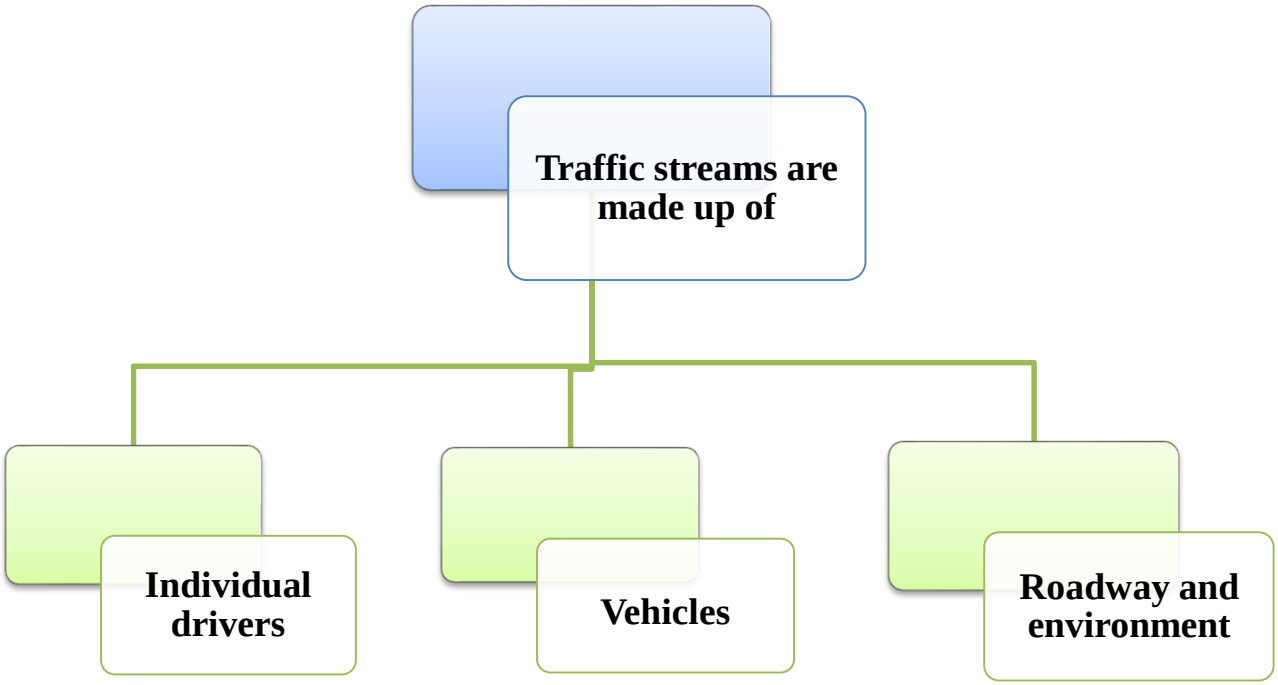
Basic Traffic Engineering Concepts

What is A Traffic?

Ttraffic can be defined as the movement of pedestrians and goods along a route, and in the 21st century the biggest problem and challenge for the traffic engineer is often the imbalance between the amount of traffic and the capacity of the route, leading to congestion.

What is Traffic Engineering?

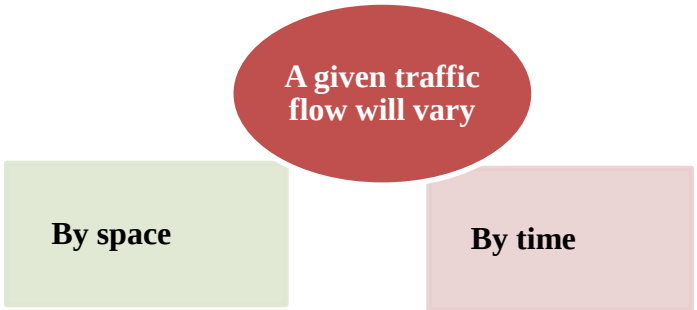
That part of engineering which deals with traffic planning and design of roads, of frontage development and of parking facilities and with the control of traffic to provide safe, convenient and economic movement of vehicles and pedestrians.

