

UNIT- IV

TRAFFIC ENGINEERING

IV. TRAFFIC ENGINEERING

Definition:- Traffic engineering is that phase of engineering which deal with planning and geometric design of street, highway, land and with traffic operation there on as their use is related to the safe , convenient and economics transportation of person and good.

3E's Traffic Engineering

The various measure to decrease the accident rates may be divided into three groups

- (a) Engineering
- (b) Enforcement
- (c) Education

These three measure are generally termed “3E’s “. The details of these measure are given below

[A] Engineering Measure

(1) Road design :- The geometric design features of the road such as sight distance, width of the pavement, horizontal and vertical alignment design details and intersection design element are checked corrected if necessary.

(2) Preventive maintenance of vehicles:- The breaking system , steering and lighting arrangement of vehicle travel on the road may be checked at suitable interval and heavy penalties levied on the defective vehicles. These measure are particularly necessary for public carriers.

(3) Before and After Studies:- The Record of accidents and their patterns for different location are maintained by the means of collision and conditioned diagram. After making the necessary improvements in design and enforcing regulation. It is again necessary to collect and maintain the record of accidents “before and after” the introduction of preventative measure to study their efficiency.

(4) Road lighting ;- Proper road lighting can decreases the rate of accidents during night due to proper visibility . lighting in particularly desirable at intersection, bridge sites and at place where there are restriction to traffic movements.

[B] Enforcement Measure:- The various measure of the enforcement of that may be useful to prevent accidents at spot to accidents are enumerated here. The motor vehicle rules are revised from time to time to make them more comprehensive.

(1) Speed Control: - To enable drivers of buses to develop correct speedometers may be fitted so as to give the records of the speed. Also check on spot speed of all fast moving vehicle should be done at selected location and timing and legal actions on those who violate the speed limits should be limit

(2) Traffic control devices:- signal may be re- designed or signal system may be introduced if necessary. Similarly proper traffic control device like sign, marking or channelizing island may be installed wherever found necessary

(3) Training and supervision :- The transport authorities should be strict in testing and issuing license to driver of public service vehicles and taxis. Even the driver who have the pass test should be kept under proper supervision and be proper trained in proper defective driving.

[C] Educational Measure

(a) Education of road users:- It is very essential to educate the road users for the various precautionary measure to use the road way facilities with safety . The passengers and pedestrians should be taught the rules of the road, correct manner of crossing etc. this may be possible by introducing necessary instruction in the school for the children's.

(b) Safety drive:- Imposing traffic safety week when the road users are properly directed by the help of traffic police and transport staff is a common means of training the public these days.

TRAFFIC CHARACTERISTICS

Road user Characteristics

The various factor which affect road user characteristics may be broadly classified under

1. Physical
2. Mental
3. Psychological
4. Environmental

1. Physical characteristics

- i. The physical characteristics of the road users may be either permanent or temporary . the pavement characteristics are the vision, hearing, strength and the general reaction to traffic situation

- ii. Vision play the important role of all these. These includes the acute of vision, eye movement
- iii. Acute vision is within the cone whose angle is only 3 degrees through the vision is fairly satisfactory up to 10 degree in general and even up to 20 degree in the horizontal plane.
- iv. However in the vertical plan the field of the clear vision may be about two third of that in the horizontal plane. These factor are particularly taken care of while designing and installing the controlling device
- v. The total time taken for the eye movement depends on the some of the physical characteristics including light and bright light to darkness should be studied
- vi. Hearing helps driver in a way it is more important for pedestrian and cyclist
- vii. The reaction to traffic situation depend on the time required to perceive and understand the traffic situation and to take the appropriate action.
- viii. This depend on many factor such as permanent and temporary physical factor, mental and psychological set up, speed and environmental factor

2. Mental characteristics

- i. Knowledge, skill, intelligence, and experience can affect the road user characteristics
- ii. Knowledge of the vehicle characteristics, traffic behaviour, driving practice, rules of roads and psychology of road user will be quite useful for safe traffic operation
- iii. Reaction to the certain traffic situation becomes more spontaneous with experience.
- iv. Understanding the traffic regulation and special instruction and time action depend upon the intelligence and literacy.

