

Faculty of Applied Engineering and Urban Planning

Civil Engineering Department

2nd Semester 2008/2009

ECGD 4121 – Transportation Engineering I

Lecture 3

Traffic Engineering (ITE's Definition)

It is the phase of transportation engineering that deals with the planning, geometric design, and traffic operations of roads, streets, and highways; their networks, terminals, abutting lands, and relationships with other modes of transportation.

Elements of Traffic Engineering

- Traffic studies and characteristics
- Performance evaluation
- Facility design (not road design)
- Traffic operations
- Transportation systems management
- Integration of ITS technologies

Objectives of Traffic Engineering

- Safety is the primary goal
- Provide mobility and access
  - ✓ Operation
  - ✓ Speed of movement
  - ✓ Ability to get from point A to point B in a timely logical manner
- Consider the environment
  - ✓ Air, water, land, and noise

Responsibilities in Traffic Engineering

- **Traffic engineers have closer relationship with public than other Civil Engineering disciplines**
- **Public safety depends on traffic engineers**
- **Key participants and decision-makers are not engineers and often do not understand basic traffic engineering concepts and how they affect projects**

Responsibilities in Traffic Engineering

- **Traffic engineering projects often affect bottom line of developers, business owners, etc**
- **Pressure to give the desired answer rather than the right answer**
- **Pressure to understimate negative impacts and overestimate positive ones**

Responsibilities in Traffic Engineering

- **Greatest risk is an incomplete analysis**
- **The traffic engineer has responsibility to protect the community from liability by good practice**

Common Areas of TE Liabilities

- Placing control devices that do not conform to applicable standards for their physical design and placement
- Failure to maintain devices in a manner that ensures their effectiveness
- Failure to apply the most current standards and guidelines in making decision on traffic control, devoting a facility plan or conducting an investigation
- Implementing traffic regulations without proper legal authority

Selection of Transit Modes

- **What factors influence choice by traveler?**
- **Selection based on characteristics of mode and traveler**

Characteristics Influencing Selection of Transit Mode

- Travel time
- Income/Cost
- Availability of transit
- Auto ownership
- Type of trip
- Stage in life
- Safety
- Social Image

Interaction of Demand and Supply

Transportation system is a function of:

- **Economy**
- **Extent and quality of the available system**

Supply

Physical capacity of transportation facilities:

- **Airport waiting area**
- **Road**
- **Marine Port**
- **Other**

Demand

- Amount of traffic desiring to use a facility
- When no queuing is involved
  - ✓ Demand = volume
  - ✓ When demand > supply or capacity, difficult to measure because trips are desired but not done

Cost

- **Direct:**
  - ✓ **Purchase price**
  - ✓ **Ticket price**
  - ✓ **Fuel**
  - ✓ **Other**
- **Indirect:**
  - ✓ **Waiting time**
  - ✓ **Delay time**
  - ✓ **Other**

Basic TE Concepts

- **Traffic demand**
- **Basic definitions**
- **Volume, Speed, Density relationships**
- **Speed:**
  - ✓ **Space mean speed**
  - ✓ **Time mean speed**

Traffic Demand

- **The highway designer must determine the 'design volume' for the proposed facility. This design volume is the volume of traffic that will use the facility in the design year.**
- **The design volume that is used typically is the hourly volume in the design direction**
- **The volume information normally available is average annual daily traffic (AADT)**

Flow Rate (q)

