

E. ACCIDENT STUDIES

4.19 Causes of Traffic Accidents

Three major factors:

1. Human Factors
 - a) Drivers
 - b) Pedestrians
2. Vehicular Factor
3. Roadway and Environmental Factors
 - a) Unfavorable weather
 - b) Road conditions

4.20 Approaches to Highway Safety

- Improving highway safety requires consideration of the three elements influencing traffic operations: the **driver**, the **vehicle**, and the **roadway**.
- Unfortunately, the traffic engineer has effective control over only one of these elements – the roadway.
- There are several different ways in which improvements in traffic safety can be approached:

a) Reducing Accident Occurrence

- The causes of traffic accidents are many and complex, but studies show that 96% of all accidents involve some form of driver error.
- Thus, the most effective means to prevent accidents from occurring is the improvement of driver skills through training and testing programs, and the removal of drivers with bad accident and/or violation records from the highway.

b) Reducing the Severity of Accidents

- Proper use of guardrail, median barriers, breakaway signpost and light standards, for example, can reduce the damage done when a vehicle leaves the travel lane.
- These measures reduce the severity of accidents and can affect injury and fatality rates, even where accidents still occur.

c) Improving Crash Survivability

- Crash survivability primarily involves vehicle design.
- Vehicles should be designed to absorb most of the impact of an accident without transferring it to the occupants.
- Except through legislative influence, the traffic engineer has little to do with this aspect of safety.

d) Programmatic Safety Efforts

- A number of federal and state programs attempt to address traffic safety on a policy level.
- The listing below is a sampling of some of the more notable programs influencing traffic safety:
 - State vehicle inspection programs
 - National speed limit
 - Federal vehicle design standards
- Traffic engineers need to be involved in the development of these programs and to provide guidance and input to policy-makers through professional and community organizations.

e) Design Aspects of Safety

- Highway design can significantly impact traffic safety.
- Highway design features influencing safety, several are particularly vital:
 - Horizontal and vertical alignment
 - Roadside design
 - Median barriers

4.21 Accident Reports and Reporting System

General information are including:

1. Time of accident
2. Location of accident
3. Driver
4. Vehicles
5. Person injured

6. Extent of damage of vehicles
7. Location and description of traffic control devices
8. Regulations in force
9. Roadway and weather conditions
10. Possible violations
11. Probable causes
12. Diagram of accident

4.22 Accident Recording System

- The following classifications are used to characterize the manner of occurrence of motor vehicle traffic accidents:
 1. Running off road
 2. Non-collision on road
 - a) Overturning on road
 - b) Other non-collision on road
 3. Collision on road
 - a) With pedestrian with another motor vehicle in traffic
 - b) With parked motor vehicle
 - c) With railroad train
 - d) With bicyclist
 - e) With animal
 - f) With fixed object
- Furthermore, collisions between motor vehicles should be further classified on a uniform basis such as:
 1. **Angle:** Collision between vehicles moving in different directions, nor opposing directions, usually at a right angle.
 2. **Rear-End:** A vehicle being hit from behind by another vehicle moving in the same direction, usually in the same lane.
 3. **Sideswipe:** A vehicle being hit by another from the side while traveling in the same direction, or in opposite directions, usually in different lanes.
 4. **Head-on:** Collision between vehicles traveling in opposite directions (not sideswipe).

- 5. **Backing**
- 6. **Others**

4.23 Accident Statistics

1. Type of statistics

- Accident statistics are most often used to quantify and describe three principal informational elements:
 - Accident occurrence
 - Accident involvement
 - Accident severity
- Accident occurrence is generally described in terms of the types and numbers of accidents that occur, often as a rate based on population or vehicle-miles of travel.
- Involvement statistics often concentrate on the categories of vehicles and drivers involved in accidents, with population-based rates a very popular method of expressing these statistics.
- Severity is generally expressed as the numbers of deaths and/or injuries occurring.
- Rates based on the number of accidents, population, or vehicle-miles of travel are also valuable in the presentation of severity rates.