3. Psychological characteristics

- i. These affect reaction to traffic situation of road users to a great extend.
- ii. The emotional factor such as fear, anger, superstition, impatience, general attitude towards traffic and regulation.

4. Environmental characteristics

- i. The various environmental conditions affecting the behaviour of road user are traffic stream characteristics, facilities to the traffic, atmospheric conditions and the locality.

- ii. The traffic stream may consist of mixed traffic or heavy traffic whereas the facilities to overtake for faster vehicles may be limited. The adaptability to different traffic stream characteristics depends on the driver's characteristics as well as the motivation.
- iii. The purpose of entering the traffic stream can be social, recreational, business routine movement or an emergency dash. The time, place and the route are fundamentally chosen by the road user based on the needs.
- iv. Whatever be the motive of government, once the individual enters the traffic stream, the road user, is usually motivated by the desire for the time-distance economy on the one hand, and comfort and safety on the other.
- v. Together with modifying factors of motivation there is a great variation among road users and their behaviour in every traffic stream.
- vi. The locality may be a shopping center or a place with other distractions to the road users, thus affecting their behaviour. The other environmental factors of importance are the weather visibility and other atmospheric conditions.

Vehicular Characteristics

The various factors which affect road user characteristics may be broadly classified under

1. Vehicle dimension
2. Weight of loaded vehicle
3. Power of vehicle
4. Speed of vehicle
5. Braking characteristics

1. Vehicle dimension

- i. The dimensions to be mainly considered are the overall width, height and length of the different vehicles, particularly of the largest ones.
- ii. The width of the traffic lanes, shoulder and parking facilities. If the width of the lanes are not adequate in the view of the widest vehicle using the road, the capacity of road will decrease.

- iii. Height of the vehicle affect the clearance to be provided under structure such as over bridge, under bridge and other service line.
- iv. Length of the vehicle is an important factor in the design of horizontal alignment as it affect extra width of pavement and minimum turning radius
- v. Length affect the safe overtaking distance, capacity of road and parking facilities and also considered in the design of valley curve

2. Weight of loaded vehicle

The maximum weight of loaded vehicles affect the design of pavement thickness and gradient. In fact the limiting gradient are governed by both the weight and power of the vehicle

3. Power of vehicle

- i. The power of the heaviest vehicles and their loaded weights govern the permissible and limiting values of gradient of roads.
- ii. In this regard the total resistance to traction consisting of inertia, rolling resistance, air resistance and grade resistance are considered
- iii. To determine the speed and accelerations of the vehicles which is useful in traffic regulation, planning and design

4. Speed of vehicles

The vehicle speed affects the sight distance, super elevation, length of transition curve limiting radius of transition curves, width of the pavement, design gradient, capacity of traffic lane and design and control at intersection.

5. Breaking characteristics

- i. The declaration and breaking characteristics of vehicle depend upon on the design and type of breaking system and its efficiency.
- ii. The safety of vehicle operation, stopping distance and spacing between the two consecutive vehicles in traffic stream are affected by breaking capacity.

TRAFFIC STUDIES

Traffic study or survey are carried out to analyse the traffic characteristics. These studies help in deciding the geometric design feature and traffic control for safe and efficient traffic movement. The traffic surveys for collecting traffic data are also called traffic census

The various traffic studies generally carried out are

- [A] Traffic volume study
- [B] Speed studies
 - (i) spot speed study
 - (ii) speed and delay studies
- [C] Origin and destination studies
- [D] Parking studies
- [E] Accident studies

[A] Traffic volume study

Traffic volume is the number of vehicles crossing a section of road per unit time at any selected period. Traffic volume is used as a quantity measure of flow the commonly used units are vehicle per day and vehicle per hour. A complete traffic volume study may include the classified volume study by recording the volume of various types and classes of traffic, the distribution by direction and turning movement and the distribution lanes per unit time

The objects and uses of traffic volume studies are given below:

- i. Traffic volume is generally accepted as a true measure of the relative importance of road and in deciding the priority for improvement and expansion
- ii. Traffic volume study is used in planning , traffic operation and control existing facilities and also for planning and designing the new facilities
- iii. This study is used in the analysis of traffic pattern and trends
- iv. Classified volume study is useful in structure design of pavement, in geometric design and roadway capacity
- v. Volume distribution study is used in planning one way street and other regulatory measure
- vi. Turning movement study is used in design of intersection, in planning signal timing and other control design

- vii. Pedestrian traffic volume study is used for planning side walk, cross walk, subway and pedestrian signals.