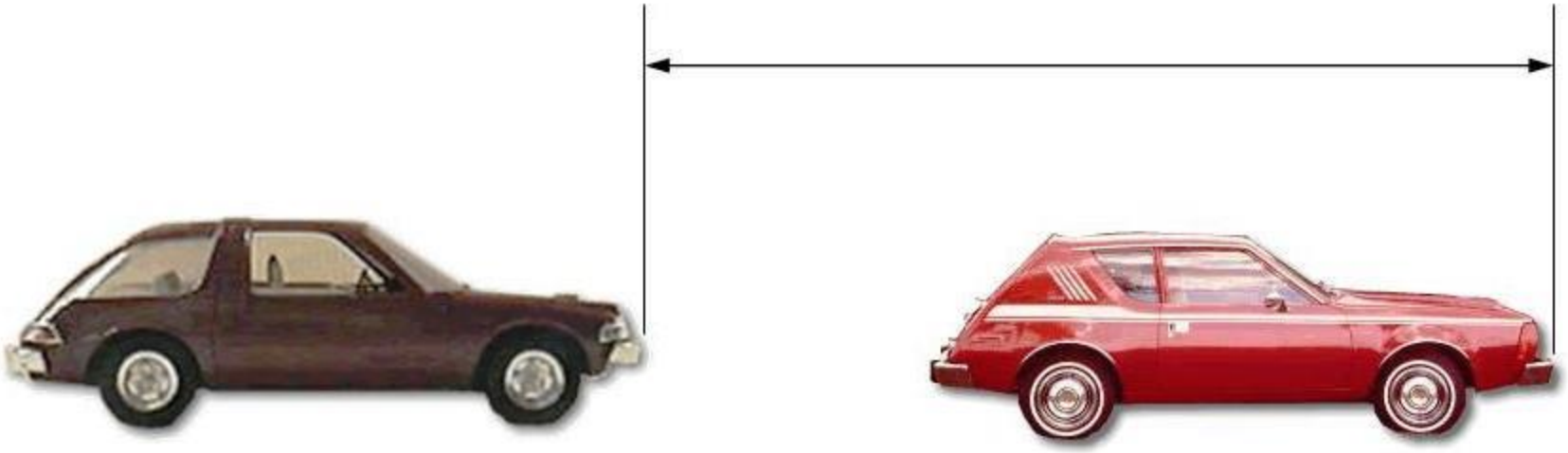
- **The number of vehicles (n) passing some designated roadway point in a given time interval (t)**

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

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

Spacing

- It is the clear distance between any two successive vehicles in a traffic stream
- It is measured from front bumper to front bumper as shown below



Headway (h)

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

$$t = \sum_{i=1}^{n} h_i$$

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

Speed

- **Running speed**
  - ✓ **The average speed maintained over a given rout while the vehicle is in motion**
- **Average journey speed**
  - ✓ **Distance traveled divided by the total time taken to complete the distance. Total time includes both running time and the time when the vehicle is at rest**