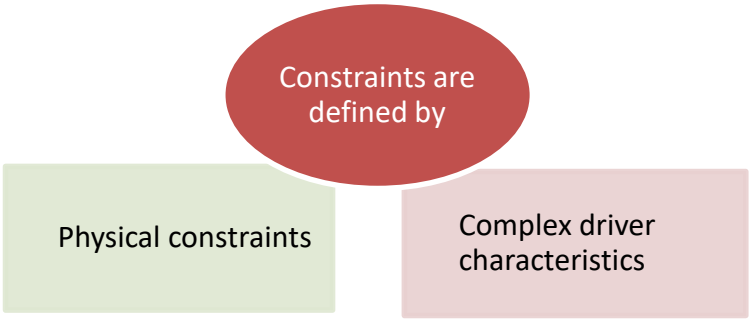


- Driver behavior and vehicle characteristics typically vary.
- No two traffic streams will behave exactly in the same way.


Variability in Traffic Stream

Traffic flow (movement of vehicles) involves variability unlike pipe flow (homogeneous).



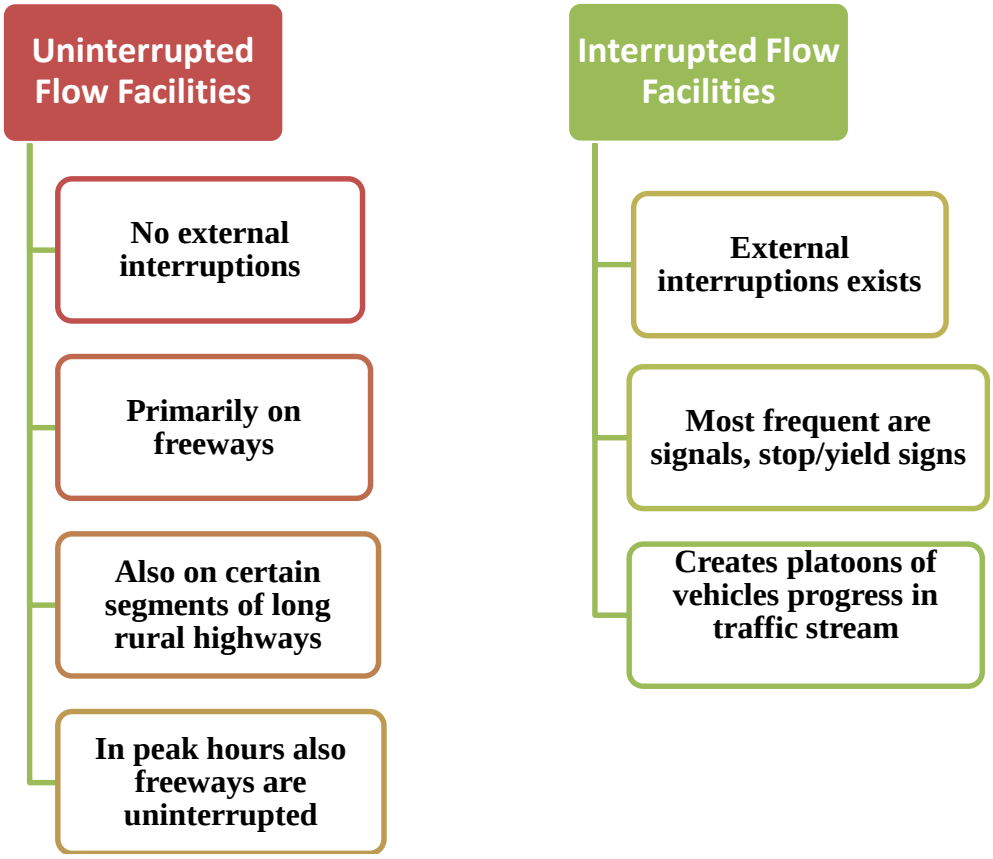


- Although traffic characteristics vary there is a reasonable range

Example: In a 65 miles/hr roadway some drivers will drive 50 miles/hr and some will drive 80 miles/hr
• There exists a range

