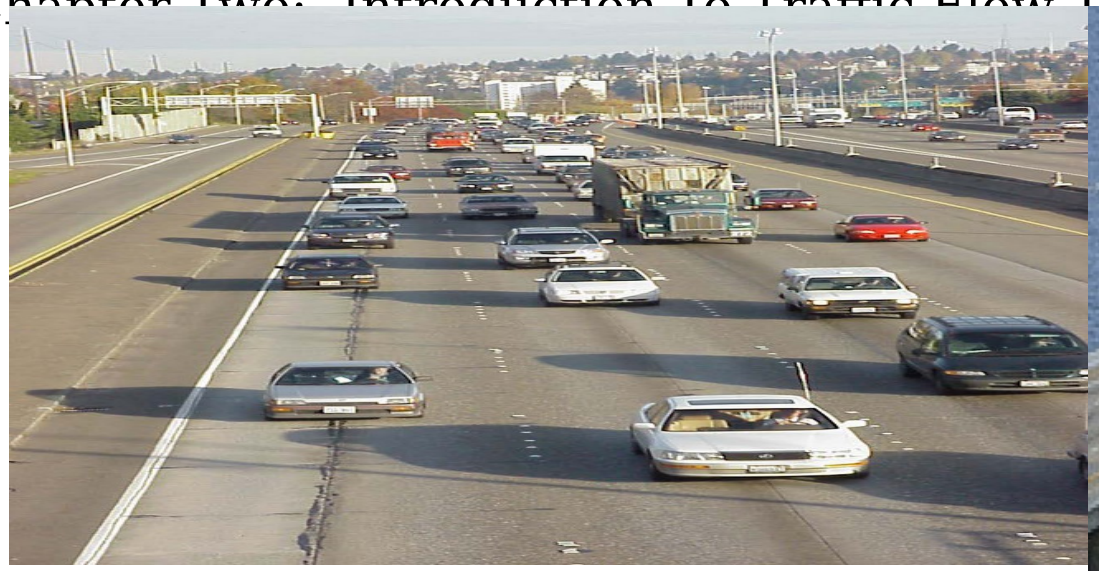
BULE HORA UNIVERSITY
ENGINEERING AND TECHNOLOGY COLLEGE
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Chapter Two: Introduction To Traffic Flow Theory







Outline

- Introduction
- Fundamental characteristics of traffic flow
- Relationship between the fundamental elements
- Basic traffic stream models

Introduction

❖Traffic flow theory

- used to understand and express the properties of traffic flow by traffic engineers.
- helps to know interaction of vehicles with each other and the roadways

❖Evaluation of traffic flow helps for

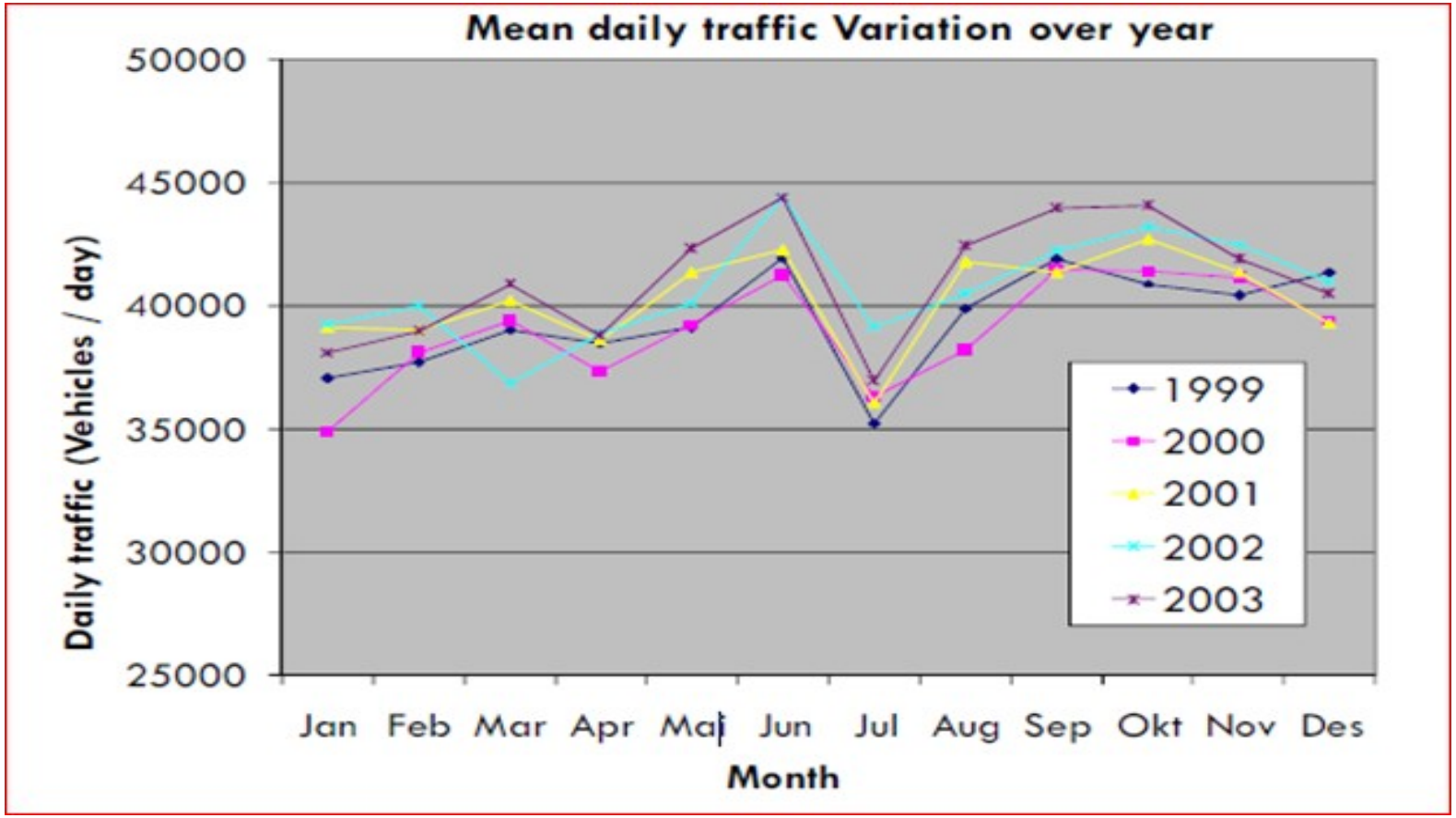
- Evaluating the capacity of the existing roadways and
- Designing of new roadways