2. Accident Rate and Their Use

- Two broad categories:
 1. Population-based rates and
 2. Exposure-based rates
- Some common bases for population-based rates includes:
 - Area population
 - Number of registered vehicles
 - Number of licensed drivers
 - Highway mileage
- These values are statistic and do not depend on vehicle usage or the total amount of travel.
- The two most common bases used for exposure-based rates are:

- vehicle-miles of travel
- vehicle-hours of travel
- The two can vary widely depending on the speed of travel, and comparisons based on mileage can yield different results from those based hours of exposure.
- For point location, such as intersections, vehicle-miles or vehicle-hours have very little meaning.
- The listing that follows indicates commonly used rate bases:

Population-Based Accident Rates

1. Deaths or accidents per 100,000 area population
2. Deaths or accidents per 10,000 register vehicles
3. Deaths or accidents per 10,000 licensed drivers
4. Deaths or accidents per 1000 miles of highway

Exposure-Based Rates

1. Deaths or accidents per 100,000,000 vehicle miles
2. Deaths or accidents per 10,000,000 vehicle-hours
3. Deaths or accidents per 1,000,000 entering vehicles

Basic Accident Rates

- Three types of accident rates are characteristically computed for most jurisdictions annually:
 1. general accident rates describing total accident occurrence,
 2. fatality rates describing accident severity, and
 3. involvement rates describing the types of vehicles and drivers involved in accidents

Example 4.8: Consider the following data for City X for the year 2001:

Fatalities:	75
Fatal accident:	60
Injury accidents:	300
PDO accidents:	2000
Total involvement:	4100

Vehicles:	1,500,000,000
Registered vehicles:	100,000
Licensed drivers:	150,000
Area population:	300,000

Solution

The following fatalities rates may be computed for City X during 2001, based on these statistics:

Population-Based Accident Rates

Rate 1 = $75 \times 100,000 / 300,000 = 25$ deaths per 100,000 population

Rate 2 = $75 \times 10,000 / 100,000 = 7.5$ deaths per 10,000 registered vehicles

Rate 3 = $75 \times 10,000 / 150,000 = 5.0$ deaths per 10,000 licensed drivers

Rate 4 = $75 \times 10,000,000 / 1,500,000,000 = 5.0$ deaths per 100,000,000 vehicles-miles

Severity Index

- A widely used statistic for the description of relative accident severity is the severity Index (SI), defined as the number of fatalities per accident.

Example 4.9: For the data of the above sample problem discussed previously, there were 75 fatalities in 2630 total accidents. Find the accident Severity Index.

Solution

The Severity Index for City X in 2000 is,

$$SI = 75 / 2630 = 0.0285 \text{ deaths / accident}$$

Classic Statistical Method

- A more scientific means of selecting locations is to assume that the number of accidents at locations of interest follows a standard normal probability distribution.
- Then analysts can select those locations that appear to be significantly higher than the mean frequency or rate.
- Using this procedure, analysis will select a location if it satisfies the inequality.

$$OB_i > XA + K S$$

where: OB_i = accident frequency or rate at location i

XA = mean frequency or rate for all locations under consideration

K = constant corresponding to a level of confidence in the finding

S = sample standard deviation for all locations

- Agencies commonly use 90, 95 and 99% levels of confidence, which correspond to K values of 1.282, 1.645, and 2.327, respectively.

Example 4.10: Application of the Classic Statistical Method

Roadway section 3 has an accident rate of 210 accidents per 100 million vehicle miles (mvm). The mean accident rate for all sections in the jurisdiction is 89 per 100 mvm, and the standard deviation corresponding to this mean rate is 64 per 100 mvm. Should an analysis flag section 3 as hazardous with 95% confidence?

Solution

For these data, the inequality above holds true as follows:

$$OB_i > XA + K S$$

$$210 > 89 + (1.645 \times 64)$$

$$210 > 190$$

Therefore, one should flag section 3 as hazardous with 95 % confidence using the classic statistical method.

Rate Quality Control Method

- It differs from the classic statistical method in several important ways, including:
 - It applies only to accident rates, not frequencies.
 - It assumes that the number of accidents at a set of locations follows a Poisson distribution.