- Before we study traffic characteristics let us see what are
  - Facilities
  - Basic flow parameters

Types of Facilities



Types of Facilities and Major Difference

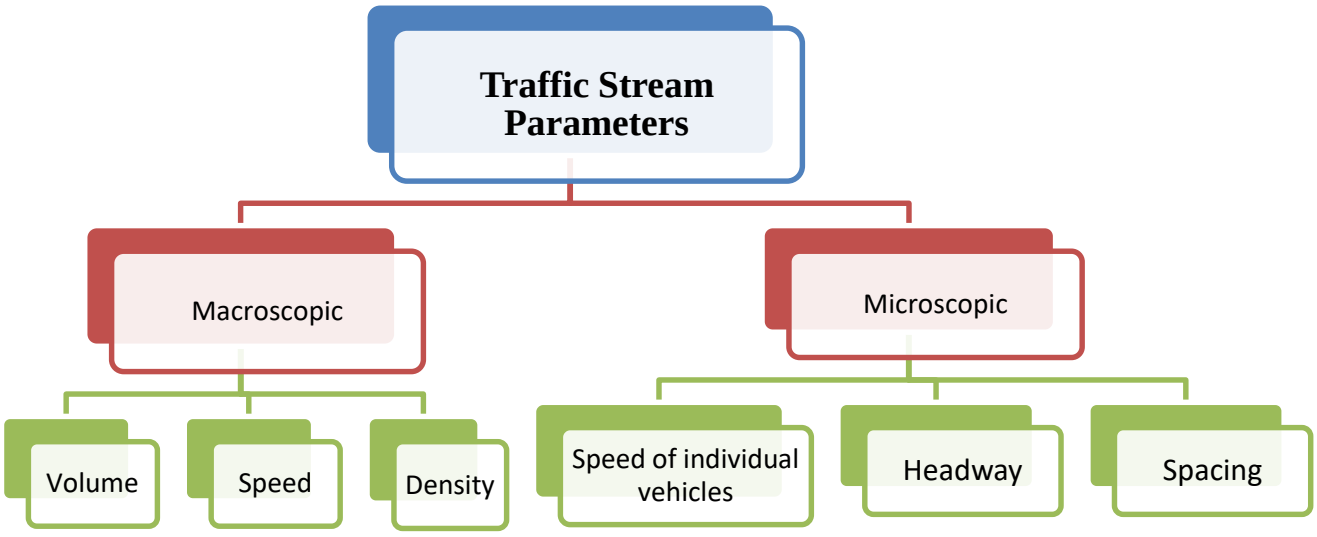
The major difference between two facilities:

- Impact of time (no interventions at any time)
- Availability of roadways
  - On uninterrupted facilities roadways are available to users all the time.
  - But sections of roadway are not available to users because of traffic control (signal, stop, and yield signs).

Uninterrupted facilities roadways

Interrupted facilities roadway

Traffic Stream Parameters



Volume

Traffic volume is defined as the number of vehicles passing a point on highway or a given lane or direction of a highway in a specific time.

- Unit: vehicles per unit time
- Usually expressed as vehicles / hour
- Denoted as veh/hr

Rate of Flow

Rate of flow are generally expressed in units of "veh/hr" but represents flows that exists for period of time less than an hour.

- Example: 200 vehicles are observed for 15min.
- The equivalent hourly volume will be 800 veh/hr.
- Even though 800 veh/hr would not be observed if one hour was counted.

Daily Volumes

Average Annual Daily Traffic (AADT)

- The average 24 hour volume at a given location over a full 365 day year.
- Average 24-hour volume at a site over a full year.

AADTs are used in several traffic and transportation analyses for:

- Estimation of highway user revenues.
- Computation of crash rates in terms of number of crashes per 100 million vehicle miles.
- Establishment of traffic volume trends.
- Evaluation of the economic feasibility of highway projects.
- Development of freeway and major arterial street systems.
- Development of improvement and maintenance programs.