Introduction cont…

- Before designing a new highway we need to determine various dimentions of traffic like
  - Number of vehicles per unit time
  - Vehicle type (passenger car, bus, truck….)
  - Vehicle speed
  - Variation of traffic flow over time (seasonal, monthly, daily, hourly……)

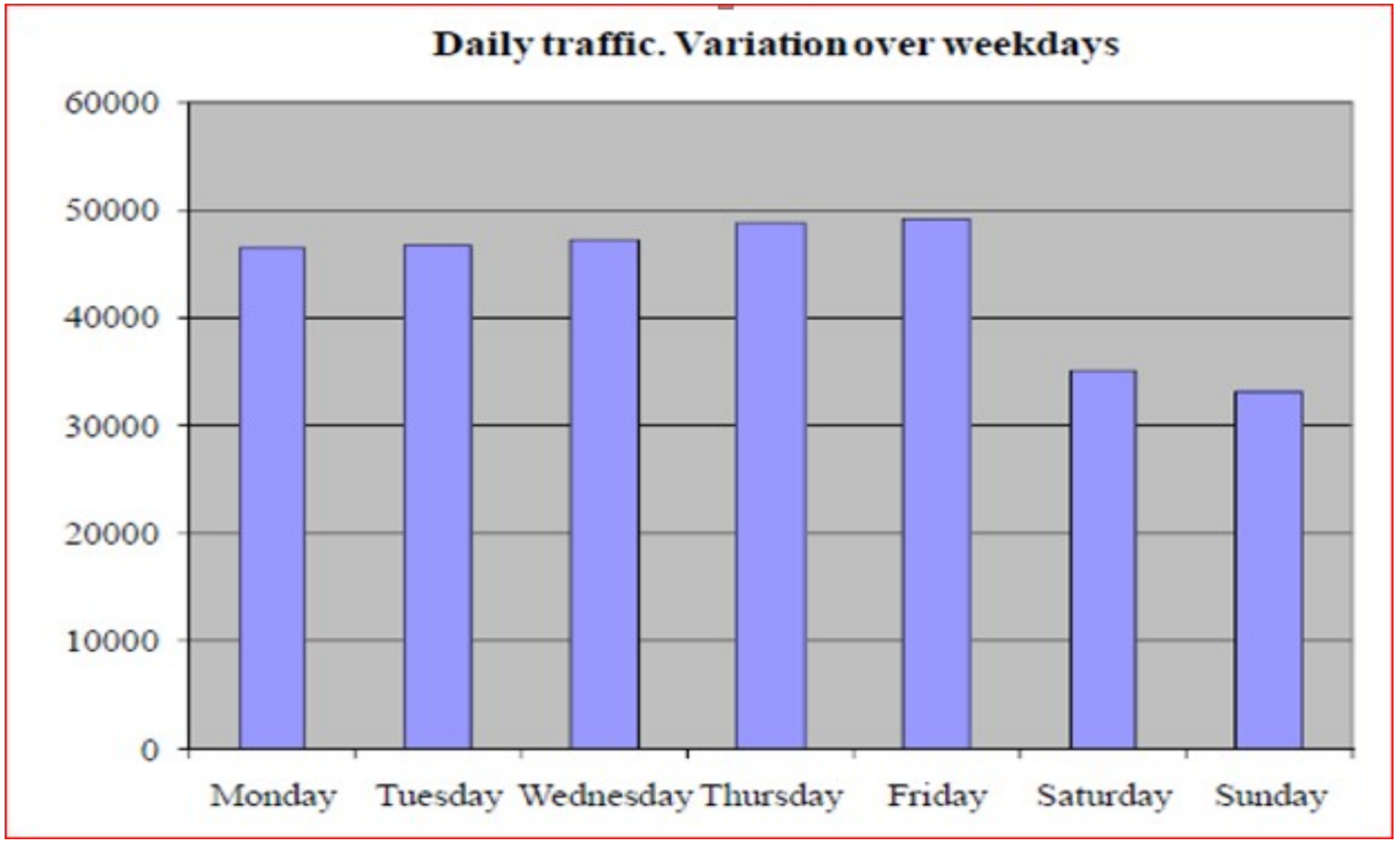
Introduction cont...

