} \]

- Av. Headway = Inverse of flow
  \[ h_{av} = \frac{1}{q} \]
Derived parameters

• **Distance headway**
  - Distance between corresponding points of two successive vehicles at any given time
  - Adding all the spacing \[ \sum_{i=1}^{n_x} s_i = x \]
  - But density is defined as \[ k = \frac{n_x}{x} = \frac{n_x}{\sum_{i=1}^{n_x} s_i} = \frac{1}{s_{av}} \]
  - Av. Spacing = Inverse of density \[ s_{av} = \frac{1}{k} \]
Derived parameters

• **Travel time**
  
  – Inversely proportional to the speed
  
  – In practice, the speed of a vehicle fluctuates over time and the travel time represents an average measure
Time-space diagram

• **Trajectory**
  – A graph which gives position of vehicle with respect to time
  – The trajectory provide an intuitive, clear, and complete summary of vehicular motion in one dimension.
Time-space diagram

• Single vehicle
Time-space diagram

Distance (x) vs. Time (t)

- $x_1$
- $x_2$

Formula:

$$k = \frac{5}{x_1 - x_2}$$
Time-space diagram

\[ q = \frac{4}{(t_2-t_1)} \]
Time-space diagram

Distance (x) vs. Time (t)

Spacing (S) and Headway (h)
Conclusion

• **Fundamental Parameters**
  – Flow or volume $q$
  – Density or concentration $k$
  – Speed: Time and Space mean $v_s$ and $v_t$

• **Derived Parameters**
  – Headway $h$
  – Spacing $s$
  – Travel time $t$

• **Time-Space diagram**
Thank You

Questions?