Average Annual Weekday Traffic (AAWT)

- The average 24 hour volume at a given location occurring on weekdays over a full 365 day year.
- Usually 260 days week days per year.

Average Daily Traffic (ADT)

The average 24 hour volume at a given location over a defined time period less than a year.

ADTs may be used for:

- Planning of highway activities.
- Measurement of current demand.
- c. Evaluation of existing traffic flow.

Average Weekday Traffic (AWT)

The average 24 hour weekday volume at a given location over a defined period less than one year.

Example: Daily 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

Hourly Volume

- Measured in volume/hour
- Used for design and operational purposes
- The hour with highest volume is referred as – **Peak hour**
- Peak hour volume is stated as directional volume
- Sometimes referred as **Directional Design Hourly Volume (DDHV)**

PHVs are used for:

- Functional classification of highways.
- Design of the geometric characteristics of a highway, for example, number of lanes, intersection signalization, or channelization.
- Capacity analysis.
- Development of programs related to traffic operations, for example, one-way, street systems or traffic routing.
- Development of parking regulations.

DDHV

DDHV = directional design hourly volume

DDHV = AADT * K * D

Where:
K = proportion of AADT that occurs during design hour.
D = proportion of peak hour traffic traveling in the peak direction.

K-Factor

Typically, K factor represents proportion of AADT occurring during 30th peak hour of the year.

• How does K-factor vary by urban density?
– Urban, suburban, and rural
• D Factors
– More variable than K
– Influenced by development density, radial vs. circumferential route

K and D Factor

Facility Type	Normal Range of Values	
	K-Factor	*D*-Factor
Rural	0.15–0.25	0.65–0.80
Suburban	0.12–0.15	0.55–0.65
Urban:		
Radial Route	0.07–0.12	0.55–0.60
Circumferential Route	0.07–0.12	0.50–0.55

Flow Rate vs. Volume
Example:

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	

Volume vs. Flow Rate
Example:
If capacity = 4200vph

Time Interval	Arriving Vehicles (vehs)	Departing Vehicles (vehs)	Queue Size at End of Period (vehs)
5:00–5:15 PM	1,000	1,050	0
5:15–5:30 PM	1,100	1,050	0 + 1,100 − 1,050 = 50
5:30–5:45 PM	1,200	1,050	50 + 1,200 − 1,050 = 200
5:45–6:00 PM	900	1,050	200 + 900 − 1,050 = 50

Peak Hour Factor

- 15 minutes is considered to be minimum period of time over which traffic can be considered statistically stable
- Peak hour factor (PHF) represents the uniformity of flow in the peak hour.

$$PHF = \frac{V}{4 \times V_{m15}}$$

Where:
V = hourly volume, vehs
V_{m15} = max15min volume within the hour, vehs

PHF = 4200/(4*1200) = 0.875

Peak hour factor lie between 0.25-1

- 0.25 when all traffic is concentrated in one 15 minute period
- when traffic on all 15 minute period are same

• Under very congested conditions PHF~1
• Practical studies show that

- PHF~0.7 for rural roadways
- PHF~0.98 in dense urban roadways

Speed

Speed and travel time are inversely related

S = d/t

Where:
S: speed in mi/hr;
D: distance traversed in mi;
t: time to traverse distance d in hr.

Average speed in a traffic stream can be computed in two ways:

Time mean speed (TMS): average speed of all vehicles passing a point over a specified time period.

$$TMS = \frac{\sum_i (\frac{d}{t_i})}{n}$$

Space mean speed (SMS): average speed of all vehicles occupying a given section of roadway over a specific time period.