- Variation of Traffic flow over time



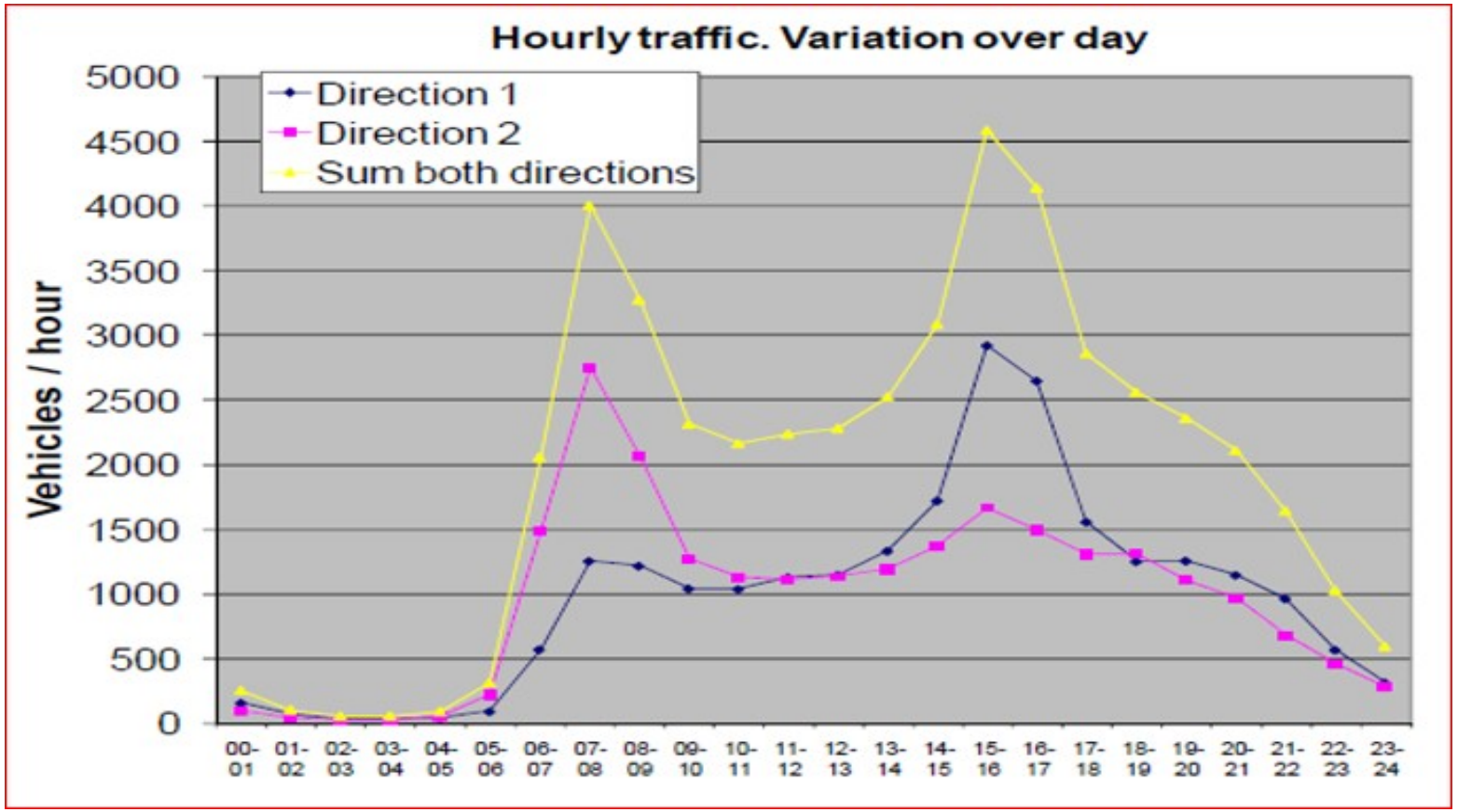
Introduction cont...

- Variation of Traffic flow over time



Introduction cont...

- Variation of Traffic flow cont....



Introduction cont...

- These dimentions of traffic influence highway design in two ways
  - Influence highway design (no.of lanes, geo.design, structural design...)
  - Influence highway operations (traffic signs, road markings, traffic signals...)
- Functional effectiveness of highway can be measured by its ability to accommodate as much traffic as possible, subjected to safety and environmental constraints.
- Fandamental parametrs used to characterise flow of traffic in a roadway are:
- Flow rate, Density and Speed

Introduction cont...

- Types of traffic flow:

- Uninterruped flow-regulared by vehicle-vehicle and vehicle roadway interaction (usually found in rural areas)

  eg. Vehicle travelling in freeway/rural highway

- Interrupted flow- regulated by external means like traffic signals (usually common in urban areas)

Fundamental chracteristics of traffic flow

- **Flow (q)**:-number of vehivles passing a point in a road/lane in an interval of time (measure of quantity)

  $q = n_t/t$.....expressed by vehicle/hr

- Volume (V) :- the total number of vehicles that pass over a given point or section of a lane or roadway during a given time interval; volumes maybe expressed in terms of annual, daily, hourly, or sub-hourly periods.

Daily Volume

- ✓ Annual Average Daily Traffic (AADT)
- ✓ Average Daily Traffic (ADT)

Hourly Volume

- ✓ Peak Hour Volume (PHV)
- ✓ Design Hour Volume

Fundamental cont...

- **AADT:** The annual average daily traffic volume at a given location over a year- i.e., the total number of vehicles passing the site in a year divided by 365
- **ADT:** Average daily traffic volume at a given location for some period of time less than a year.
- **AWT:** Average weekday traffic volume occurring on weekdays for some period less than a year, when averaged over a year then called **AAWT**

Example on Traffic volume

1. Month	2. No. of Weekdays In Month (days)	3. Total Days in Month (days)	4. Total Monthly Volume (vehs)	5. Total Weekday Volume (vehs)	6. AWT 5/2 (veh/day)	7. ADT 4/3 (veh/day)
Jan	22	31	425,000	208,000	9,455	13,710
Feb	20	28	410,000	220,000	11,000	14,643
Mar	22	31	385,000	185,000	8,409	12,419
Apr	22	30	400,000	200,000	9,091	13,333
May	21	31	450,000	215,000	10,238	14,516
Jun	22	30	500,000	230,000	10,455	16,667
Jul	23	31	580,000	260,000	11,304	18,710
Aug	21	31	570,000	260,000	12,381	18,387
Sep	22	30	490,000	205,000	9,318	16,333
Oct	22	31	420,000	190,000	8,636	13,548
Nov	21	30	415,000	200,000	9,524	13,833
Dec	22	31	400,000	210,000	9,545	12,903
Total	**260**	**365**	**5,445,000**	**2,583,000**	—	—