Counting of traffic volume

I] Mechanical Count

1. These may be either fixed or portable type
2. The mechanical counter can automatically record for the total number of vehicle crossing the section of the road in a desire period
3. The working may be by the effect of impulse or stimuli caused by traffic movement across the road way or by using any type of sensor
4. Traffic count is recorded by electrically operated counter and recorders capable of recording the impulses. The impulse caused by vehicle of light weight may not be enough in some cases to actuate the counter
5. It is not possible to easily record pedestrian traffic by this method and other method of mechanical detectors are by magnetic detector and radar detector
6. The main advantages of this mechanical counter is that it can work through out the day and night for the desire period.

II] Manual Count

1. This method employs a field team to record traffic volume on the prescribed record sheet
2. By this method it is possible to obtained data which can not be collected by mechanical counter such as vehicle classification, turning movement and count where the loading condition are required
3. Hence it is necessary to resort to statistical sampling techniques in order to cut down the manual hours of the day and the daily variation are observed
4. Then by selecting typical short count period, the traffic volume study made by manual counting then by statistical analysis the peak hourly traffic volume as well as the average daily traffic volumes are calculated

[B] Speed studies

The actual speed of vehicle over a particular route may be fluctuate widely depending upon the several factor such as geometric feature, traffic condition, time, place, environment and driver

1. Spot speed:- it is the instantaneous speed of vehicle at a specified section or location
2. Average speed:- it is the average of the spot speeds of all the vehicles passing a given point on the highway
3. Space mean speed:- it is the average speed of all vehicles in a certain road length at any time
4. Time mean speed:- it is the speed distribution of vehicles at as point on the roadway and it is the average of instantaneous speed of observed vehicle at the spot

There are two types of speed study

- (i) spot speed study
- (ii) speed and delay studies

(i) spot speed study

Spot mean study may be useful in any of the following aspect of traffic engineering

1. To used in planning traffic control and it traffic regulation
2. To used in geometric design for redesigning existing highway
3. To use in accident studies
4. To used the traffic capacity
5. To decide the speed trends
6. To compare diverse types of drivers and vehicles under specified condition

One of the simplest method of finding spot speed is used by using enoscope which is just a mirror box supported on tripod stand it is the simplest principle the observer is stationed on one side of the road and start the stop watch when vehicle crosses that section. An enoscope is placed at a convenient distance of say 30 m in such way that the image of the vehicles is seen by the observer when the vehicle crosses the section where the enoscope os fixed and at this is instant stop watch is stopped. Thus the time required for vehicle to cross the known length is found and it is converted to the speed in kmph. The main

advantage of this method is that it is a simple and cheap equipment and easy to use. The greatest disadvantage is that the progress is slow as it is difficult to spot out typical vehicles and number of samples observed will be less. There is also possibility of human error.

(ii) Speed and Delay studies

- A. The speed and delay studies give the overall speed, fluctuation in speed, and delay between two stations of the road spaced far apart. They also give the information such as the amount, duration, frequency and causes of the delay in the traffic stream
- B. The result of the speed and delay studies are useful in detecting spots of congestion, the causes and in arriving at a suitable remedial measure
- C. There are various methods of carrying out the speed and delay studies as follows
 - 1. floating car or riding check method
 - 2. License or vehicle number method
 - 3. interview technique
 - 4. elevated observation
 - 5. photographic technique

1. Floating car or riding check method

It is a test a vehicle over a given course of travel at approximately the average speed of the stream thus trying to float with the traffic stream. One observer seated in the floating car with two stop watches. One of the stop watches is used to record the time at various control points like intersection, bridge or any other point in each trip. The other stop watch is used to find the duration of individuals delays. The time, location and causes of the delays are recorded by the second observer either on suitable tabular form or by voice recording equipment. The number of the vehicle overtaking the test vehicle and that overtaken by the test vehicles are noted in each trip by the third observer. The number of vehicles travelling in the opposite direction in each trip is noted by third observer.