Speed/continued

- **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**

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

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

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

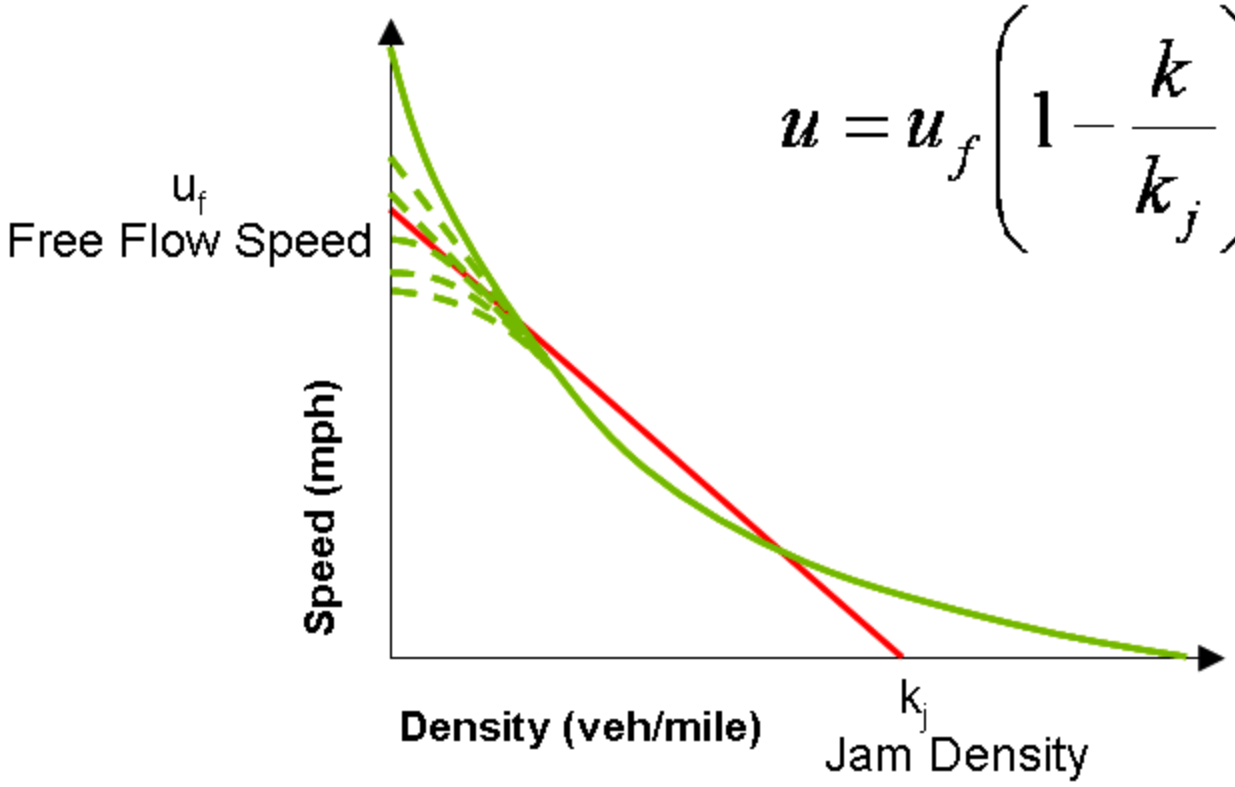
- $Flow\ rate\ (veh/hr) = \dfrac{3{,}600}{headway\ (s/veh)}$