AADT = 5,445,000/365 = 14,918 veh/day

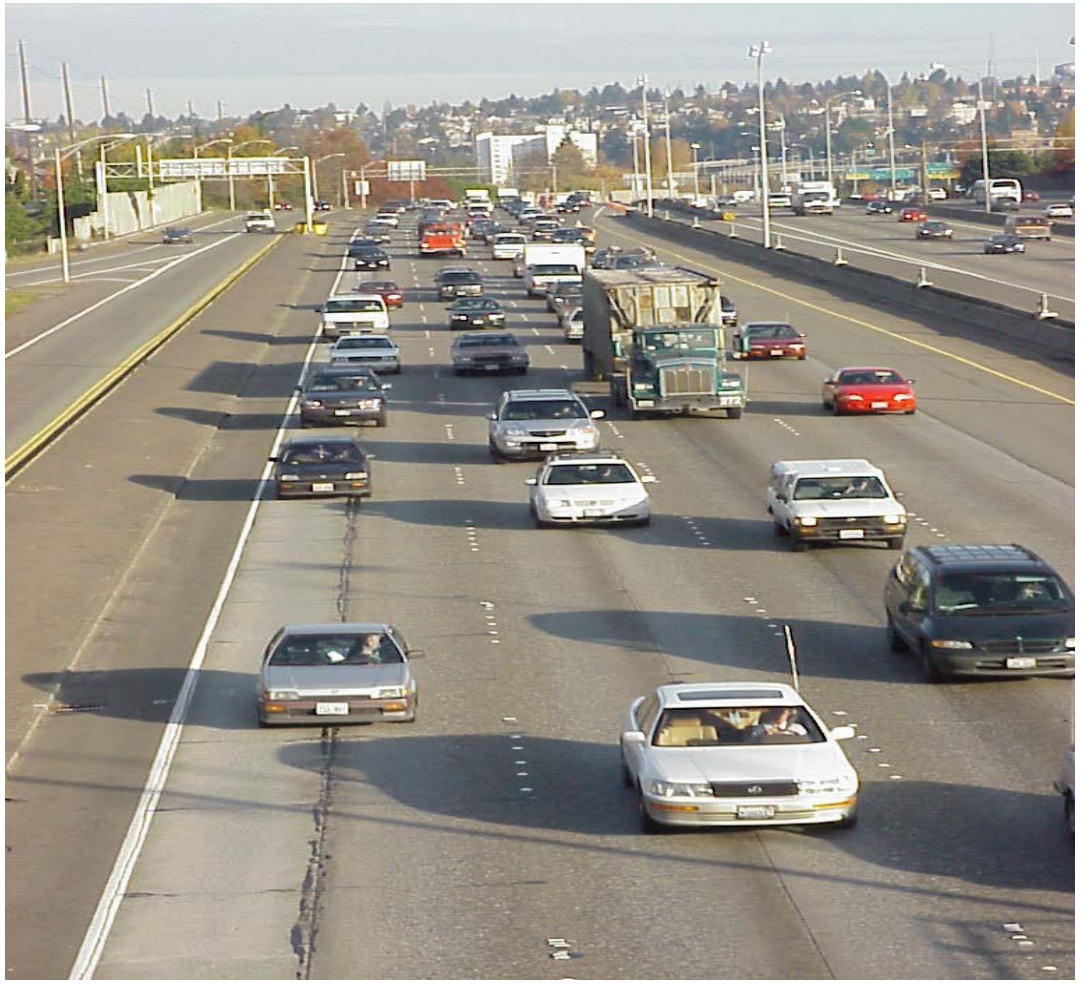
AAWT = 2,583,000/260 = 9,935 veh/day

Fundamental cont....

Density (k)

Density is defined as the number of vehicles (or pedestrians) occupying a given length of a lane or roadway at a particular instant

K = n_x/x.....expressed by vehicle/km,



Fundamental cont....

❖Speed (u)

- Distance covered by vehicle in unit time
- Due to vehicle- vehicle or vehicle – roadway interactions, vehicles will not have similar speed in a given traffic stream
- Average or mean speed is a significant variable for traffic flow analysis

➢Different types of average values of speed are used to characterize a traffic stream.

- Time mean speed (TMS)
- Space mean speed (SMS)

Fundamental cont....

❖Time mean speed (TMS)

- This is the arithmetic average of speeds of vehicles observed passing a point on a highway.
- also referred to as the average spot speed.
- Individual speeds of vehicles passing a point are recorded and are arithmetically averaged.

$$u_t = \frac{\sum_{i=1}^{n} u_i}{n}$$ ← radar

Where u_i = speed of vehicle i at desiginated point x

n = number of mesured vehicle speeds at point x

Fundamental cont....