2. License or vehicle number method

Stop watches or voice recording equipment are used. Observers are stationed at the entrance and exit of the test section where information of time travel is required. the timing and the vehicle numbers are noted by the observer of the selected sample. From the office computation, travel time of each vehicle are found. But the method does not give important details such as causes of delays and the duration and number of delays within the test section.

3. Interview technique

The work can be completed in a short time by interviewing and collecting details from the road user from the spot. However the data collected may not provide with all the detail correctly.

4. Elevated observation and photographic technique

It is useful for studying short test section like intersection etc

[C] ORIGIN AND DESTINATION STUDIES

The various application of O and D studies are as follows:

1. To judge the adequacy of existing route and to use the planning new networks of roads.
2. To plan the transportation system in cities including route and schedule of operation.
3. To locate the express way or major route along the desire lines.
4. To locate the terminal and to plan the terminals facilities.
5. To locate the new bridge as per traffic demand.
6. To locate the intermediate stops or public transport.

7. To establish the design standard for the road, bridge and culverts along the routes.
8. To establish routes for various category of vehicles including by pass.

There are a number of method for collecting the O and D data. Some of the methods commonly adopted are

1. Road side interview method
2. License plate method
3. Return post card method
4. Tag-on-car method
5. Home interview method

1. Road side interview method

1. The vehicle are stopped at previously decided interview station by the group of person and answer to the prescribed questionnaires are collected on the spot.
2. The information collected include the place and time of origin and destination , route, location of stoppage, the purpose of the trip, type of vehicle and number of passenger of each vehicle.
3. The traffic may filtered through a prescribed lane by previous warning sign and with the help of police so that the each driver of the selected sample of Vehicles is interviewed.
4. In this method the data is collected quickly in short duration and the field organization is simple and the team can be trained quickly
5. The main drawback of the method is that the vehicle are stopped for interview and the delay to the vehicular movement.

2. License plate method

1. The entire area under study is cordoned out and the observer are simultaneously stationed at all the point of entry and exist on all the routes leading to and out of the area.
2. Each party at the observation station is note down the license plat number of the vehicle entering and leaving the cordoned area and the time.
3. Separate recording sheet are maintained for each direction of movement for specified time interval

4. After collecting the field data major work remains of the office computation and analysis by tracking each vehicle number and time of entering and leaving the cordoned area.

3. Returned post card method

1. Pre-paid business reply post card with return address are distributed to the road users at some selected point along the route or card are mailed to the owner of the vehicle.
2. The questionnaires to be filled by the road user is printed on the card
3. The distributing station for the cards may be selected where vehicles have to stop as in the case of toll booth.
4. The method is suitable where the traffic is heavy.

4. Tag on car method

1. In this method a pre coded card is stuck on the vehicle as it enter the area under the study
2. When the car leave the cordon area the other observation are recorded on the tag
3. This method is useful where the traffic is heavy mover continuously
4. This method gives only information regarding the point of entry and exist

[D] PARKING STUDIES

the demand by automobile user of parking space is one of the major problem of the highway transportation especially in metropolitans cities. In industrial, commercial and residential places with multi- storied building, parking demand is particularly high. Parking studies are useful to evaluate the facilities available

various aspect to be investigated during parking studies are:

(i) parking demand :

one of the method is bye making the cordon count of the selected area and recording accumulation of vehicles during the peak hours by subtracting the outgoing traffic from the traffic volume entering the cordoned area.

One other method is by counting the number of vehicle parked in the area under study during different period of the day. This method is useful when the parking demand is less than the space available for the parking. By noting the registration number of each parked vehicle at any desire time interval. It is possible to estimate the duration of vehicle at the parking area.