- It compares the rate of particular location to the mean rate at similar locations rather than at all locations.
- The rate quality control method can apply to spots or sections. For spots, analysts use accidents per million vehicles. For sections, analysts use accidents per mvm or per 100 mvm.
- The rate quality control method flags a location as hazardous if it satisfies the following inequality:

$$OBR_i > XS + K \left[\frac{XS}{V_i} \right]^{0.5} + \frac{1}{2 V_i}$$

where:

OBR_i = accident rate observed at location i

XS = mean accident rate for locations with characteristics similar to those of location i

V_i = volume of traffic at location i , in the same units as the accident rates are given

K = 1.282, 1.645, 2.327 for 90, 95, 99% levels of confidence

Example 4.11: Application of the Rate quality Control Method

Roadway section 3 had 40 reported accidents in 3 years, and the agency responsible for the section estimated that travel on the section was 19 mvm during that time. The mean accident rate for all sections in the jurisdiction similar to section 3 is 140 per 100 mvm. Should an analyst flag section 3 as hazardous with 95% confidence?

Solution

The rate quality control method requires the same units for each variable in the inequality, so the analyst should convert XS to 1.4 accidents per mvm to be consistent with the units given for V_i . OBR_i is 40 accidents/19 mvm = 2.1 accidents per mvm. For these data, the rate quality control inequality above holds true as follows:

$$\text{OBR}_i > \text{XS} + K \left[\frac{\text{XS}}{V_i} \right]^{0.5} + \frac{1}{2 V_i}$$

$$2.1 > 1.4 + 1.645 [1.4/19]^{0.5} + 1/(2 \times 19)$$

$$2.1 > 1.9$$

Therefore, the agency should consider section 3 hazardous with 95% confidence using the rate quality control method.

Identification of Hazardous Location by Rate Quality Control Method, RCQM

- RCQM uses the critical value of severity index rate of intersection as an index to evaluate such intersection to be either normal or hazardous.
- The critical value of Severity Index rate identified as follow:

$$R_{ic} = \lambda_o + k \sqrt{\frac{\lambda_o}{V_i}} + \frac{1}{2 V_i}$$

where:

R_{ic} = critical value of a severity index rate at intersection i

λ_o = mean of severity index rates

k = value of statistical distribution for one-tail test with specified significant level

V_i = vehicles exposure for the study period at intersection i

- An intersection can be evaluated either normal or hazardous by comparing between observed and critical values of severity index rate.
- Intersection with observed severity index rates greater than or equal to a critical value of severity index rate is classified as “**hazardous intersection**”.
- On the other hand, any intersection with observed severity index rates less than a critical value of severity index rate is classified as “**normal section**”.

3. Examples of Statistical Displays and Their Use

- Graphic and tabular displays of accident statistics can be most useful in transmitting information in a clear and understandable manner.
- If a picture is worth 1,000 words, then a skillfully prepared graph of table is at least as useful in forcefully depicting facts.
- However, in preparing and reviewing statistical displays, the engineer must know what they do not say as well as what they do say.
- Figure 4.10 is an example of a statistical display.

4. Determining High-accident Location

- A primary function of an accident record system is to regularly identify locations with an unusually high number of rates of accidents.
- As part of a manual filing system, most jurisdictions also maintain an accident spot map.
- Each time an accident report is filed, a color-coded pin or other symbol is placed on a map of the jurisdiction at the appropriate location.
- Color and/or symbol codes indicate the type and severity of the accident.
- Figure 4.11 shows a typical spot map.
- Some locations with high numbers of accidents reflect high volumes, and have relatively low accident rates.
- A small number of accidents at a remote location with low volumes may produce a high accident rate.
- Thus, while such ranking give the engineer a starting point, judgement must be applied in the identification and selection of sites most in need of improvement during any given budget year.