❖Space Mean Speed (SMS)

• SMS is the average speed of vehicles measured at an instant of time over a specified stretch of road. *SMS* is theharmonic mean of all speeds.

$$u_s = \frac{n}{\sum_{i=1}^{n} \frac{1}{u_i}} = \frac{nl}{\sum_{i=1}^{n} t_{i/}}$$

• Used in traffic models, but harder to measure

Example

Computation of Time Mean Speed and Space Mean Speed

1 Vehicle No.	2 Distance (m)	3 Travel Time (sec)	2/3 Speed (mps)
1	1000	18.0	1000/18 = 55.6
2	1000	20.0	1000/20 = 50.0
3	1000	22.0	1000/22 = 45.5
4	1000	19.0	1000/19 = 52.6
5	1000	20.0	1000/20 = 50.0
6	1000	20.0	1000/20 = 50.0
Totals	6000	119.0	303.7
Averages		119/6 = 19.8	303.7/6 = 50.6

$TMS = 50.6$ mps

$SMS = 1000/19.8$ or $6000/119 = 50.4$ mps

Additional Parameters important in the Study Traffic Flow

- **Peak hour volume (PHV):** the traffic volume measured over the busiest hour of the day at a given location. PHV gives the highest hourly volume in a day
- **Peak Hour Factor (PHF):** is the ratio of total hourly volume to the peak flow rate within the hour

,

- **Design Hour Volume (DHV):** Peak hourly volumes are different for everyday of the year. The thirtieth highest peak hour volume is considered for rural design and the fiftieth highest peak hour volume is considered for urban design and are often called DHV.

DHV = AADT X *k*

where, *k* is the ratio of 30^{th} or 50^{th} HV to the AADT from a similar site

Example

- Calculate hourly volume, flow rate & PHF

Illustration of Volumes and Rates of Flow

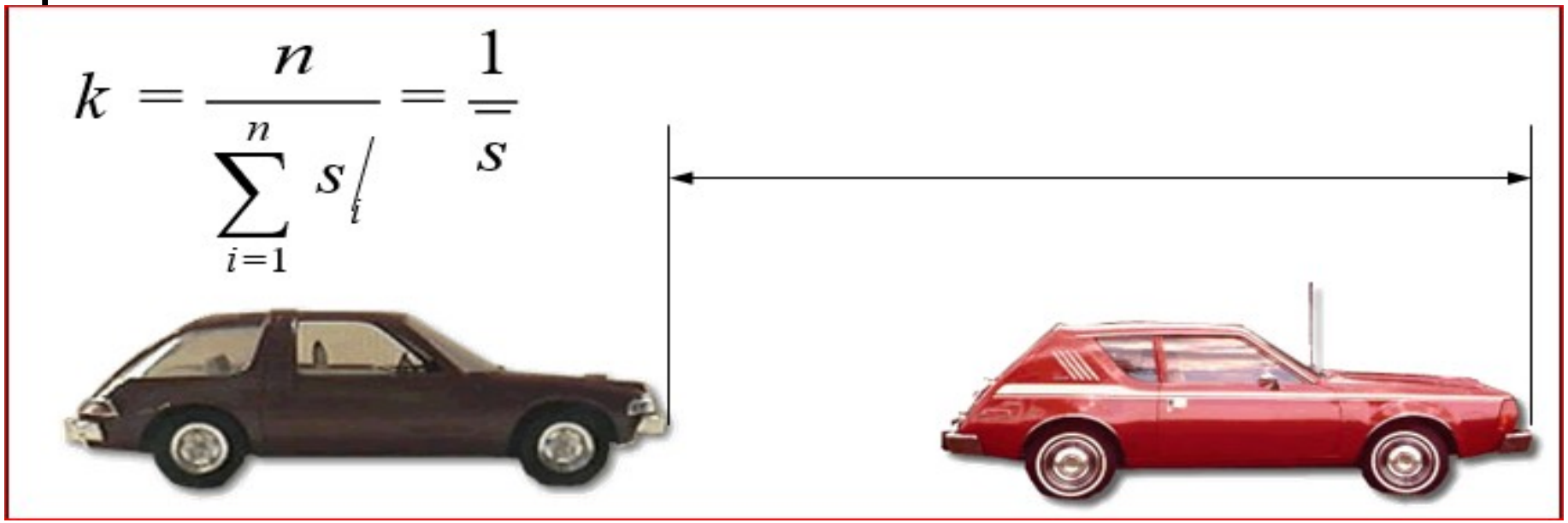
Time Interval	Volume for Time Interval (vehs)	Rate of Flow for Time Interval (vehs/h)
5:00–5:15 PM	1,000	1,000/0.25 = 4,000
5:15–5:30 PM	1,100	1,100/0.25 = 4,400
5:30–5:45 PM	1,200	1,200/0.25 = 4,800
5:45–6:00 PM	900	900/0.25 = 3,600
5:00–6:00 PM	Σ = 4,200	

- PHF= PHV/Q_{peak} = 4200/4800 = 0.875

Additional Parameters...

❖Spacing (s)

- Is the distance (m) between successive vehiclesin a traffic stream, as measured from front bumper to front bumper