(ii) Parking characteristics :

The study is directed to note the present parking practices prevalent in the area under the consideration and the general problem in parking. In the case of the kerb parking it is also to necessary to study the parking patteren, interference the smooth flow of traffic.

(iii) Parking space inventory:

The area under study is full surveyed and a map is prepared showing all places where kerb parking and off street parking facilities can be provided to meet the parking demand.

[E] ACCIDENT STUDIES

Objectives of accident studies

Some objectives of accident studies are listed below:

1. To study the causes of accidents and suggest corrective measures at potential location
2. To evaluate existing design
3. To compute the financial losses incurred
4. To support the proposed design and provide economic justification to the improvement
5. suggested by the traffic engineer
6. To carry out before and after studies and to demonstrate the improvement in the problem.

Causes of road accidents

The various causes of road accidents are:

1. **Road Users** - Excessive speed and rash driving, violation of traffic rules, failure to perceive traffic situation or sign or signal in adequate time, carelessness, fatigue, alcohol, sleep etc.
2. **Vehicle** - Defects such as failure of brakes, steering system, tyre burst, lighting system.
3. **Road Condition** - Skidding road surface, pot holes, ruts.
4. **Road design** - Defective geometric design like inadequate sight distance, inadequate width of shoulders, improper curve design, improper traffic control devices and improper lighting,.
5. **Environmental factors** -unfavorable weather conditions like mist, snow, smoke and heavy rainfall which restrict normal visibility and and makes driving unsafe.

6. **Other causes** -improper location of advertisement boards, gate of level crossing not closed when required etc..

Accident Analysis

Accident data collection

The accident data collection is the first step in the accident study. The data collection of the accidents is primarily done by the police. Motorist accident reports are secondary data which are filed by motorists themselves. The data to be collected should comprise all of these parameters:

1. **General** - Date, time, person involved in accident, classification of accident like fatal, serious, minor
2. **Location** - Description and detail of location of accident
3. **Details of vehicle involved** - Registration number, description of vehicle, loading detail, vehicular defects
4. **Nature of accident** - Details of collision, damages, injury and casualty
5. **Road and traffic condition** - Details of road geometry, surface characteristics, type of traffic, traffic density etc..
6. **Primary causes of accident** - Details of various possible cases (already mentioned) which are the main causes of accident.
7. **Accident cost** - Financial losses incurred due to property damage, personal injury and Casualty

These data collected need proper storing and retrieving for the following purpose.

1. Identification of location of points at which unusually high number of accident occur.
2. Detailed functional evaluation of critical accident location to identify the causes of accidents.
3. Development of procedure that allows identification of hazards before large number of accidents occurs.
4. Development of different statistical measures of various accident related factors to give insight into general trends, common casual factors, driver profiles, etc.

Traffic Signs

Requirements

The requirements of traffic control devices are listed below:

1. **The control device should fulfill a need :** Each device must have a specific purpose for the safe and efficient operation of traffic flow. The superfluous devices should not be used.
2. **It should command attention from the road users:** This affects the design of signs. For commanding attention, proper visibility should be there. Also the sign should be distinctive and clear. The sign should be placed in such a way that the driver requires no extra effort to see the sign.
3. **It should convey a clear, simple meaning:** Clarity and simplicity of message is essential for the driver to properly understand the meaning in short time. The use of color, shape and legend as codes becomes important in this regard. The legend should be kept short and simple so that even a less educated driver could understand the message in less time.
4. **Road users must respect the signs:** Respect is commanded only when the drivers are conditioned to expect that all devices carry meaningful and important messages. Overuse, misuse and confusing messages of devices tends the drivers to ignore them.
5. **The control device should provide adequate time for proper response from the road users:** This is again related to the design aspect of traffic control devices. The sign boards should be placed at a distance such that the driver could see it and gets sufficient time to respond to the situation. For example, the STOP sign which is always placed at the stop line of the intersection should be visible for at least one safe stopping sight distance away from the stop line.

TYPES OF TRAFFIC SIGNS

There are several hundreds of traffic signs available covering wide variety of traffic situations. They can be classified into three main categories.

