TOPIC 3

Traffic Engineering Studies

Introduction

- Several problems are associated with the highway mode of transportation including:
  1. Highway-related accidents,
  2. Parking difficulties,
  3. Congestion, and delay
- Adequate collection of data is essential in attempting to reduce the negative impacts of highways
- Traffic engineering studies address the process of adequate data collection and presentation
- They are generally grouped into three main categories:
  - Inventories:
    - Provide a list or graphical display of existing information
    - e.g. street widths, parking spaces, transit routes, …
  - Administrative studies:
    - Use existing engineering records available in government agencies to prepare inventory of relevant data
    - e.g. licensed cars and drivers, …
  - Dynamic traffic studies:
    - Involve collection of data under operational conditions
- In this section we focus on dynamic traffic studies

Dynamic traffic studies

- Involve collection of data under operational conditions and include studies of
  - Speed,
  - Traffic volume,
  - Travel time,
  - Parking, and
  - Crashes.

Spot Speed Studies

- Speed is the most common measure of the quality of traffic flow
- Types of speed include:
  - Spot speed - the instantaneous speed of a vehicle as it passes a specified point along a street or a highway
  - Overall speed – the average speed of all observed vehicle speeds
  - Running speed -The average or 85th percentile speed of all vehicles along a specific roadway as determined by the distance and the running times (travel time minus involuntary delay stops) between two selected points

Spot Speed

- Objectives of spot speed studies include:
  - Design geometric alignments
  - Analyze accident data
  - Evaluate improvements or enforcement measures (before and after studies)
- Location and duration of spot speed measurement depends on the objective of the study

Methods of Conducting Spot Speed Studies

- Methods of conducting spot speed studies can be divided into two:
  - Manual - Manual methods are seldom used
  - Automatic methods
- Automatic methods can be grouped into three main categories:
  1. Those that use road detectors
  2. Those that are radar-based – these are non-intrusive methods that utilize the doppler-principle. Examples include:
     - » Radar guns
     - » Lidar guns
  3. Methods that use the principles of electronics – These methods use electronic-principle detectors:
     - » Microwave radar based
     - » Video image processing

Methods of Conducting Spot Speed Studies

- Road detectors can be classified into two general categories:
  - Pneumatic road tubes - laid across the lane in which data are to be collected
  - Induction loops - rectangular wire loop buried under the roadway surface
- These devices can be used to collect data on speeds at the same time as volume data are being collected
- The advantage of the detector meters is that human errors are considerably reduced. The disadvantages are:
  1. These devices tend to be rather expensive and
  2. When pneumatic tubes are used, they are rather conspicuous and may, therefore, affect driver behavior, resulting in a distortion of the speed distribution.

Methods of Conducting Spot Speed Studies

Road detectors

Methods of Conducting Spot Speed Studies

Figures 4.2 (Garber & Hoel 2013)

Figure 4.2 An Example of a Sensor Setup of a Surface Detector Using Pneumatic Road Tubes

SOURCE: Photograph by Lewis Woodson, Virginia Transportation Research Council, Charlottesville, VA.

Road detectors

Figures 4.3 (Garber & Hoel 2013)

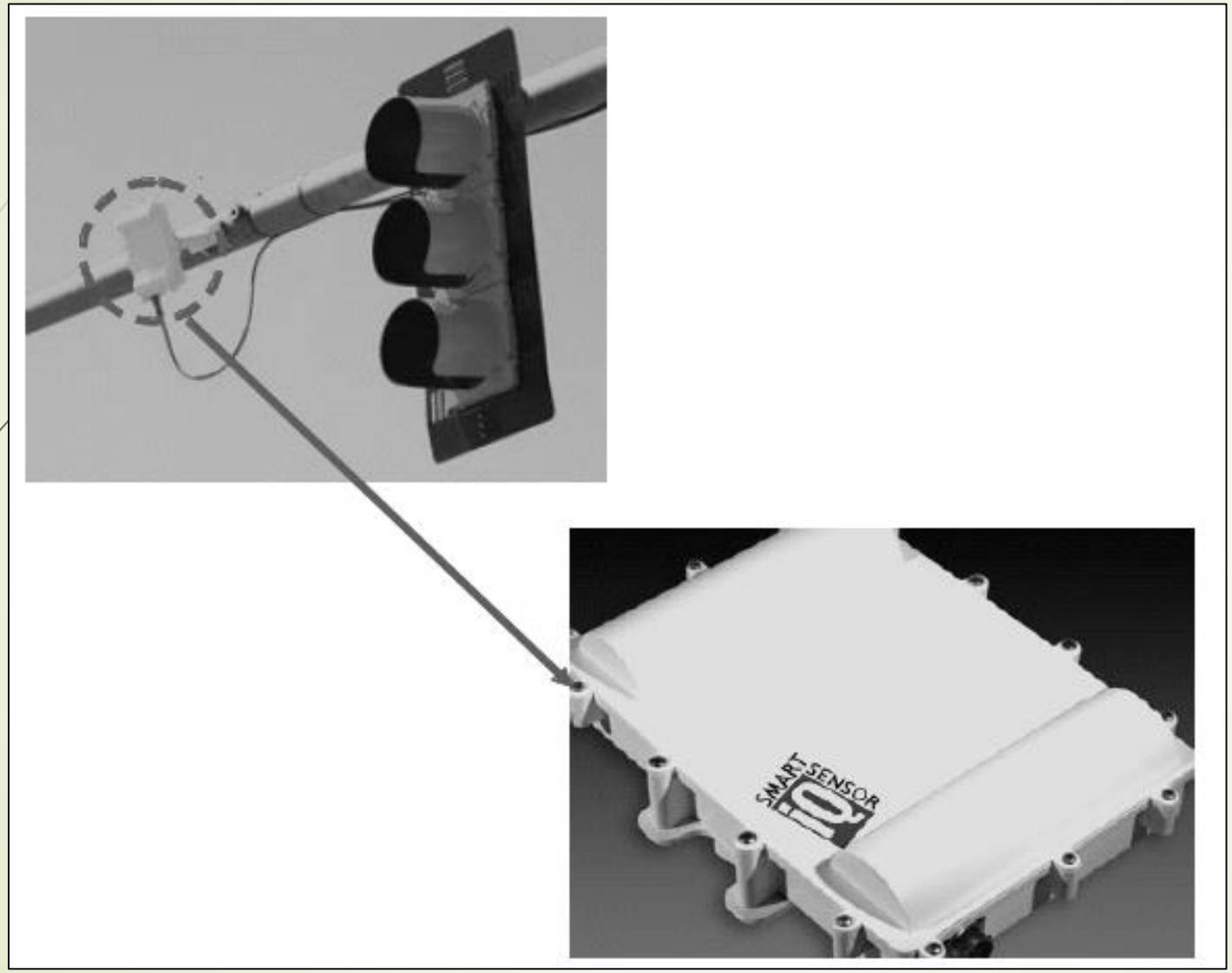
Figure 4.3 PEEK JR 161 Portable Loop Traffic Counter

SOURCE: Photograph by Lewis Woodson, Virginia Transportation Research Council, Charlottesville, VA.