4.24 Site Analysis

- Perhaps the most complex task in traffic safety is the analysis of site-specific accident data to identify contributing causes and to develop site improvements.
- Once a particular location has been identified as a "high accident" location, detailed information is required in two principal areas:
 1. The occurrence of accidents at the location in question, and

2. The environmental and physical conditions existing at the location.
- A detail site investigation conducted by appropriate field personnel is required.
 - These analyses result in two graphical documents:
 1. The collision diagram, and
 2. The condition diagram.

Collision Diagram

- A collision diagram is a schematic representation of all accidents occurring at a given location over a specified period, generally from one to three years.
- Each collision is represented by a set of arrows, one for each vehicle involved, which schematically represents the type of accident and directions of all vehicles.
- Arrows are labeled with codes for vehicle types, date and time of accident, and weather conditions.
- Arrows are placed on a schematic, not-to-scale drawing of the intersection, with no interior details shown.
- One set of arrows represents one accident.
- It should be noted that arrows are not necessarily placed at the exact location of the accident on the drawing.
- Several accidents may have taken place at the same spot.
- Arrows are placed to illustrate the occurrence of the accident, as close to the actual spot as possible while still clearly indicating each accident as a separate set of symbols.
- Table 4.3 lists the standard symbols and codes used in the preparation of collisions diagrams.
- Figure 4.12 illustrates a collision diagram for an intersection.
- The intersection has experienced primarily rear-end and right-angle types of collisions, with several injuries but no deaths occurring during the period shown.
- Many of the accidents appear to be clustered at night.

- The diagram clearly points out these patterns, which now must be correlated to the physical and control characteristics of the site to determine contributing situations and corrective measures.

Condition Diagrams

- A condition diagram describes all physical and environmental conditions at the accident site under study.
- The diagram must show all geometric features of the site, the location and description of all controls (signs, signals, markings, lighting, etc.), and all relevant features of the roadside environments such as the location of objects, driveways, land uses, and so on.
- The diagram must encompass a large enough area around the location to include all potentially involved features.
- This diagram must encompass a large enough area around the location to include all potentially involved features.
- This may range from several hundred feet on intersection approaches to 1/4-1/2 mile on rural highway sections.
- Figure 4.13 illustrates a condition diagram for an intersection in a suburban community.
- This is the same intersection illustrated in the collision diagram of Figure 4.12.
- The diagram includes several hundred feet of each intersection approach and clearly shows all driveway locations and the commercial land uses they serve.
- Control details include signal locations and timing, location of all stop lines, crosswalks, and even the location of roadside trees, which could block signal visibility lines.