$$SMS = \frac{d}{\sum_i (\frac{t_i}{n})}$$

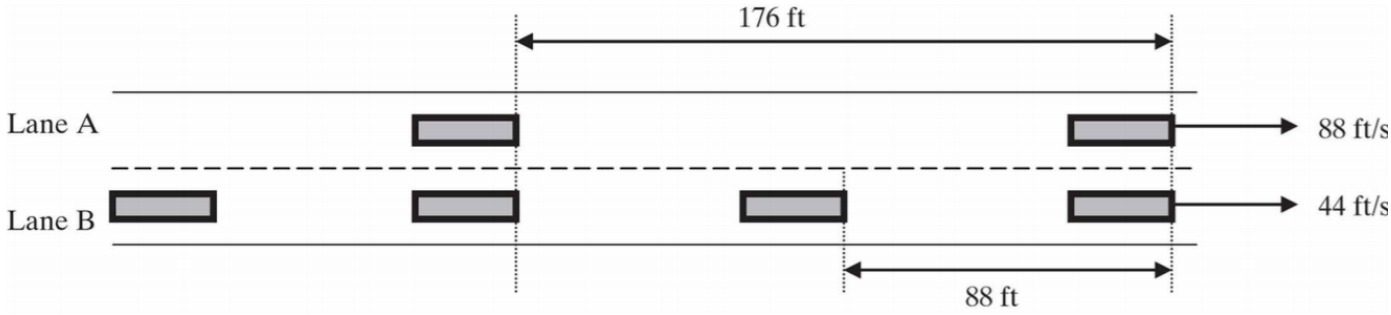
Where:
d: distance traversed, ft
n: number of observed vehicles
t_i: time for vehicle "i" to traverse the distance d

Example: TMS and SMS

Vehicle No.	Distance d (ft)	Travel Time t (s)	Speed (ft/s)
1	1,000	18.0	1,000/18 = 55.6
2	1,000	20.0	1,000/20 = 50.0
3	1,000	22.0	1,000/22 = 45.5
4	1,000	19.0	1,000/19 = 52.6
5	1,000	20.0	1,000/20 = 50.0
6	1,000	20.0	1,000/20 = 50.0
Total	**6,000**	**119**	**303.7**
Average	**6,000/6 = 1,000**	**119/6 = 19.8**	**303.7/6 = 50.6**