Methods of Conducting Spot Speed Studies

Radar and Lidar Guns

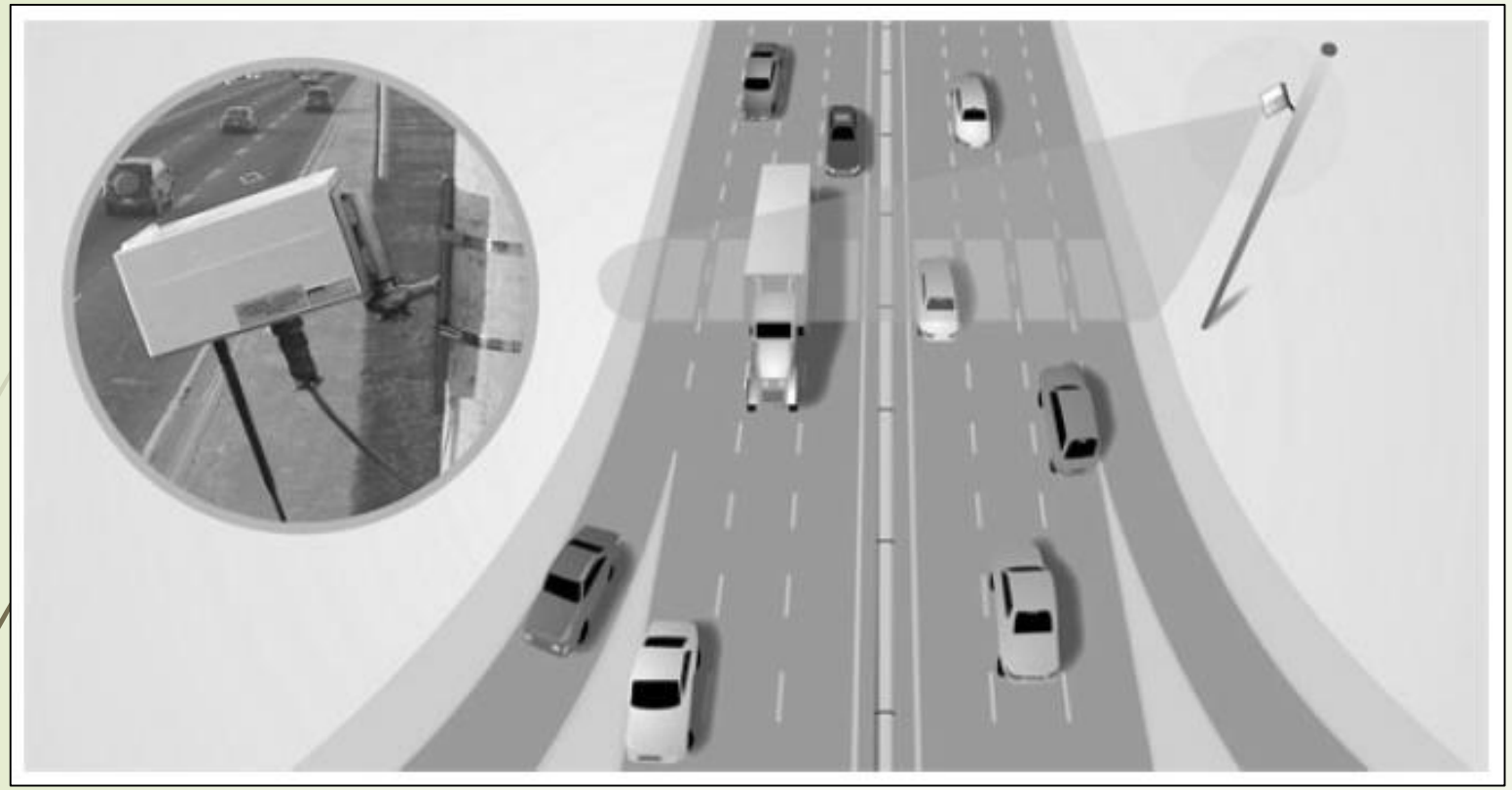
Methods of Conducting Spot Speed Studies



Figures 4.5
(Garber & Hoel 2013)

Radar-based traffic sensor in forward looking mode

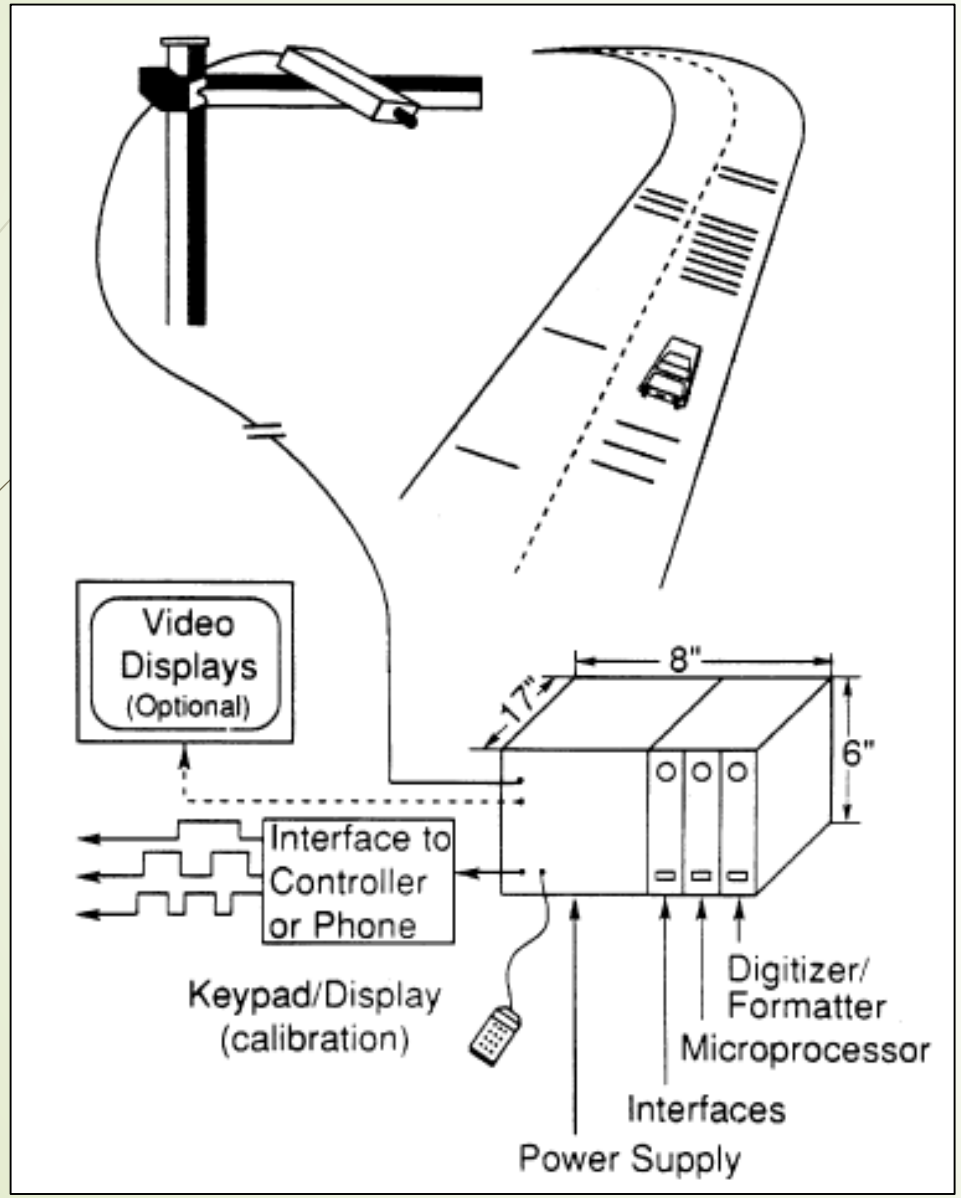
Methods of Conducting Spot Speed Studies