Other Concepts

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

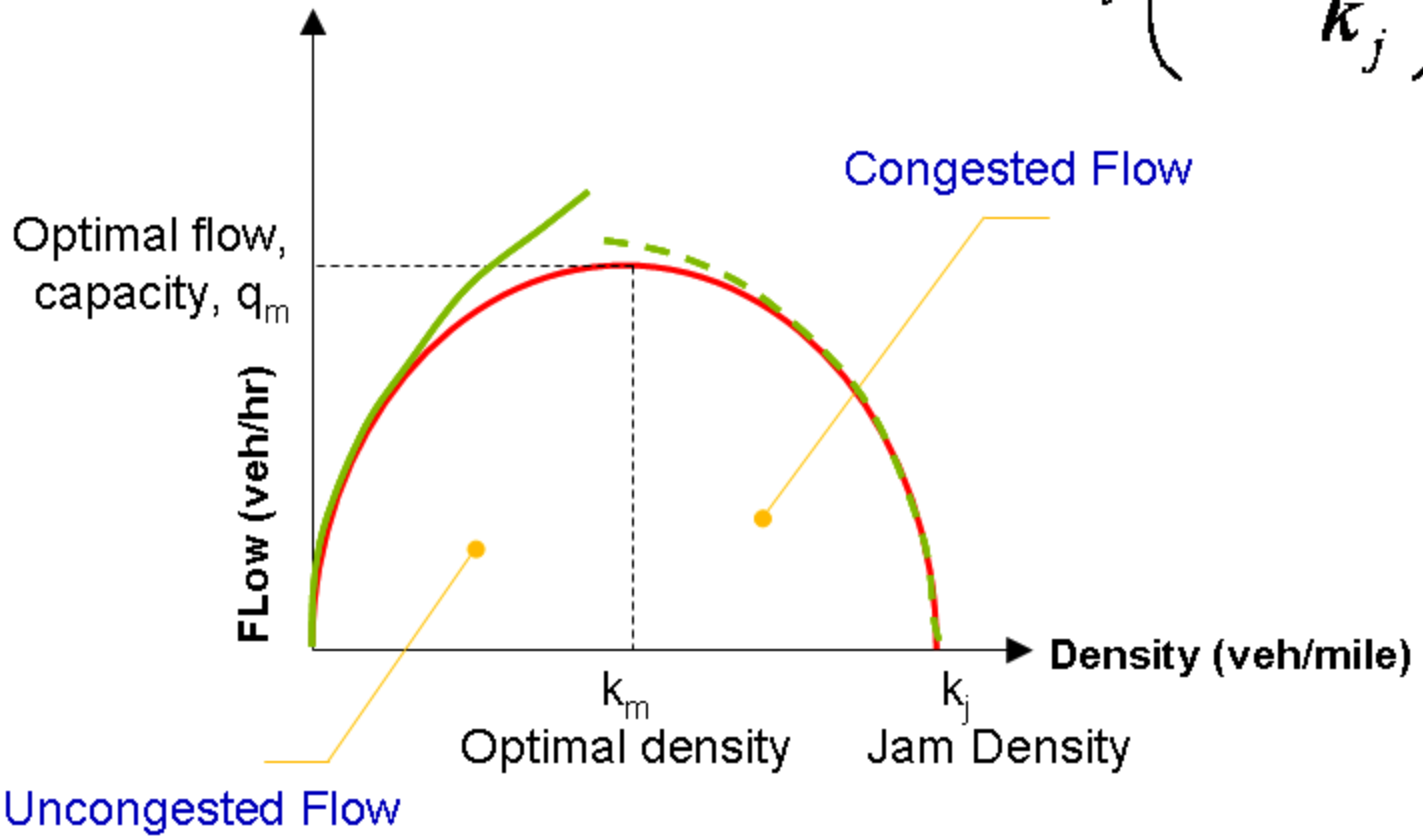
Speed vs. Density

$$u = u_f\left(1 - \frac{k}{k_j}\right)$$



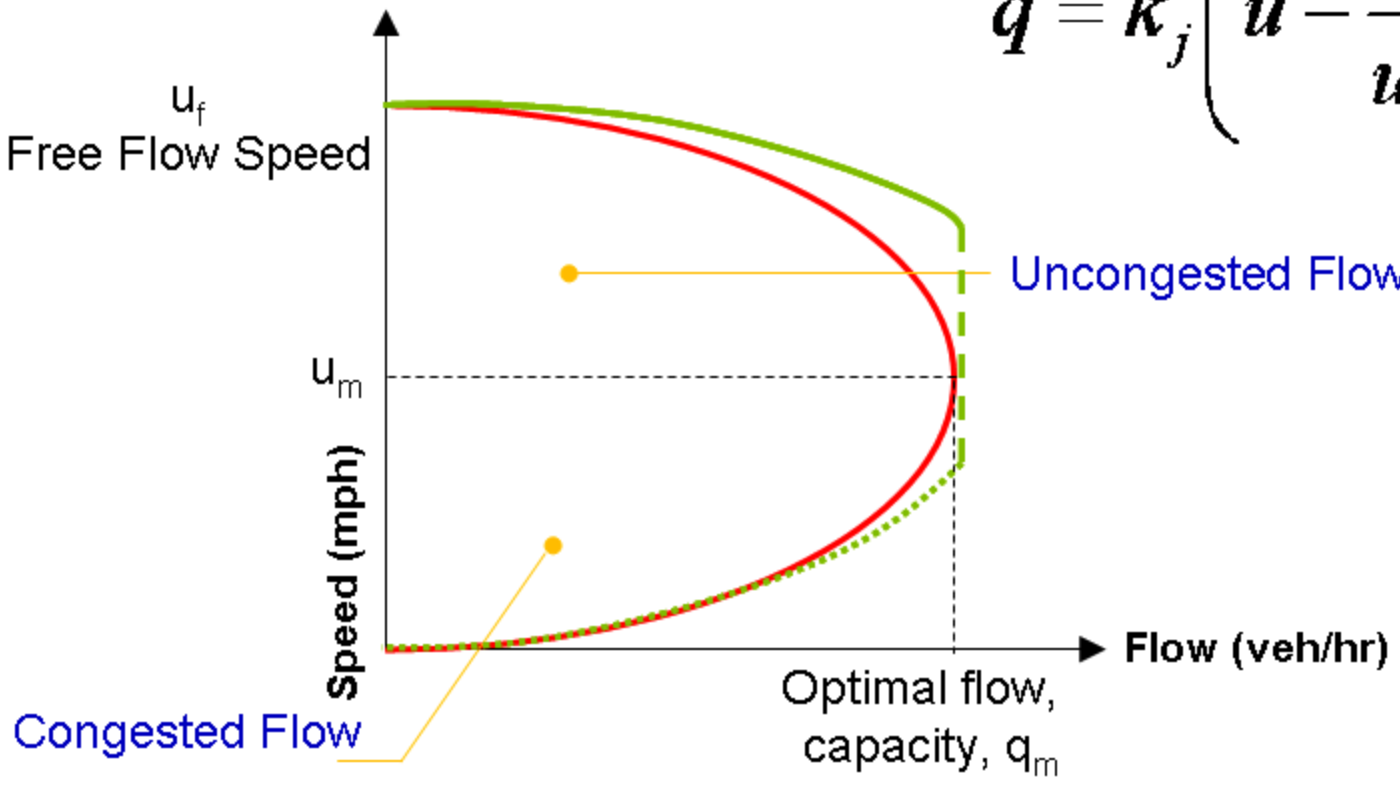
Flow vs. Density

$$q = u_f\left(k - \frac{k^2}{k_j}\right)$$



Speed vs. Flow

$$q = k_j\left(u - \frac{u^2}{u_f}\right)$$



Example 1

A major road has 4 lanes in each direction. The northbound capacity is 8125 veh/hr/lane and the free-flow speed is 65 mph. What is the maximum flow rate, maximum density, jam density? If a one-hour vehicle count in the northbound direction for the outside lane gives 7034 vehicles in an uncongested condition, what is the estimated space mean speed of these 7034 vehicles?

Solution

$$q_m = (8125)(4) = 32500\, vehicle/hr$$

$$u_m = u_f / 2 = 65/2 = 32.5\, mile/hr$$

$$k_m = \frac{q_m}{u_m} = \frac{32500}{32.5} = 1000\, vehicle/mile$$

$$u_m = u_f\left(1 - \frac{k_m}{k_j}\right)$$