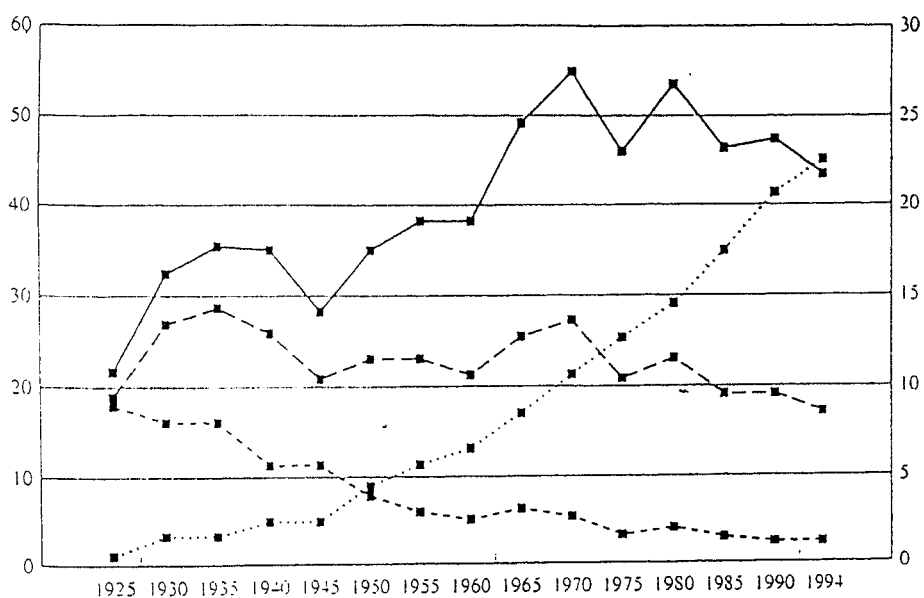


Figure 4.10 National Trends in Traffic Fatalities

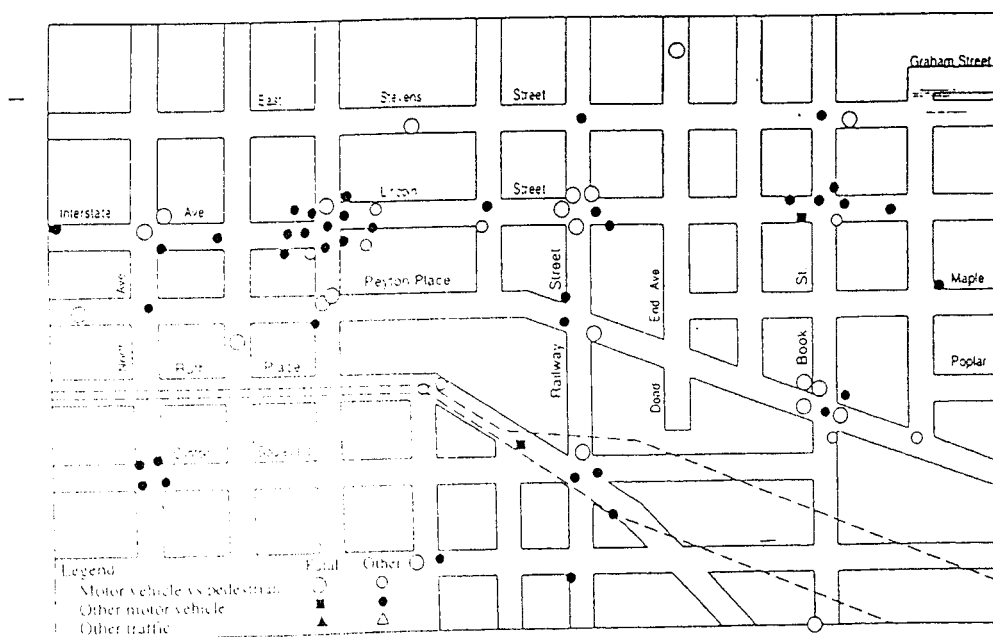


Figure 4.11 A Typical Accident Spot Map

Table 4.2 Elements of Information Required for Accident Records and Research

General	Time, date (day, month and year). Locality of event and weather conditions. Holiday period. Highway classification.
Road Users	Personal Information Age, sex, marital status, occupation, and any physical dis-abilities. Travel mode and journey purpose, and previous accident record. If a driver—experience. General Information Position of fatalities and injured. Type of injuries and property. If in vehicle—driver or passenger and number of passengers. Impairments—drink, drugs, or illness. Interview of witness and statements of events.
Vehicles	Type, make, year of manufacture. External and internal features—ornaments, etc. Condition of tyres, brakes, suspension (post accident investigation). Equipment check and functioning—lights, and vehicles. Seating capacity. Vehicle use at time and loading condition. Type of movement. Ancillary equipment—safety belts and crash helmets.
Road	Traffic Control Environment Signs (directional, mandatory, warning and information) and other controls (one-way, speed, parking, loading, bus stops, laybys, etc.) Pedestrian crossings. Road markings. Traffic Volume, speeds and traffic composition. Public service vehicles. Road Design Features Grade, alignment, width and cross-sectional elements. Intersection layout, bends, crossfall, curbs and barrier rails. Visibility distances. Street furniture. Road Surface State and type of surface. Skid resistance values. Defects. Drainage and lighting conditions. Adjacent Land Use Special buildings—schools, old people's homes, factories, etc., position of accesses. Special Consideration Movement of vehicles and pedestrians. Animals involved.