Figures 4.5
(Garber & Hoel 2013)

Radar-based traffic sensor deployed in side fire mode

Methods of Conducting Spot Speed Studies

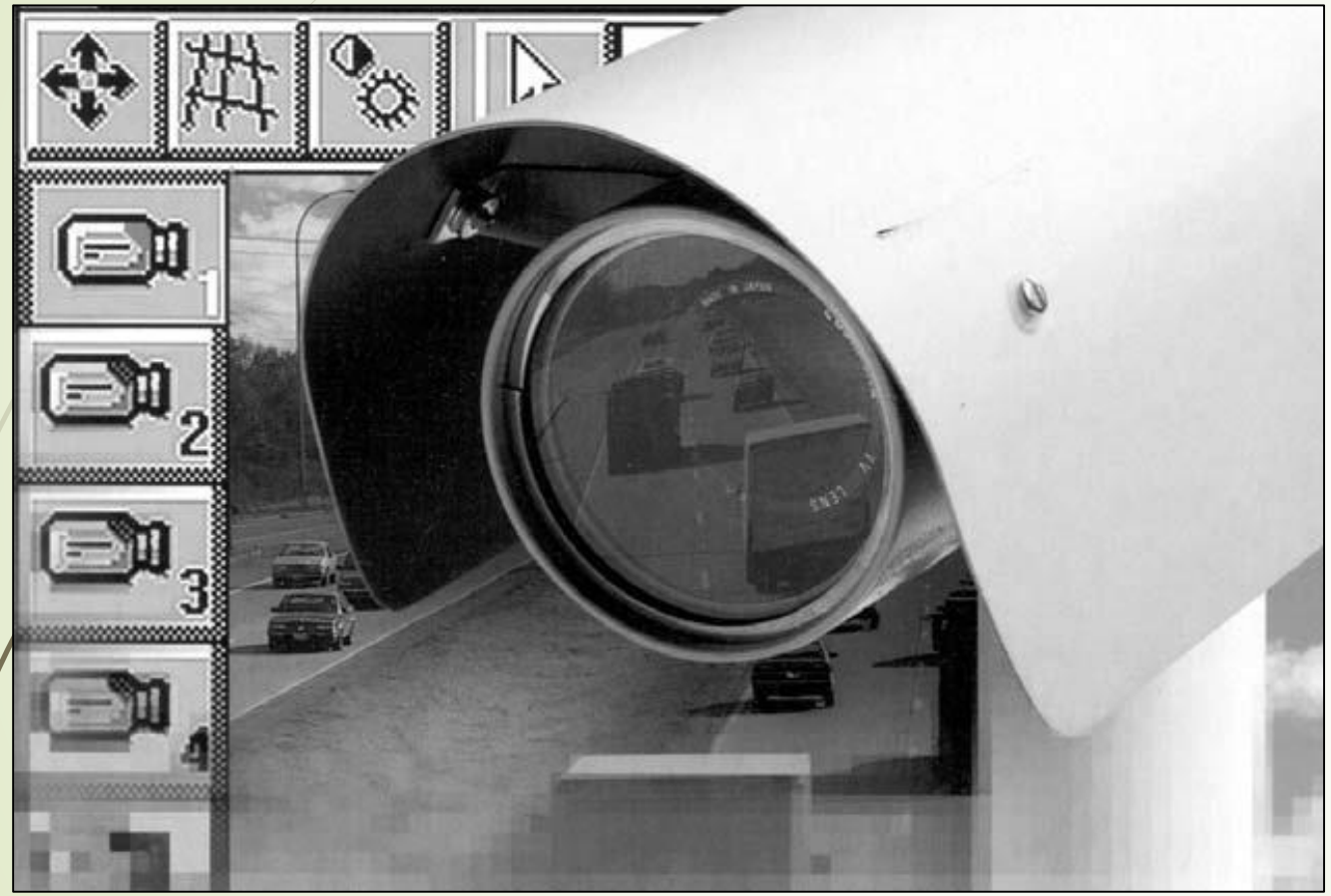


Figures 4.6 (Garber & Hoel 2013)

Electronic-Principle Detectors - Autoscope

- Advantage over loops is that it can detect traffic in many locations within the camera's field of view

Methods of Conducting Spot Speed Studies



Figures 4.6 (Garber & Hoel 2013)

Electronic-Principle Detectors – Autoscope deployed

Presentation of spot speed data:

1. Average speed:

- The arithmetic mean of all observed vehicle speeds

$$\bar{u} = \frac{\sum_{i=1}^{n} u_i}{n}$$

2. Median speed:

- The middle value in a series of spot speeds that are arranged in an ascending order