$$32.5 = (65)\left(1 - \frac{1000}{k_j}\right) \Rightarrow k_j = 2000\, vehicle/mile$$

Solution/continued

$$q = k_j\left(u - \frac{u^2}{u_f}\right)$$

$$(7034)(4) = (2000)\left(u - \frac{u^2}{(65)}\right)$$

$$\Rightarrow u = 20.59\, mile/hr\ (rejected)$$

$$OR$$

$$\Rightarrow u = 44.41\, mile/hr\ (accepted)$$

Example 2

For a 500 ft road section, the following data were measured. Calculate time mean speed and space mean speed.

Vehicle	Measured Time (sec)	Measured Speed (mph)
1	6.0	63
2	6.5	58
3	5.3	60
4	5.8	65
5	5.9	64
6	6.1	61
7	5.7	66
8	5.2	72
9	5.5	68
10	5.4	69

Solution

- $Time\ Mean\ Speed = \overline{u}_t = \frac{1}{n}\sum_{i=1}^{n} u_i$

$$\overline{u}_t = \frac{63+58+60+65+64+61+66+72+68+69}{10} = 64.60\ mph$$

- $Space\ Mean\ Speed = \overline{u}_s = \frac{nL}{\sum_{i=1}^{n} t_i}$

$$\overline{u}_s = \frac{(10)(500)}{6.0+6.5+6.3+5.8+5.9+6.1+5.7+5.2+5.5+5.4} = 85.62\ \ ft/s$$

$$\overline{u}_s = 85.62\ \ ft/s = 58.37\ mph$$