Table 4.3 Symbols Used in Accident Diagrams

Symbol used	Interpretation	Symbol used	Interpretation
Vehicle-type symbols		Accident-type symbols	
	Passenger car		Rear-end
	Truck		Head-on
	Bus		Right angle
	Cycle		Other angle (opposing directions)
	Other		Other Angle (common directions)
	Pedestrian		Sideswipe (common directions)
Movement symbols			Sideswipe (opposing direction)
	Left turn		Out-of-control
	Right turn		Collision with fixed object
	Straight		
Severity symbols			
	PDO		
	Injury		
	Fatal		

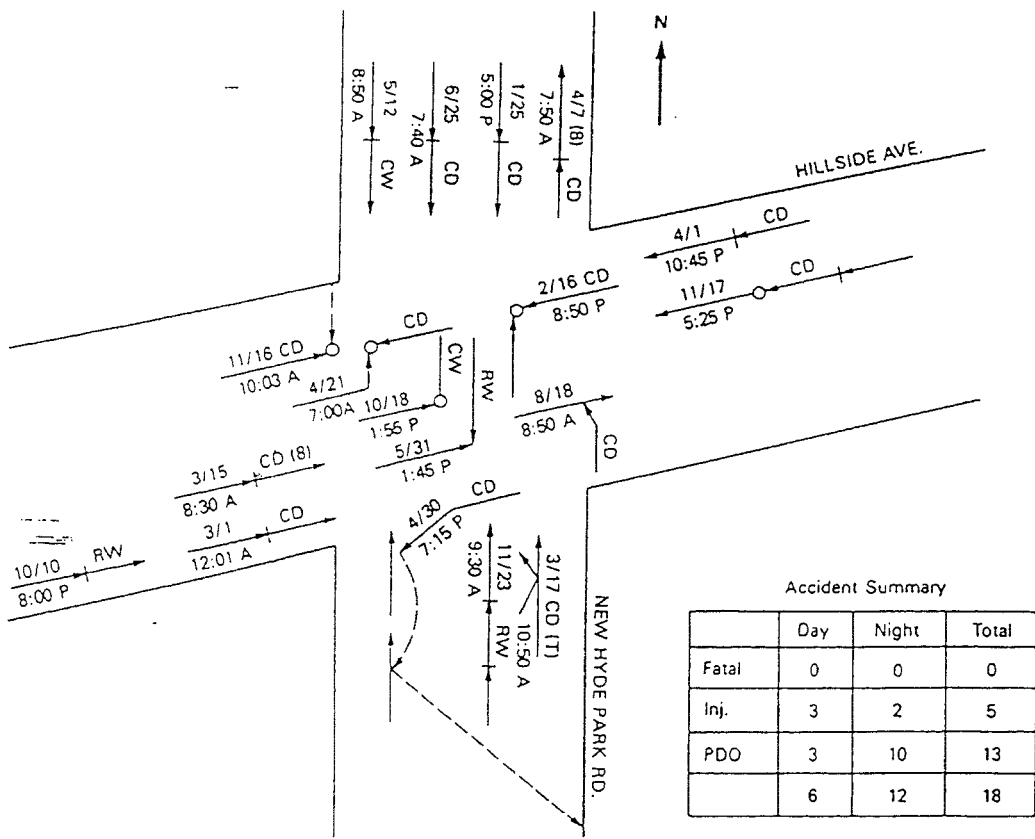


Figure 4.12 A Collision Diagram

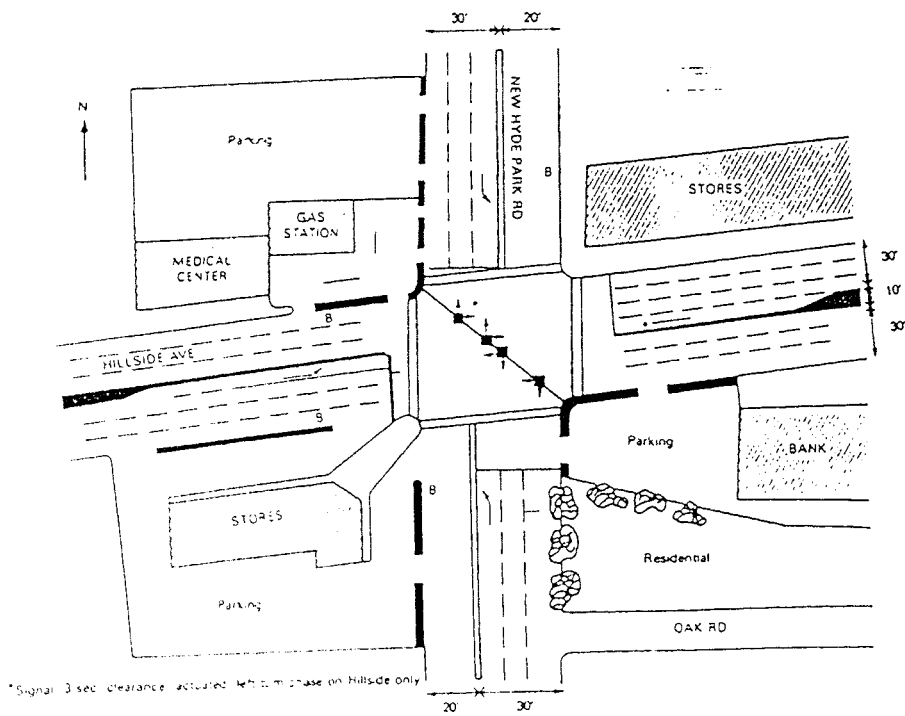


Figure 4.13 A Condition Diagram

F. INTRODUCTION TO TRANSPORTATION PLANNING

4.25 Definition

- **Planning** is a process of looking ahead, a means of preparing for the future.
- **Transportation planning** is a methodological process of preparing physical facilities and services of all modes for future transportation needs.
- **Transportation planning** is concerned with the planning, functional design, operation, and management, of facilities for any mode of transportation in order to provide for the safe, rapid, comfortable, convenient, economical, and environmentally compatible movement of people and goods.

4.26 Urban Transportation Planning

- **Objectives**
 - (1) To analyze the deficiencies of existing transportation facilities.
 - (2) To estimate future requirement.
- **General Approach**

To determine

 1. Transportation Demand... the design for movement of persons and goods.
 2. Transportation Supply... the location, capacity, and condition of transportation facilities.
- **Specific Approach**
 1. Performance of transportation studies to obtain information.
 2. Development of transportation models to organize and use of information.

4.27 Urban Transportation Planning Process (UTP)

- The Urban Transportation Planning Process (UTP) consists of 9 steps comprised of various field studies to obtain information and a series of mathematical models to utilize this information rationally.

