Introduction to Infrastructural Engineering

Introduction to Traffic Engineering

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Outlines

1. **Basic Concepts**
   a. **Flow Rate**
   b. **Spacing**
   c. **Headway**
   d. **Speed**
   e. **Density**
2. **Relationships**
3. **Example**

Flow Rate (q)

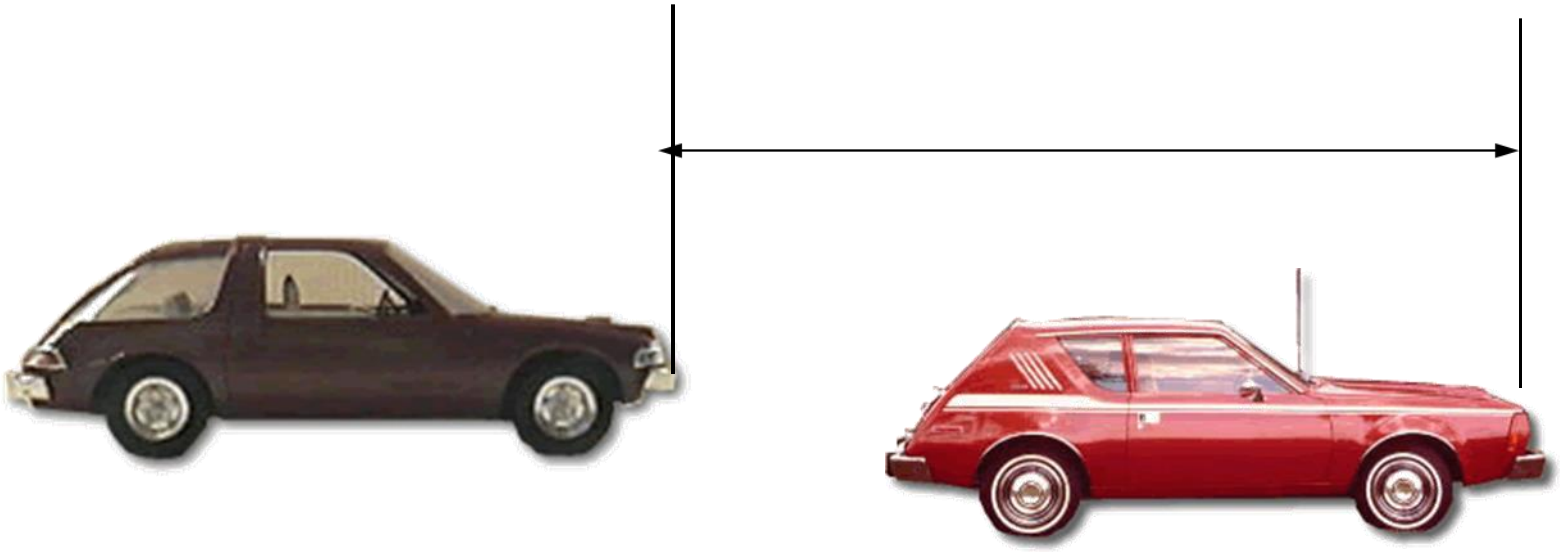
- **The number of vehicles (n) passing some designated roadway point in a given time interval (t)**

$$q = \frac{n}{t}$$

- **Units are typically vehicles/hour**
- **Flow rate is different than volume**

Spacing

- **The distance (ft) between successive vehicles in a traffic stream, as measured from front bumper to front bumper**