3. Modal speed:

- The most frequently observed speed

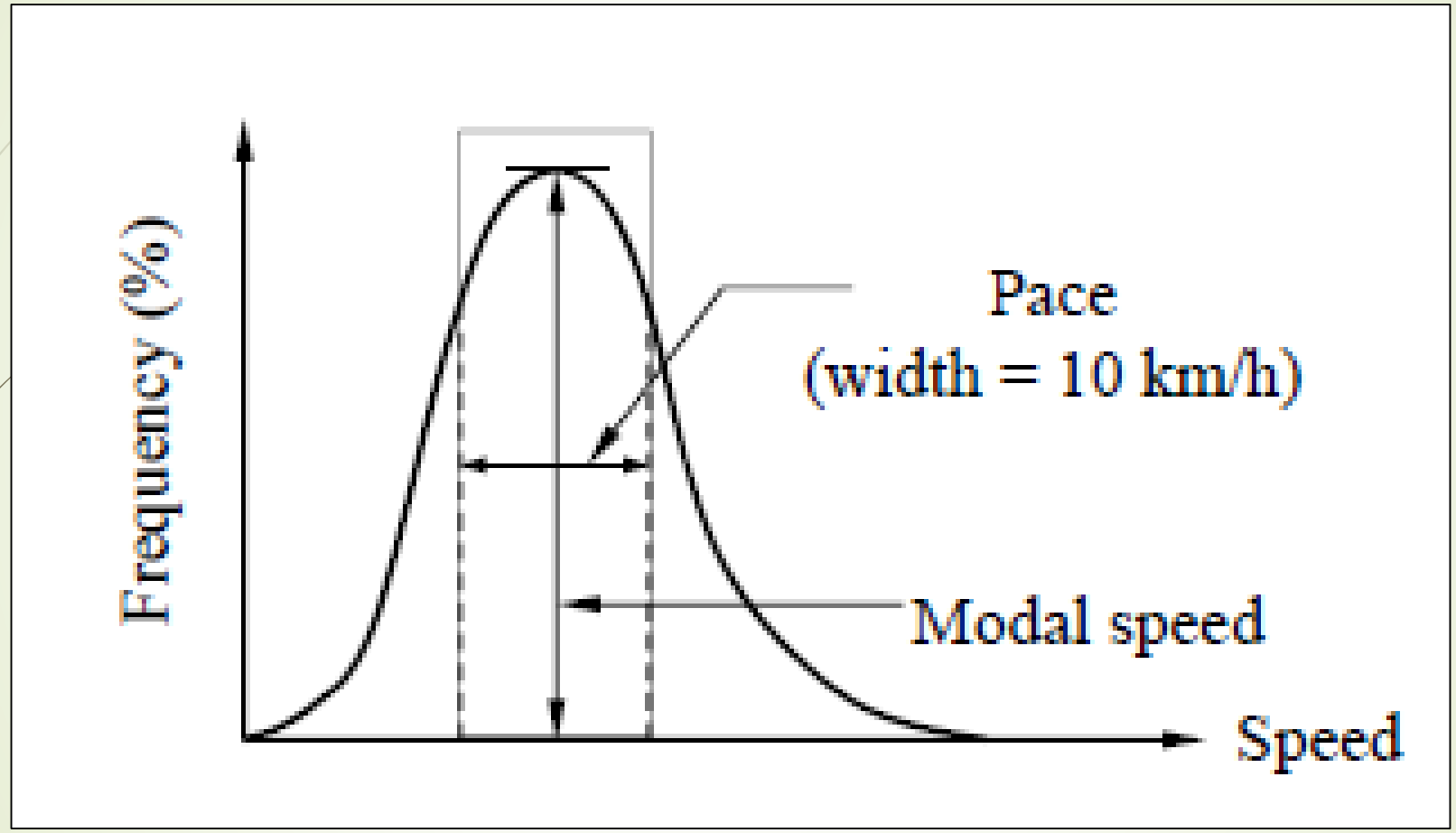
4. The i-th percentile speed:

- The spot speed below which i% of vehicles travel

5. Pace:

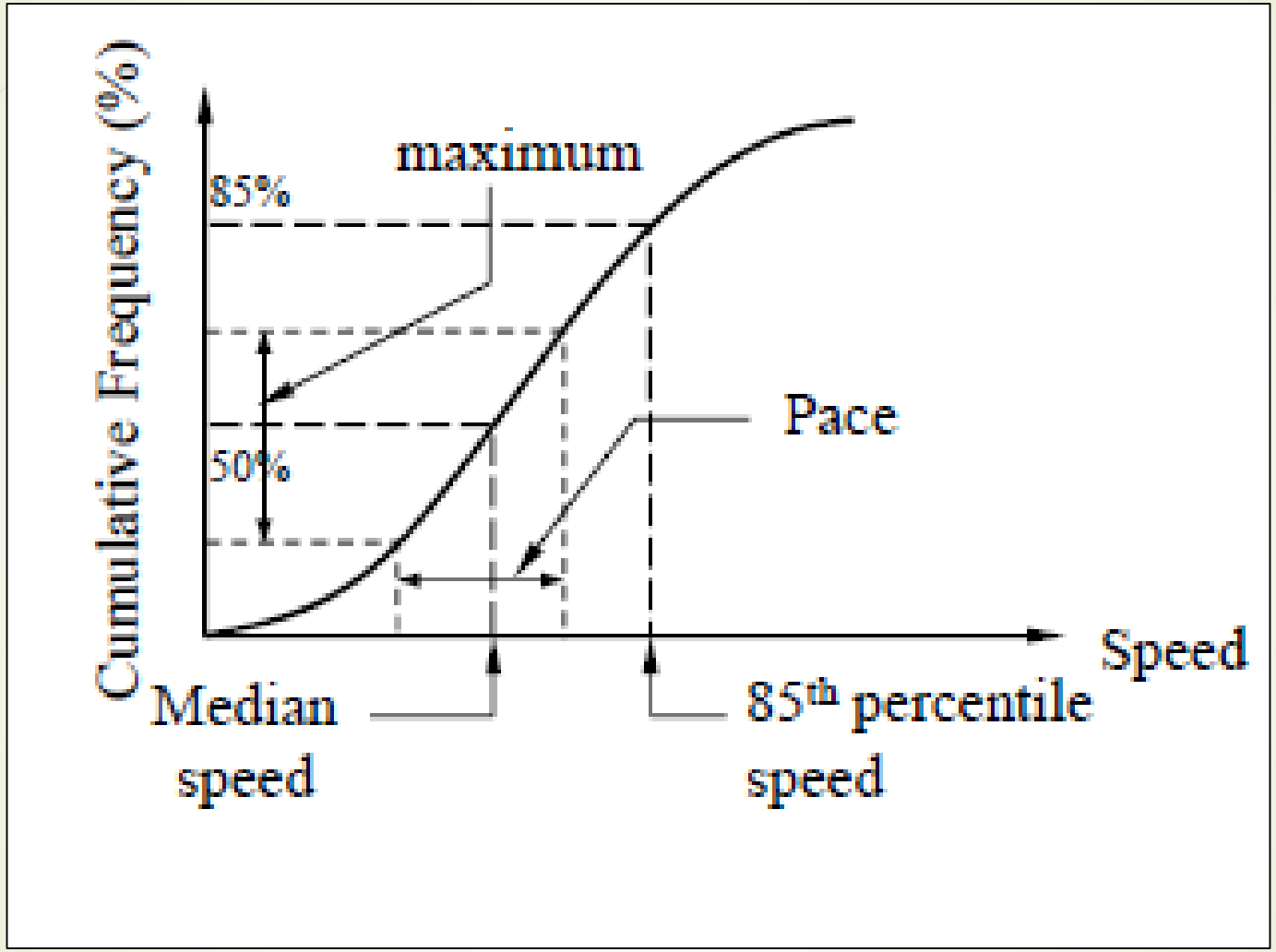
- The range of speed (10 mph or 10 km/h) that has the greatest number of observations