TMS = 50.6 ft/s
SMS = 1,000/19.8 = 50.4 ft/s

Example: Time Mean vs Space Mean Speed

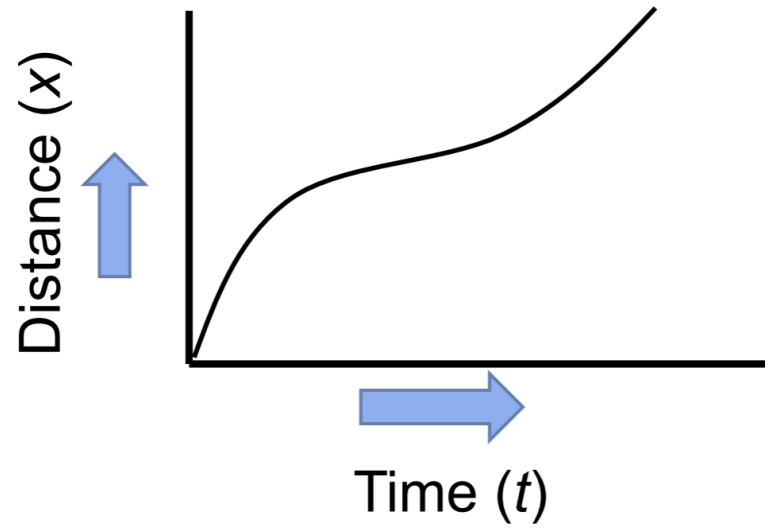


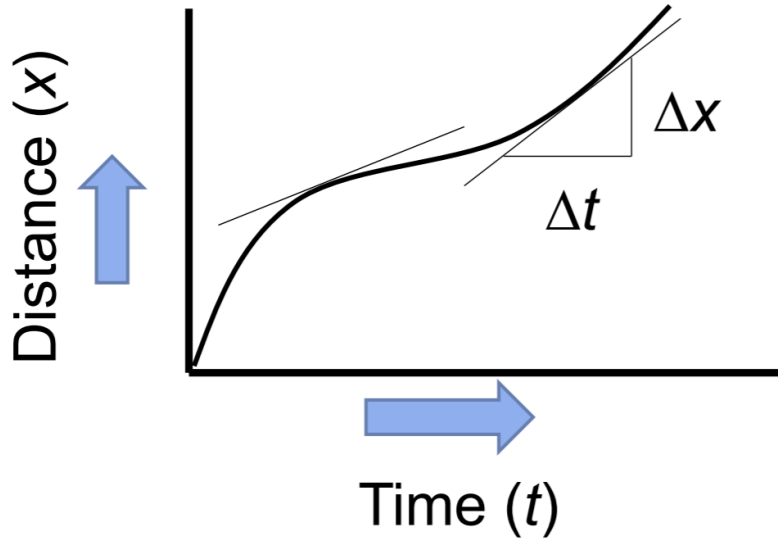
TMS = (88n+44n)/ (2n) = 66 ft/sec SMS = (88n+44*2n)/ (3n) = 58.7ft/sec

Traffic Flow Basics

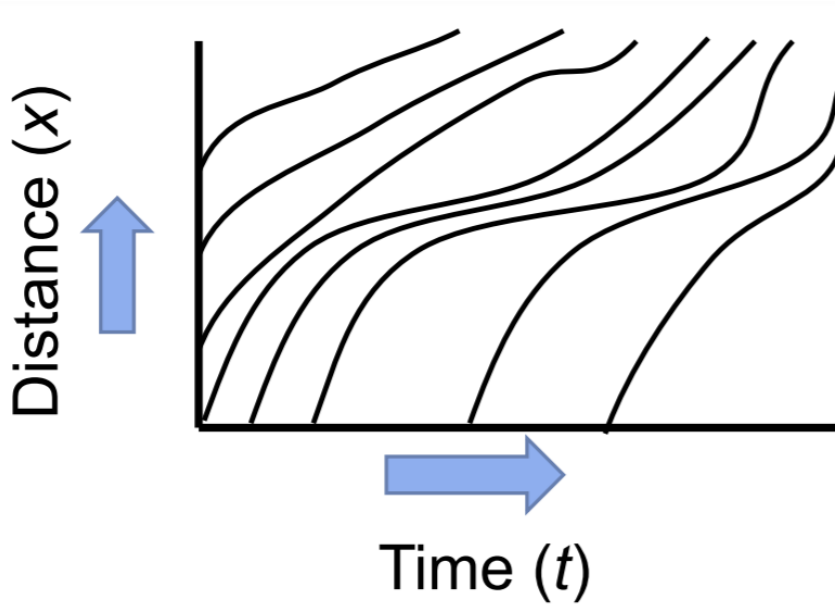
Consider a long, uninterrupted, single lane roadway:

No passing, no opposing traffic, no intersections

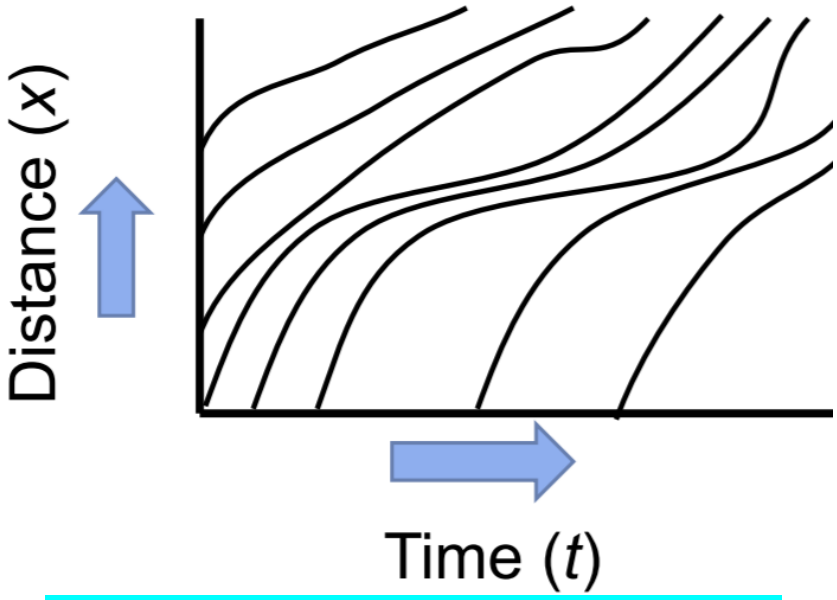




Traffic Flow Basics-Speed

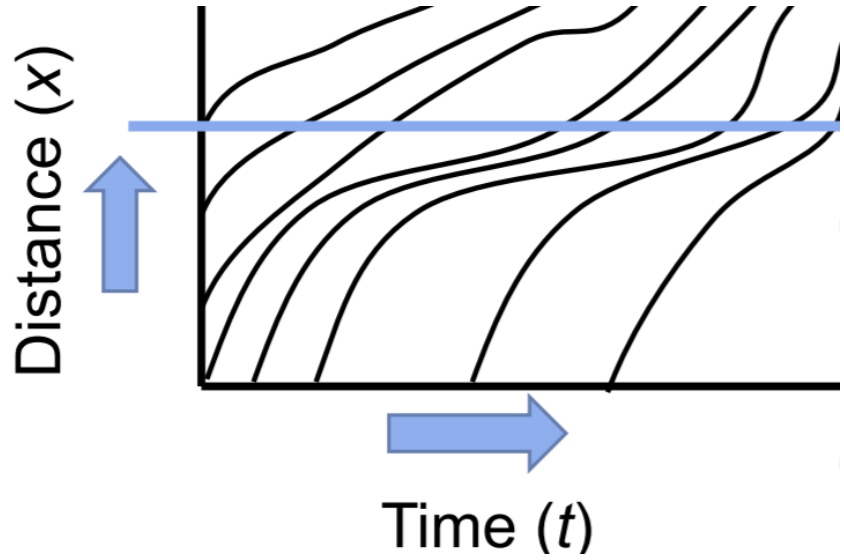


Traffic Flow Basics-Trajectories

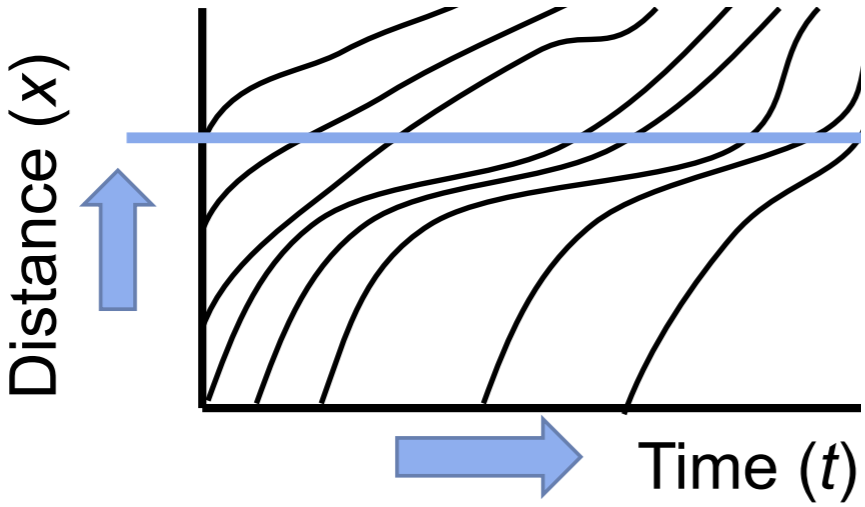


This is called a time-space diagram

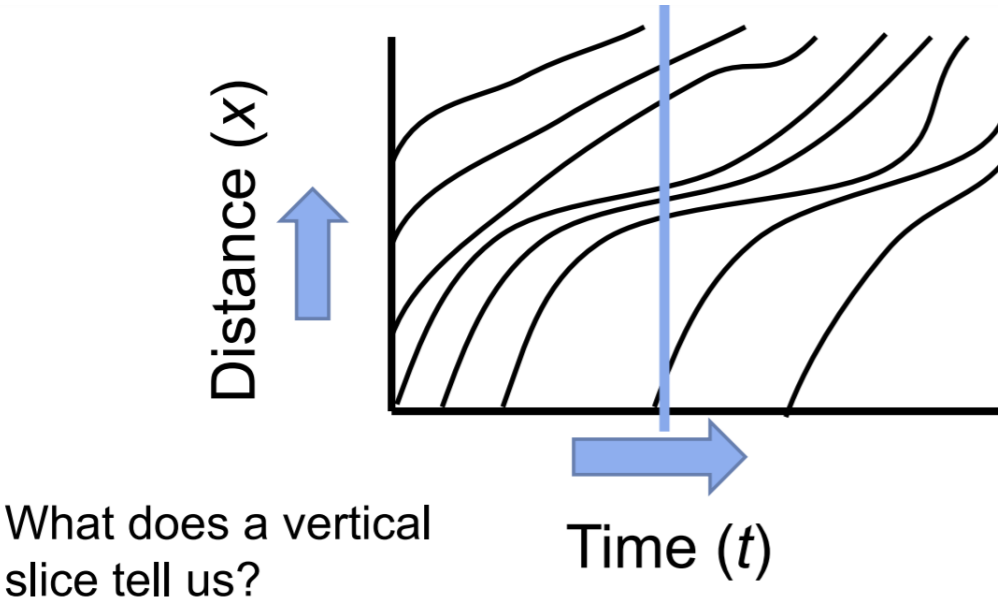
Consider a horizontal "slice" of the diagram:



The number of trajectories crossing this line is the number of vehicles passing a fixed point on the road. This is called the volume or flow, and has units of vehicles per time (usually veh/hr)



Traffic Flow Basics-Volume