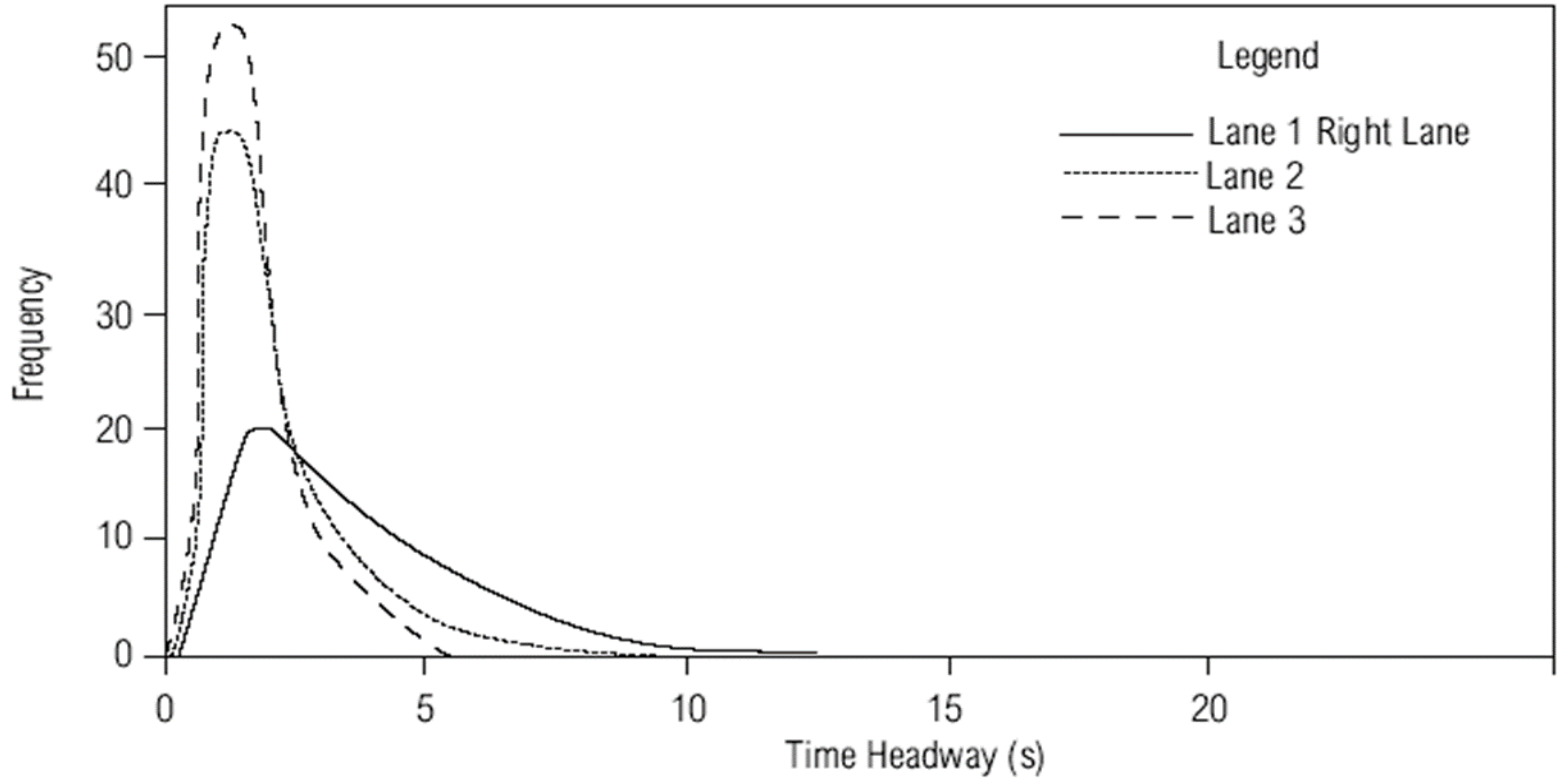
Headway (h)

- **The time (in seconds) between successive vehicles, as their front bumpers pass a given point.**

$$t = \sum_{i=1}^{n} h_i \qquad q = \frac{n}{\sum_{i=1}^{n} h_i} = \frac{1}{\overline{h}}$$

Headway

EXHIBIT 8-28. TIME HEADWAY DISTRIBUTION FOR LONG ISLAND EXPRESSWAY



Source: Berry and Gandhi (*13*).

Speed

- **Time mean speed (spot speed)**
  - **Arithmetic mean of all instantaneous vehicle speeds at a given "spot" on a roadway section**
- **Space mean speed (u)**
  - **The mean travel speed of vehicles traversing a roadway segment of a known distance (d)**
  - **More useful for traffic applications**