Presentation of spot speed data:



Speed Frequency Distribution

Presentation of spot speed data:



Speed Cumulative Distribution

Traffic Volume

- Traffic volume is defined as the number of vehicles and/or pedestrians that pass a point on a highway facility during a specified period of time
- Types of traffic volumes:
  1. **Average Annual Daily Traffic (AADT)** - The average of 24-hr counts collected everyday in the year

$$AADT = \frac{\text{Volume count in a full year}}{365}$$

AADTs are used in several traffic and transportation analyses for:

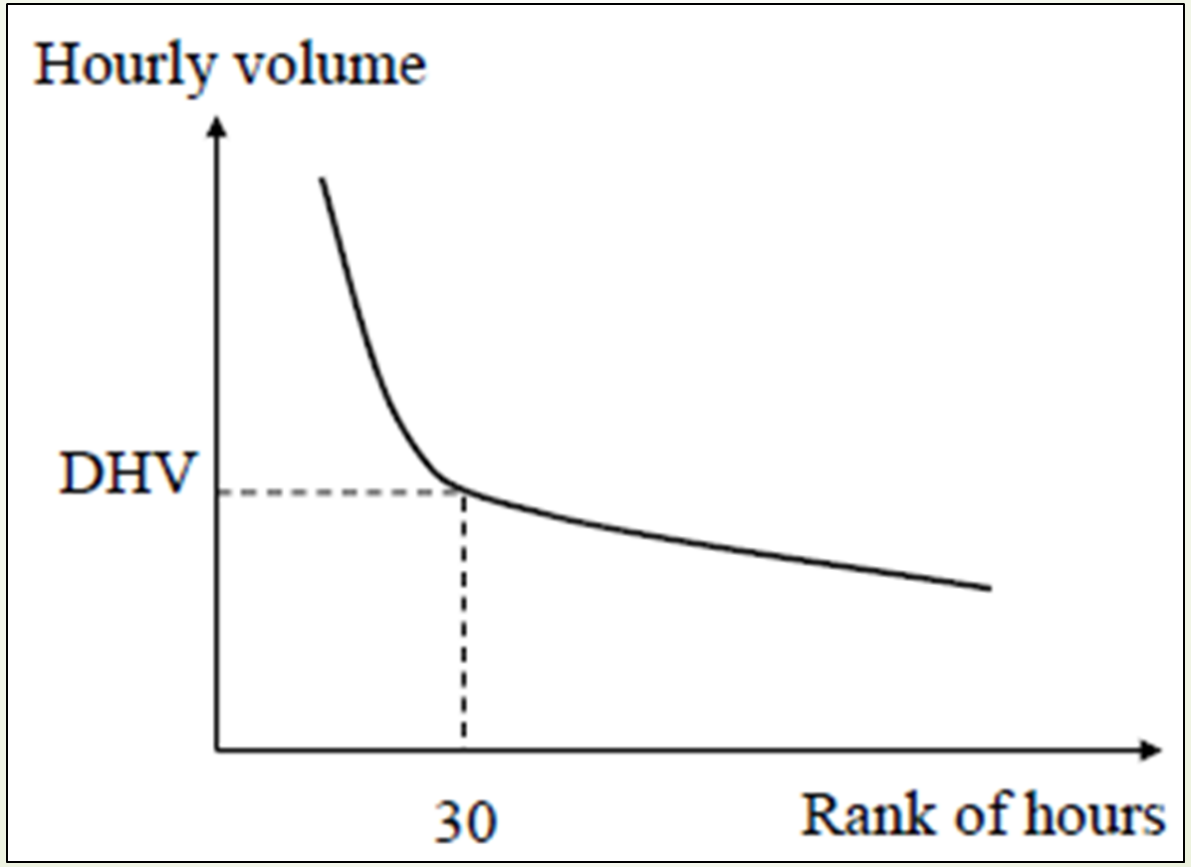
a) Estimation of highway user revenues
b) Computation of crash rates in terms of number of crashes per 100 million vehicle miles
c) Establishment of traffic volume trends
d) Evaluation of the economic feasibility of highway projects
e) Development of freeway and major arterial street systems
f) Development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

Traffic Volume

2. **Average daily traffic (ADT)** – The average of 24-hr counts collected over a number of days greater than 1 but less than a year. ADTs may be used for:
   a) Planning of highway activities
   b) Measurement of current demand
   c) Evaluation of existing traffic flow
3. **Peak hour volume (PHV)** – The maximum number of vehicles that cross a point on a highway during a period of 60 consecutive minutes. PHVs are used for:
   a) Functional classification of highways
   b) Design of the geometric characteristics of a highway, for example, number of lanes, intersection signalization, or channelization
   c) Capacity analysis
   d) Development of programs related to traffic operations, for example, one-way street systems or traffic routing
   e) Development of parking regulations

Traffic Volume

4. **Design hourly volume (DHV)** – Usually taken as the 30th hourly volume: the hourly volume that is exceeded for 29 hrs/year.



Traffic Volume

5. **Vehicle Classification (VC)** – Records volume with respect to the type of vehicles, for example, passenger cars, two-axle trucks, or three-axle trucks. VC is used in:
   a) Design of geometric characteristics, with particular reference to turning-radii requirements, maximum grades, lane widths, and so forth
   b) Capacity analyses, with respect to passenger-car equivalents of trucks
   c) Adjustment of traffic counts obtained by machines
   d) Structural design of highway pavements, bridges, and so forth
6. **Vehicle Miles of Travel (VMT)**

   – This is a measure of travel along a section of road.

   – It is the product of the traffic volume (that is, average weekday volume or ADT) and the length of roadway in miles to which the volume is applicable.

   – VMTs are used mainly as a base for allocating resources for maintenance and improvement of highways.

Traffic Volume

Relationship between AADT & DHV

$$DHV = K \times AADT$$

- The K-factor generally decreases as the AADT on a highway increases

EXHIBIT 8-9. TYPICAL K-FACTORS

Area Type	K-Factor
Urbanized	0.091
Urban	0.093
Transitioning/Urban	0.093
Rural Developed	0.095
Rural Undeveloped	0.100

Source: Florida Department of Transportation (7).