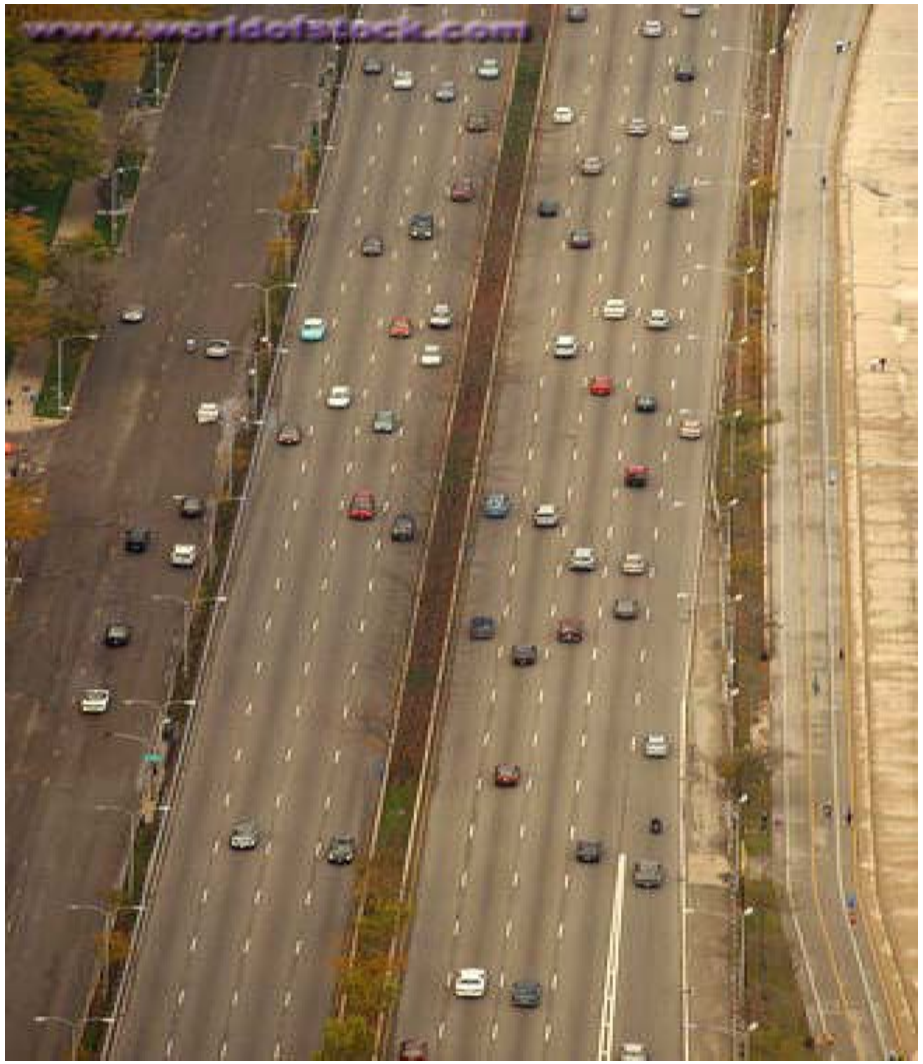


Additional Parameters...

Headway (h):

- The time (in seconds) between successive vehicles, as their front bum a give

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



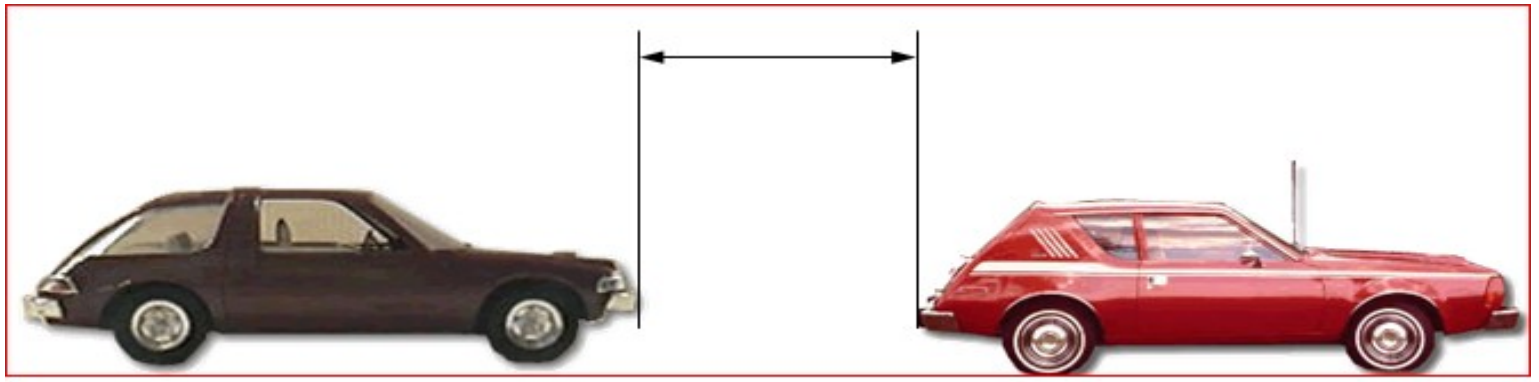
Additional Parameters...

- **Clearance (c):** similar to spacing, expect it is the distance b/n rear bumper of the leading vehicle and front bumper of the next vehicle

  c – measured in meter

- **Gap (g):** similar to headway expect it is the time b/n rear bumper of leading vehicle & front bumper of the next to cross same point

g



Relationship Among Elements of Traffic Flow (q, k and u).