Space Mean Speed

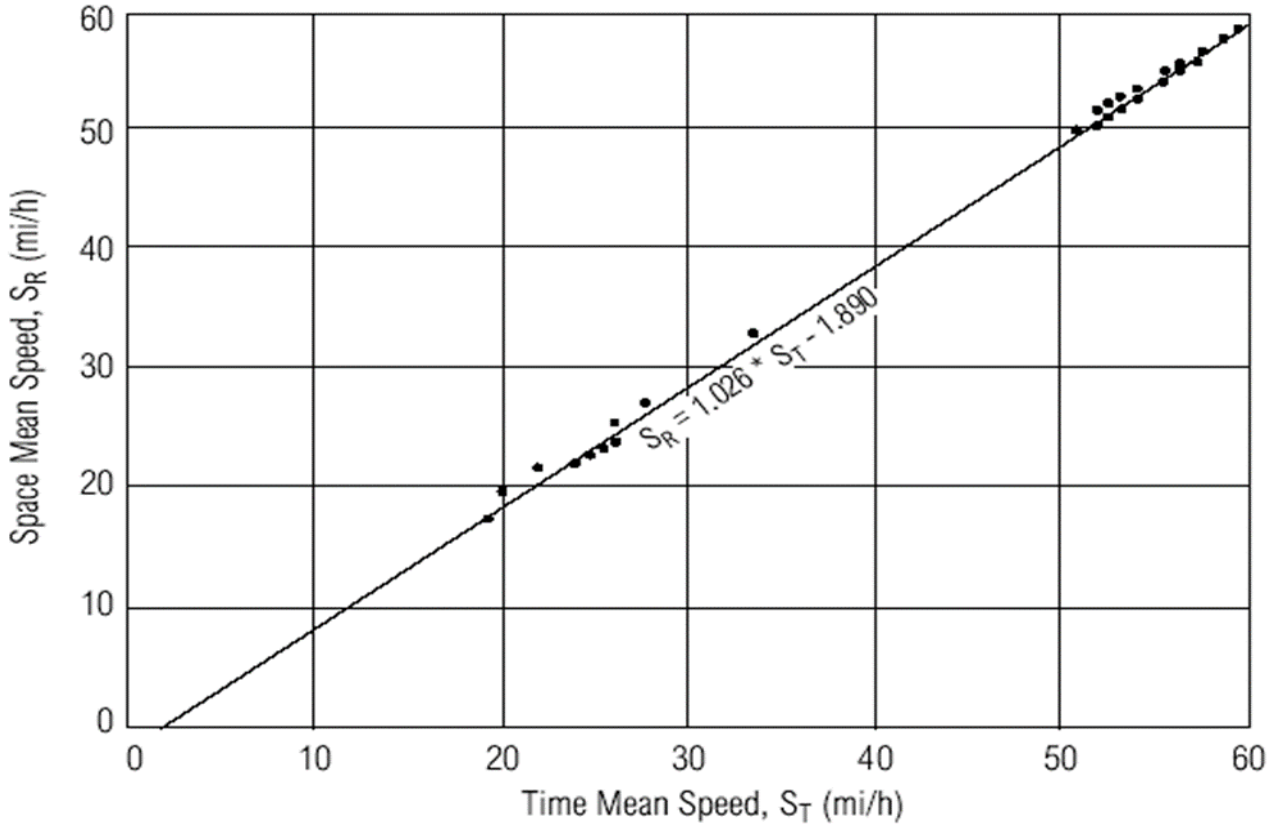
- **It is the harmonic mean (1/H = 1/a + 1/b + …)**

$$u = \frac{\frac{1}{n}\sum_{i=1}^{n} l_i}{\bar{t}} \qquad \bar{t} = \frac{1}{n}\left(t_1 l_1 + t_2 l_2 + \ldots + t_n l_n\right)$$

- **Space mean speed is always less than time mean speed**

Time Mean vs. Space Mean Speed

EXHIBIT 7-1. TYPICAL RELATIONSHIP BETWEEN TIME MEAN AND SPACE MEAN SPEED



Source: Drake et al. (*1*).

Density (k)

- **The number of vehicles (n) occupying a given length (l) of a lane or roadway at a particular instant**

- **Unit of density is vehicles per mile (vpm).**

$$k = \frac{n}{l} = \frac{q}{u}$$

Other Concepts

- **Free-flow speed (u_f)**
- **Jam density (k_j)**
- **Capacity (q_m)**

$$Density\ (veh/mi) = \frac{5{,}280}{spacing\ (ft/veh)}$$

$$Headway\ (s/veh) = \frac{spacing\ (ft/veh)}{speed\ (ft/s)}$$

$$Flow\ rate\ (veh/hr) = \frac{3{,}600}{headway\ (s/veh)}$$

Sub-Surface Drainage Using Ditches

Given five observed velocities (60 km/hr, 35 km/hr, 45 km/hr, 20 km/hr, and 50 km/hr), what is the time-mean speed and space-mean speed?

Solution:

Time-Mean Speed:

= (60+35+45+20+50)/5 = 42 km/hr

Space-Mean Speed:

= 5/(1/60+1/35+1/45+1/20+1/50)

=36.37 km/hr

Exercise example

Given that 40 vehicles pass a given point in 1 minute and traverse a length of 1 kilometer, what is the flow, density, and time headway?

Solution:

Compute flow and density:

$$Flow\ rate\ (veh/hr) = \frac{3{,}600}{headway\ (s/veh)}$$

q=(3600 x 40)/60= 2400 veh/hr

K= N/L= 40/1=40 veh/km

Find space-mean speed: q=kVs=2400=40 Vs

Vs= 60 km/hr

Compute space headway: k=40=1/Hs

Hs=0.025 km = 25 m

Compute time headway: Hs=Vs x Ht =25= [(60 x1000)/3600]Ht

Ht= 1.5 s

The time headway is 1.5 seconds.