The area types in Exhibit 8-9 are defined as follows:

- Urbanized areas are those designated by the U.S. Bureau of the Census.
- Urban areas are places with a population of at least 5,000 not already included in an urbanized area.
- Transitioning areas are the areas outside of, or urbanized areas expected to be included in, an urbanized area within 20 years.
- Rural areas are whatever is not urbanized, urban, or transitioning.

Traffic Volume

Objectives of traffic volume studies – Summary

- Planning of highway activities
- Evaluation of current demand
- Functional classification of highways
- Design of geometric characteristics
- Vehicle classification

Methods of conducting volume counts

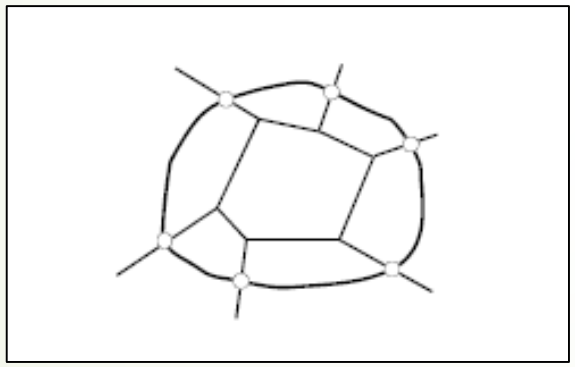
1. Manual method:
   - Observers with counters
2. Automatic counters:
   - Pneumatic tubes
   - Detectors

Traffic Volume

Types of volume counts

1. Cordon Counts:

- When information is required on vehicle accumulation within an area such as the central business district (CBD) of a city, particularly during a specific time
- The area for which the data are required is cordoned off by an imaginary closed loop; the area enclosed within this loop is defined as the cordon area



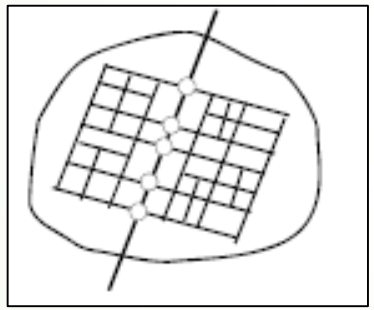
- The information obtained from such a count is useful for planning parking facilities, updating and evaluating traffic operational techniques, and making long-range plans for freeway and arterial street systems.

Traffic Volume

Types of volume counts

2. Screen Line Counts:

- In screen line counts, the study area is divided into large sections by running imaginary lines, known as screen lines, across it.
- In some cases, natural and manmade barriers, such as rivers or railway tracks, are used as screen lines.



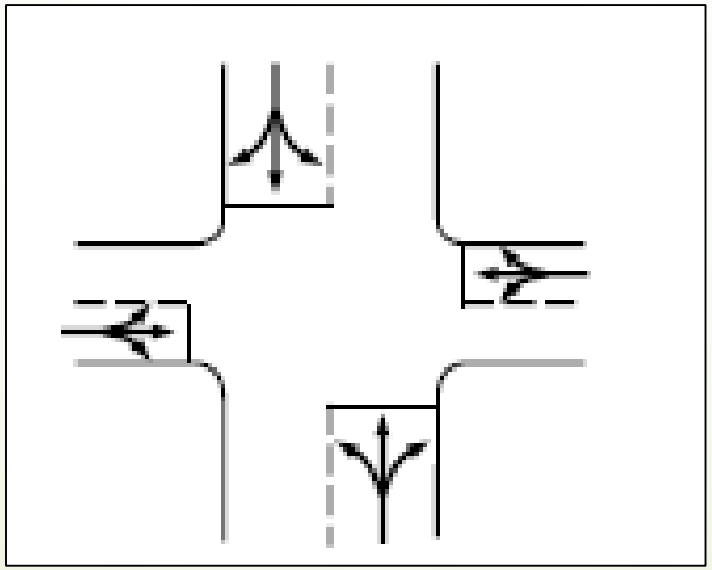
- These traffic counts facilitate the detection of variations in the traffic volume and traffic flow direction due to changes in the land-use pattern of the area.

Traffic Volume

Types of volume counts

3. Intersection counts :

- Taken to determine vehicle classifications, through movements, and turning movements at intersections.
- These data are used mainly in determining phase lengths and cycle times for signalized intersections, in the design of channelization at intersections, and in the general design of improvements to intersections.



Traffic Volume

Types of volume counts

4. Pedestrian Volume Counts:

- Volume counts of pedestrians
- They are made at locations such as subway stations, midblocks, and crosswalks.
- The counts are usually taken at these locations when the evaluation of existing or proposed pedestrian facilities is to be undertaken.
- Such facilities may include pedestrian overpasses or underpasses.

5. Periodic Volume Counts:

- In order to obtain certain traffic volume data, such as AADT, it is necessary to obtain data continuously.
- However, it is not feasible to collect continuous data on all roads because of the cost involved.
- To make reasonable estimates of annual traffic volume characteristics on an area-wide basis, different types of periodic counts, with count durations ranging from 15 minutes to continuous, are conducted
- The data from these different periodic counts are used to determine values that are then employed in the estimation of annual traffic characteristics.

Traffic Volume

Types of volume counts

5. Periodic Volume Counts:

- The periodic counts usually conducted are
  - **Continuous** - Permanent count stations :
    - Automatic count
    - 365 days/year, 24 hours/day
  - **Control** - Help establish seasonal and daily variation
    - Stations represent traffic volume on each type of highway or street
    - Two types of control stations:
    - » Major: count is monthly, 24-hr directional, at least 3 days of a week
    - » Minor: 48-hrs, non-directional, at least once every 2 years
  - **Coverage counts** - To estimate average daily traffic
    - 24-hr non-directional count every 4 years

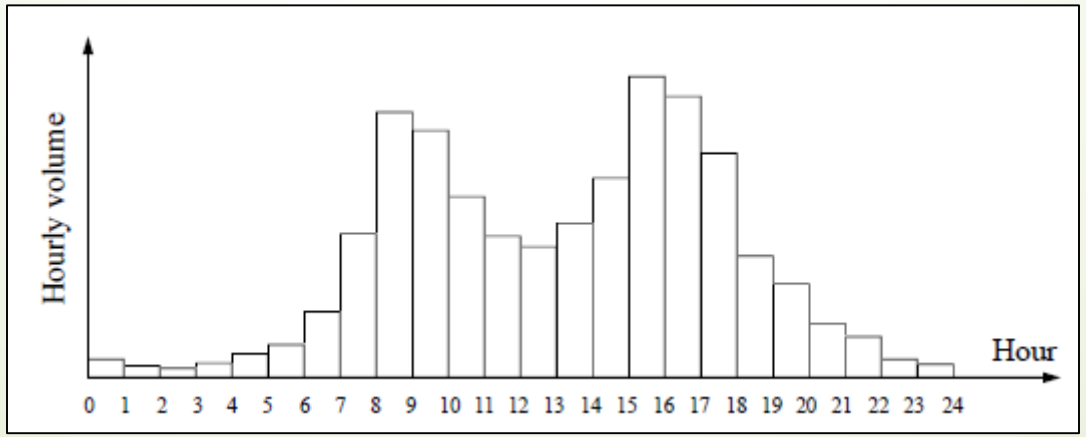
Traffic Volume

Estimation of ADT

- ADT on coverage counting stations is estimated using expansion factors obtained from a continuous or control counting station with similar characteristics
- These expansion factors account to the hourly, daily, and seasonal variations of traffic