Important terms and their definitions

- **Free-flow speed (u_f)**

✓ The speed at which vehicles will travel unimpeded

- **Jam density (k_j)**

✓ The density of vehicles in stopped traffic

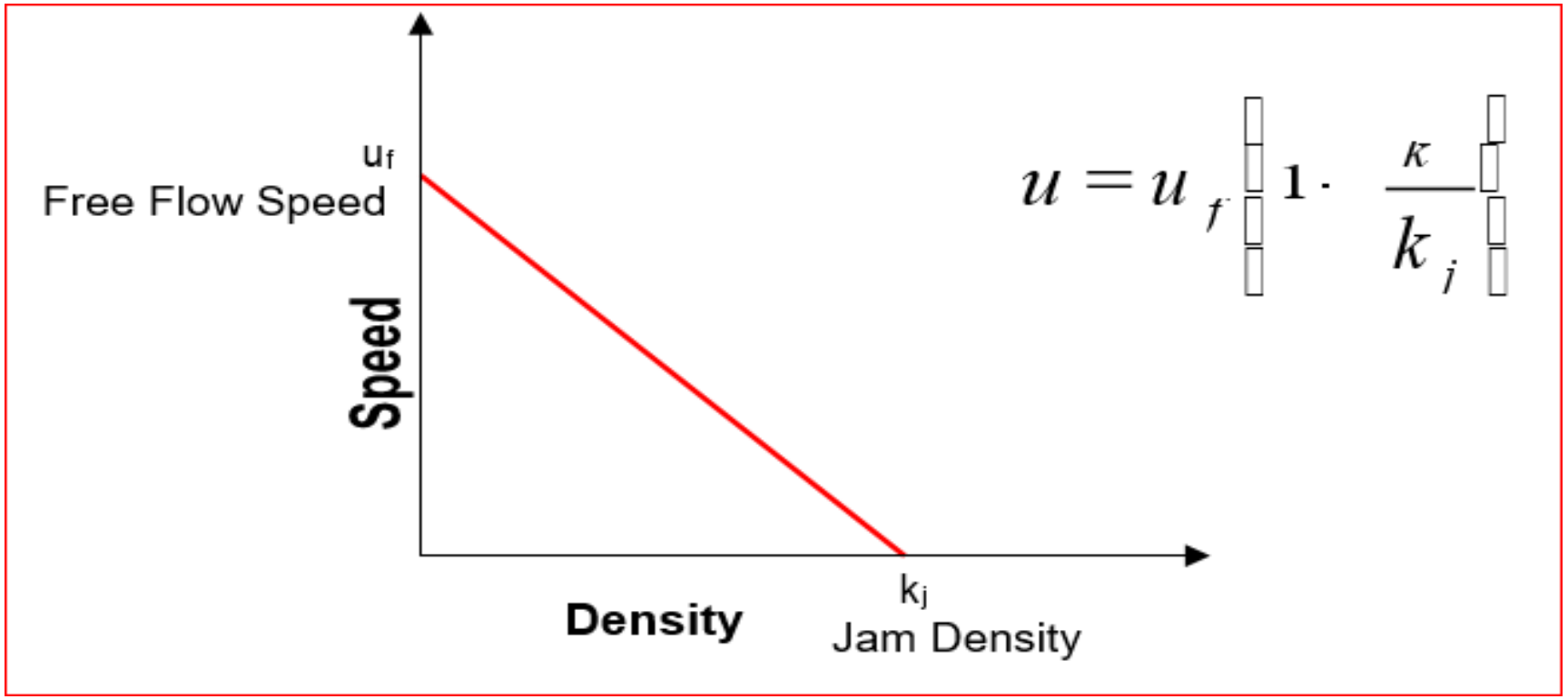
- **Capacity (q_m)**

✓ The maximum flow a section of roadway can maintain



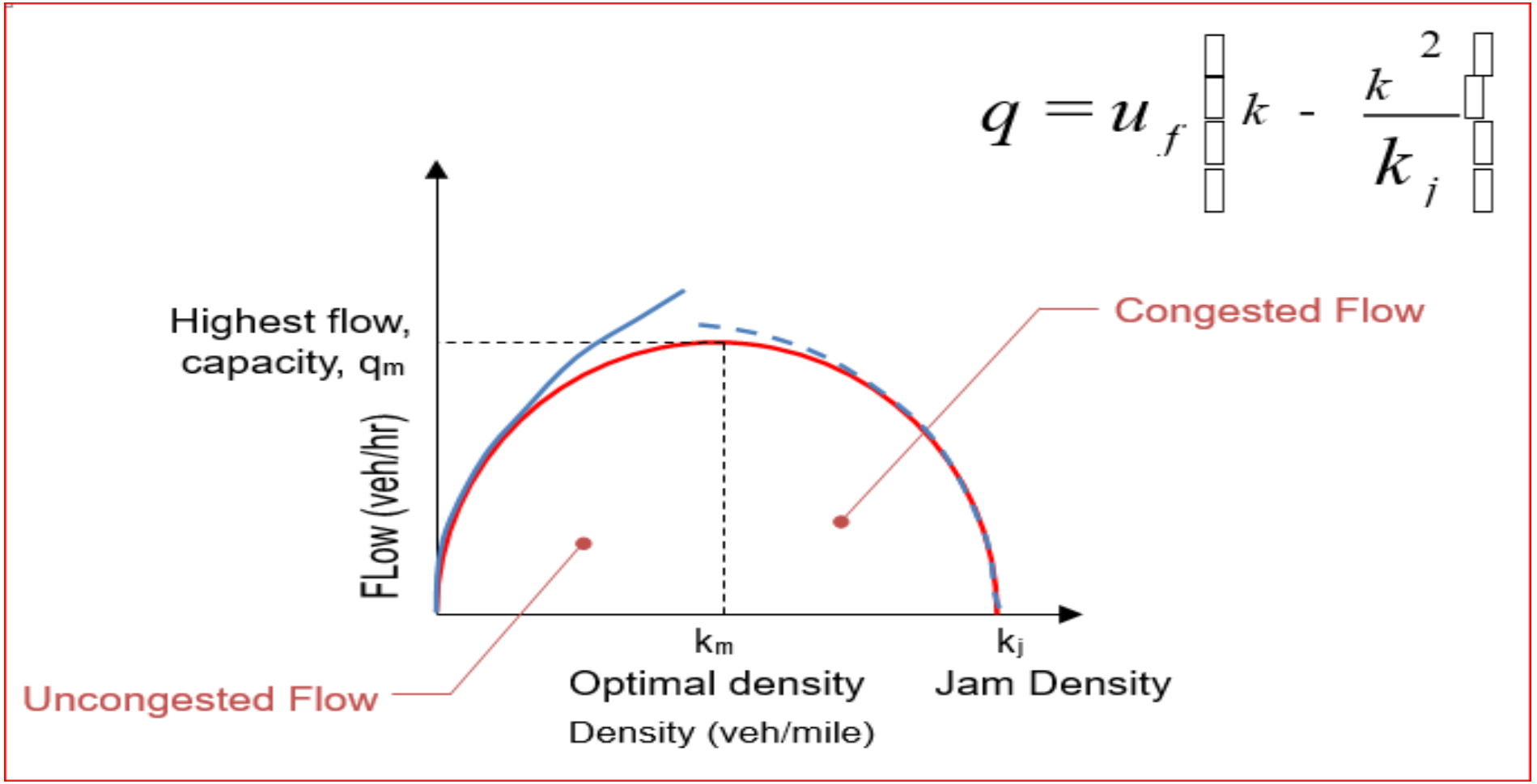
Speed vs Density (Greenshield's Model - 1994)