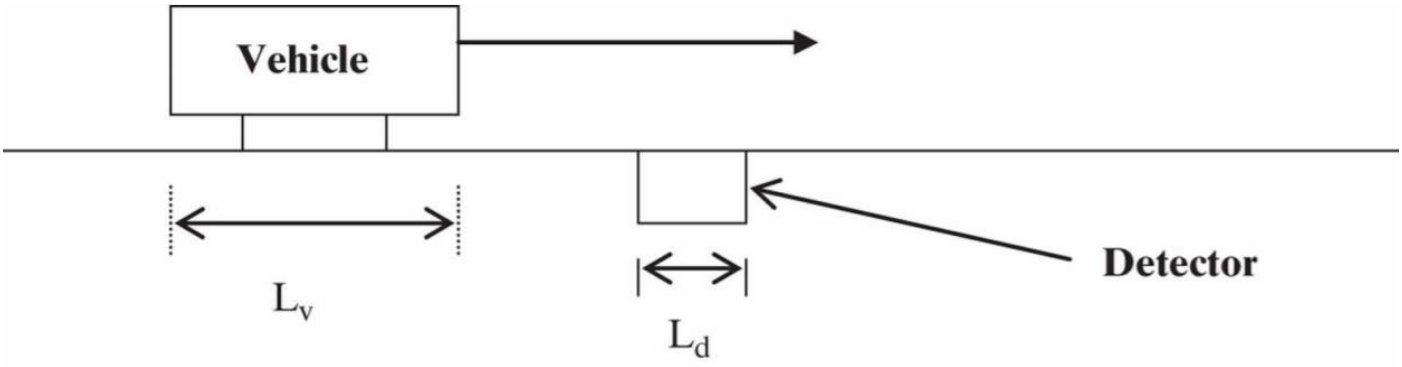
Traffic Flow Basics-Density

The number of trajectories crossing this line is the number of vehicles on the road at one instant in time. This is called the density, and has units of vehicles per distance (usually veh/mi).

Density

- Most direct measure of traffic demand.
- Difficult to measure directly.
- Important measure of quality of traffic flow.
- Occupancy is related, and can be measured directly.
- Occupancy – proportion of time that a detector is occupied by a vehicle in a defined time period.

Density and Occupancy



Density and Occupancy Illustrated