1. **Hourly expansion factor (HEF)** – Used to expand counts of durations shorter than 24 hrs to 24-hr volumes

$$\text{HEF} = \frac{\text{Total volume for 24 – hr period}}{\text{Volume for particular hour}}$$

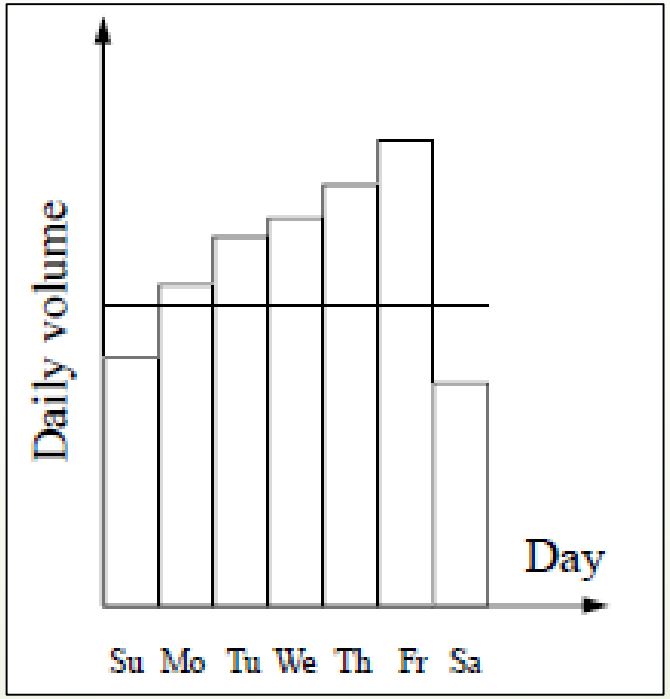


Traffic Volume

Estimation of ADT

2. **Daily expansion factor (DEF)** – Used to determine weekly volumes from counts of 24-hr duration

$$\text{DEF} = \frac{\text{Average total volume for week}}{\text{Average volume for particular day}}$$

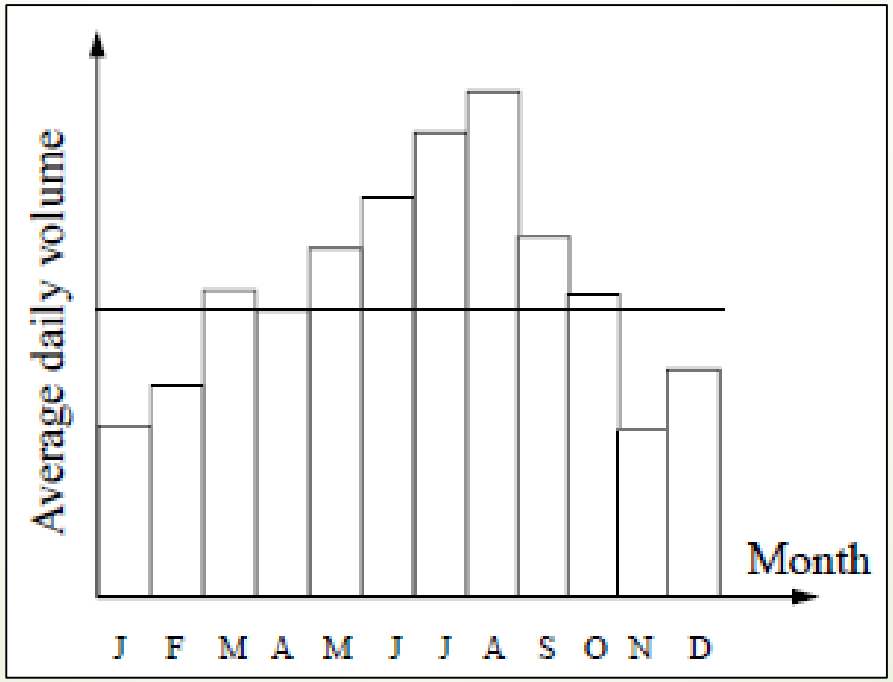


Traffic Volume

Estimation of ADT

3. **Monthly expansion factor (MEF)** – To determine AADT for a given year from the ADT for a given month

$$MEF = \frac{AADT}{ADT \text{ for particular month}}$$



Traffic Volume

	Expansion of Traffic Volume
1	Total Volume for 24 Hrs = Hourly Expansion Factor *Volume of Particular Hour
2	Total Volume for 7 Days = Daily Expansion Factor *Volume of Particular Day
3	Average Daily Traffic = (Total Volume for 7 Days)/7 = (Daily Expansion Factor *Volume of Particular Day)/7
4	Average Annual Daily Traffic = Monthly Expansion Factor *Volume (ADT) of Particular Month

Traffic Volume

Example - Estimation of ADT

The traffic volume data collected on a roadway section on a Tuesday of the month of May were:

Hour	Volume
7:00-8:00 am	400
8:00-9:00 am	535
9:00-10:00 am	650
10:00-11:00 am	710
11:00-12:00 noon	650

Traffic volume data collected

Estimate the AADT if the expansion factors determined from a similar continuous counting station are:

– DEF for Tuesday = 7.727

– MEF for May = 1.394

Hour	HEF
7:00-8:00 am	29.00
8:00-9:00 am	22.05
9:00-10:00 am	18.80
10:00-11:00 am	17.10
11:00-12:00 noon	18.52

Traffic Volume

Solution:

Use HEF's to estimate the 24-hr volume for Tuesday:

Hour	Daily volume
7:00-8:00 am	400*29.00 = 11,600
8:00-9:00 am	535*22.05 = 11,797
9:00-10:00 am	650*18.80 = 12,220
10:00-11:00 am	710*17.10 = 12,141
11:00-12:00 noon	650*18.52 = 12,038
Average volume	59,796/5 = 11,959 vpd

Use DEF to estimate the ADT for May:

$$ADT = \frac{11{,}959 \times 7.727}{7} = 13{,}201 \text{ vpd}$$

Use MEF to estimate AADT:

AADT = 13,201*1.394 = 18,402 vpd

Travel Time and Delay

- Travel time and delay studies are conducted to determine the amount of time required to travel from one point to another
- Location, duration, and causes of delay may also be investigated

Definitions:

1. **Travel time**: time taken by a vehicle to traverse a given section of a highway
2. **Running time**: the time a vehicle is actually in motion while traversing a given section of the highway
3. **Running speed**: the total distance traveled divided by the running travel time
4. **Delay**: the time lost by a vehicle due to causes beyond the control of the driver
5. **Operational delay**: that part of the delay caused by the impedance of other traffic (may be due to side friction or internal friction)
6. **Stopped-time delay**: that part of the delay during which the vehicle is at rest
7. **Fixed delay**: that part of delay caused by control devices (independent of traffic volume)
8. **Overall speed**: the total distance traveled divided by the overall travel time

Travel Time and Delay

Applications of travel time and delay data:

- Determining efficiency of a route
- Identifying locations with relatively high delays and the causes for these delays
- Before-and-after studies

Methods for conducting travel time and delay studies:

- Average speed techniques:
- Speed of the test car is the average speed of the traffic stream (in the opinion of the driver)
- Floating-car techniques:
    - An observer driving a test car that floats with the traffic (passes as many cars as those passing the test car)
- Moving-vehicle technique:
    - Observer drives in both directions and records data on traffic in both directions
- License-plate observations:
    - Observing and matching licence-plates at the beginning and end of the test section
- Interviews

Parking

- The provision of parking facilities is an essential element of the highway mode of transportation

- Types of parking facilities:

  - On-street (curb facilities):
    - Parking bays alongside the curb of one or both sides of a street
    - Would affect road capacity and traffic speed

  - Off-street:
    - Privately and publicly owned lots and garages

Parking

Definitions:

1. **Space-hour:** a unit of parking that defines the use of a single parking space for a period of 1 hr

2. **Parking volume:** total number of vehicles that park in a study area during a specific length of time(usually a day)

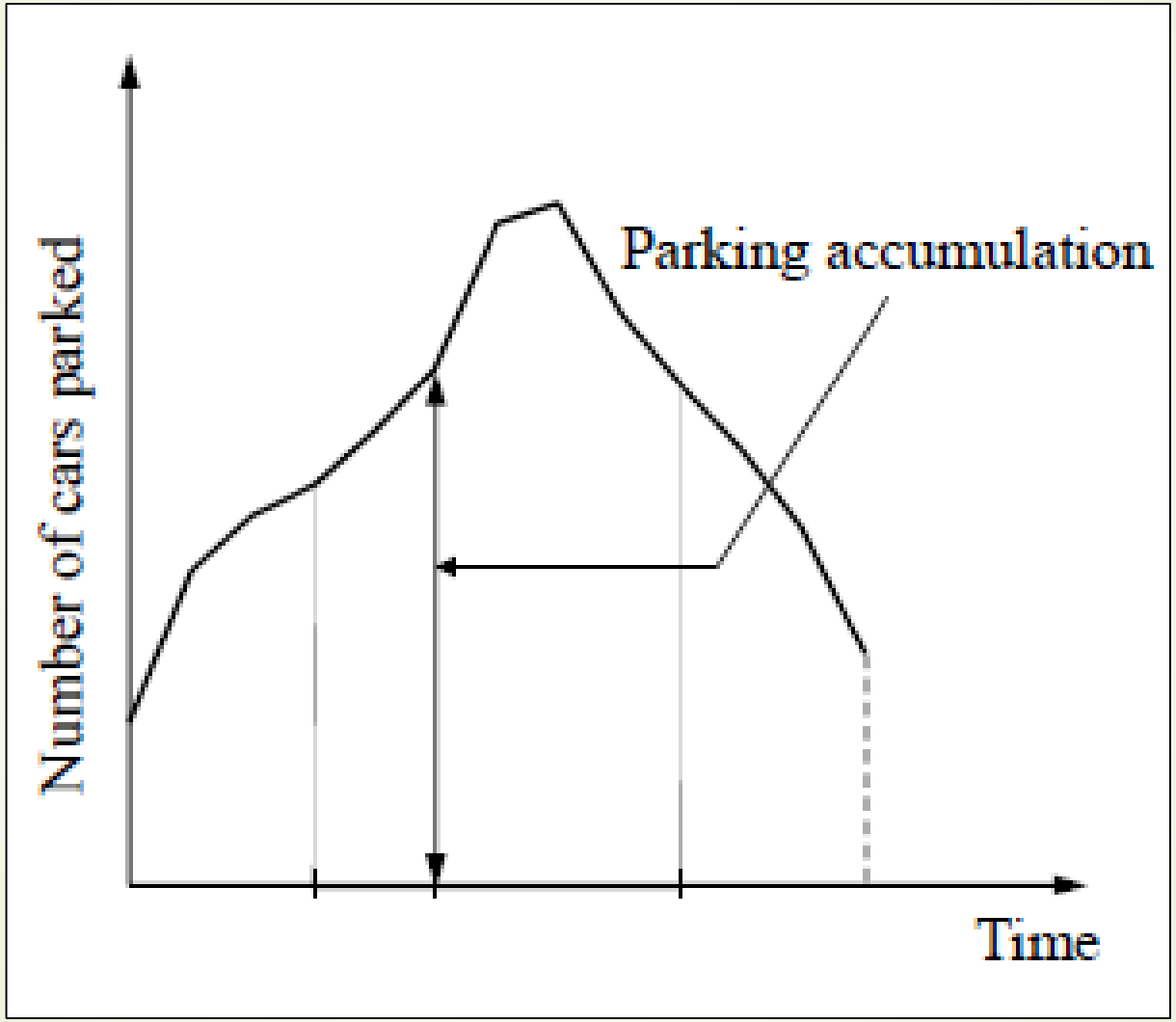
3. **Parking accumulation:** the number of parked vehicles in the study area at any specific time (usually presented in an accumulation curve)

4. **Parking load:** the number of spacehours used during a specified period of time (area under the accumulation curve between beginning and end of the time period)

5. **Parking duration:** the length of time a vehicle is parked at a parking bay

6. **Parking turnover:** the rate of use of a parking space (parking volume for a specific time period divided by the number of parking spaces

Parking



Parking

Parking Study

- A comprehensive parking study usually involves:

1. Inventory of existing parking facilities:
   – Detailed listing of the location and characteristics of each legal parking facility

2. Collection of parking data:
   – Related to volume, accumulation, turnover, duration, …

3. Identification of parking generators:
   – e.g. shopping centres, transit terminals, …

4. Collection of information on parking demand:
   – Interviewing drivers using the parking facilities

Thank You!!!