These are:

1. Coding and zoning

The urban study area is broken down into homogenous spatial units called zones. Each is given a number. In addition, each modal network is coded numerically as a series of links. Each link begins and ends at a node.

2. Inventory Studies

Each zone is classified according to land use... residential, commercial, industrial, etc. Information is collected regarding the intensity of land use and the socio-economic characteristics of the population. Also, the capacity and condition of all links on the transportation system are determined... link capacity, link volume, link travel time, etc.

3. Travel Studies

The most important of these is the origin-destination survey, (O-D survey) which includes a transit terminal survey, and a home interview survey. The O-D identifies where and when trips begin and end, the land use at the trip ends, the purpose of the trip, the mode and route of travel, and the socio-economic characteristics of the trip maker.

Origin-destination Data

To be able to analyze trip making, the planner needs information on where trips come from, where they go, by what mode, for what purpose, and the characteristics about the trip maker and activities at the origin and destination of the trip. This information is termed origin-destination data.

O-D Survey Techniques:

- home interviews
- telephone interviews

- on-board transit surveys
- mailed questionnaires
- pick-up postal cards

Following information is usually collected:

- household characteristics:
 - no. of persons who live there;
 - nos. of cars;
 - occupation of the head of the household;
 - income etc.
- location of the origin and destination of the trip
- time at the trip started and ended
- mode of transportation
- types of activities at the origin and destination

4. Forecasts for the Horizontal Year

These require an estimate of the intensities and spatial distribution of the population, employment, land use, and the economic and social activity that the transportation system is to be designed to serve.