- Read Greenberg’s logarithmic & Underwood’s exponential models



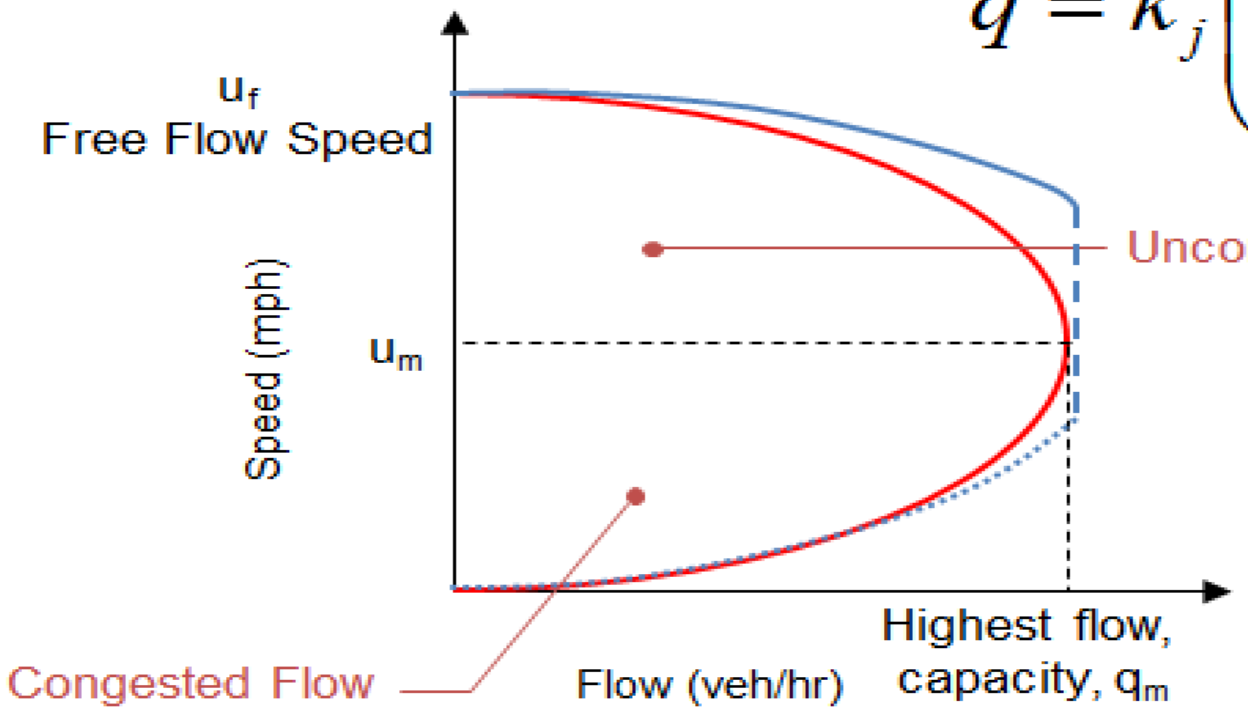
Flow vs. Density

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



Speed vs. Flow

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



q_m is bottleneck discharge rate

Examples

1) A volume of 900 veh/hr is observed at an intersection approach. Find the peak flow within the hour for the following peak-hour factors: 1.00, 0.90, 0.80, 0. 70. Plot and comment the result.
2) A traffic stream displays average head-way of 2.2s at 80km/hr. Compute the density and rate of flow for this traffic stream.
3) A study of free flow at a particular site has resulted in a calibrated speed – density relationship as follows:

$$U = 57.5 (1- 0.008k)$$

For this relation ship, determine: a) the free-flow speed, b) jam density, c) the speed-flow relationship, d) the flow-density relationship, e) capacity and f) density and speed at maximum flow

Highway Capacity and Level of service

- The capacity of a facility is the maximum hourly rate at which persons or vehicles reasonably can beexpected to traverse a point or a uniform section of alane or roadway during a given time period unde prevailing roadway, traffic, and control conditions.
- For most cases,the rate used is for the peak 15-minutes of the peak hour.

Highway Capacity and Level of service

- As per the Highway Capacity Manual Volume 2, 2010: LOS for basic, weaving, merge, and diverge segments on a freeway is defined in terms of density.
- The facility LOS will be based on the weighted average density for all segments within the defined facility. Weighting is done on the basis of segment length and the number of lanes in each segment, as shown below:

Level of service for uninterrupted flow

Level of service	Density (pc/mi/ln)
A	<=11
B	>11-18
C	>18-26
D	>26-35
E	>35-45
F	>45

Level of service for interrupted flow

Level of Service (LOS)	Delay at signalized intersection	Delay at un signalized intersection
A	≤ 10 sec	≤ 10 sec
B	10-20 sec	10-15 sec
C	20-35 sec	15-25 sec
D	35-55 sec	25-35 sec
E	55-80 sec	35-50 sec
F	≥80 sec	≥50 sec