5. Trip Generation Analysis

The purpose of this phase is to develop equations that allow the trip ends of a particular trip type generated by each zone to be estimated from knowledge of the land use properties of those zones.

6. Trip Distribution Analysis

- For each zone, a determination is made of the zones to which its produced trips will be attracted based on the attractiveness of the potential destination points and the costs or impedance of travel.
- Trip distribution models attempt to estimate the number of trips between each pair of zones.

7. Modal Split Analysis

Modal split models are used to determine the number of person trip made by each mode of travel.

Two types of modal analysis:

- a) Pre-distribution modal split analysis
- b) Post-distribution modal split analysis

a) Pre-distribution Modal Split Analysis

Trip ends estimated in the trip generation phase are partitioned into two groups: transit captive trip ends and choice rider trip ends based on socio-economic characteristics such as income, auto ownership, age and sex.

b) Post-distribution Modal Split Analysis

The purpose of this step is to determine the proportion of trip makers traveling between each origin and destination pair that will choose competing modes, based on the time and cost of travel.

8. Network Assignment Analysis

Assignments are made for each mode to alternative route based on relationships between travel times, volumes, and capacities for the routes.

9. Evaluation

Alternatives are compared on the basis of system performance and environmental impact.

1. Trip Generation Analysis

- The purpose of this step is to develop equations that allow trip ends (?) of a particular trip type generated by each zone to be estimated from knowledge of land use properties of those zones.

(Input: Land use characteristics; output: No. of trip ends)

- What are the trip ends?

✧ Trips that originate or terminate within each zone are known as trip ends from origins or destinations, or in terms of the development of productions or attractions.

Trip Origin;	Trip Destinations
Trip Productions;	Trip Attractions

- Trip generation models attempt to estimate the number of person trips produced by, or attracted to each zone.
- For the purpose of trip generation, trips are stratified by trip purpose categories.
- (Why?...the reason for doing this is that the trip making behavior of individuals differs for different trip purposes).
- The following trip purpose categories have been used by several urban area transportation studies:

(1) Home-based work

Trip between a person's home and place of employment for the purpose of working.

(2) Home-based other

Trip between a person's home and other destination for any other purpose.

- home-based shop (shopping)
- home-based social recreation
- home-based social miscellaneous

-etc-

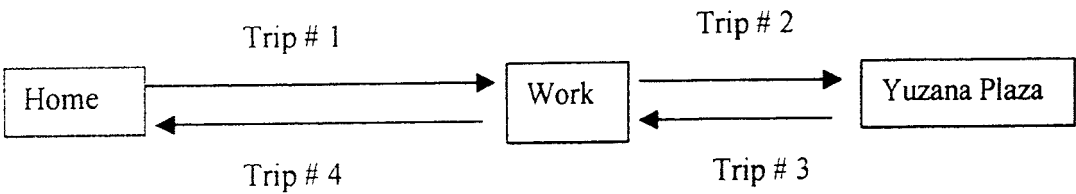
(3) Non-home based

Trip that have neither ends at home, regardless of its purpose.

(4) Truck and Taxi trips

- When person makes two journeys in the day (e.g. to work and back home), the home is both the origin and destination, as is the place of work.
- In terms of productions and attractions, however, the place of home generates two productions and the place of work generates two attractions.
- Only in the case of the non-home-based trip is the origin of the trip is the production end and the destination is the attraction end in all cases.
- (Trips that begin at a non-home location and end at another non-home location are produced at the origin and attracted to the destination).

Example 4.12: Describe trips # 1, 2, 3 and 4.



Solution

Type		Origin	Destination	Production	Attraction
Trip # 1	home-based work	Home	Work	Home	Work
Trip # 2	non-home-based	Work	Yuzana Plaza	Work	Yuzana Plaza
Trip # 3	non-home-based	Yuzana Plaza	Work	Yuzana Plaza	Work
Trip # 4	home-based work	Work	Home	Home	Work