1. **Regulatory signs:** These signs require the driver to obey the signs for the safety of other road users.
2. **Warning signs:** These signs are for the safety of oneself who is driving and advice the drivers to obey these signs.
3. **Informative signs:** These signs provide information to the driver about the facilities available ahead, and the route and distance to reach the specific destinations

1. Regulatory signs:

These signs are also called mandatory signs because it is mandatory that the drivers must obey these signs. If the driver fails to obey them, the control agency has the right to take legal action against the driver. These signs are primarily meant for the safety of other road users. These signs have generally black legend on a white background. They are circular in shape with red borders. The regulatory signs can be further classified into :

- 1. Right of way series:** These include two unique signs that assign the right of way to the selected approaches of an intersection. They are the STOP sign and GIVE WAY sign. For example, when one minor road and major road meet at an intersection, preference should be given to the vehicles passing through the major road. Hence the give way sign board will be placed on the minor road to inform the driver on the minor road that he should give way for the vehicles on the major road. In case two major roads are meeting, then the traffic engineer decides based on the traffic on which approach the sign board has to be placed. Stop sign is another example of regulatory signs that comes in right of way series which requires the driver to stop the vehicle at the stop line.
- 2. Speed series:** Number of speed signs may be used to limit the speed of the vehicle on the road. They include typical speed limit signs, truck speed, minimum speed signs etc. Speed limit signs are placed to limit the speed of the vehicle to a particular speed for many reasons. Separate truck speed limits are applied on high speed roadways where heavy commercial vehicles must be limited to slower speeds than passenger cars for safety reasons. Minimum speed limits are applied on high speed roads like expressways, freeways etc. where safety is again a predominant reason. Very slow vehicles may present hazard to themselves and other vehicles also.
- 3. Movement series:** They contain a number of signs that affect specific vehicle maneuvers. These include turn signs, alignment signs, exclusion signs, one way signs etc. Turn signs include turn prohibitions and lane use control signs. Lane use signs make use of arrows to specify the movements which all vehicles in the lane must take. Turn signs are used to safely accommodate turns in unsignalized intersections.
- 4. Parking series:** They include parking signs which indicate not only parking prohibitions or restrictions, but also indicate places where parking is permitted, the type of vehicle to be parked, duration for parking etc.
- 5. Pedestrian series:** They include both legend and symbol signs. These signs are meant for the safety of pedestrians and include signs indicating pedestrian only roads, pedestrian crossing sites etc.



Figure : Examples of regulatory signs (stop sign, give way sign, signs for no entry, sign indicating prohibition for right turn, vehicle width limit sign, speed limit sign)

2. Warning signs

Warning signs or cautionary signs give information to the driver about the impending road condition. They advise the driver to obey the rules. These signs are meant for the own safety of drivers. They call for extra vigilance from the part of drivers. The color convention used for this type of signs is that the legend will be black in color with a white background. The shape used is upward triangular or diamond shape with red borders. Some of the examples for this type of signs are given in figure and includes right hand curve sign board, signs for narrow road, sign indicating railway track ahead etc.



Figure : Examples of cautionary signs (right hand curve sign board, signs for narrow road, sign indicating railway track ahead)

3. Informative signs

Informative signs also called guide signs, are provided to assist the drivers to reach their desired destinations. These are predominantly meant for the drivers who are unfamiliar to the place. The guide signs are redundant for the users who are accustomed to the location. Some of the examples for these type of signs are route markers, destination signs, mile posts, service information, recreational and cultural interest area signing etc. Route markers are used to identify numbered highways. They have designs that are distinctive and unique. They are written black letters on yellow background. Destination signs are used to indicate the direction to the critical destination points, and to mark important intersections. Distance in kilometers. They are, in general, rectangular with the long dimension in the horizontal direction. They are color coded as white letters with green background.

Mile posts are provided to inform the driver about the progress along a route to reach his destination. Service guide signs give information to the driver regarding various services such as food, fuel, medical assistance etc. They are written with white letters on blue background. Information on historic, recreational and other cultural area is given on white letters with brown background. In the figure 28:3 we can see some examples for informative signs which include route markers, destination signs, mile posts, service center information etc.

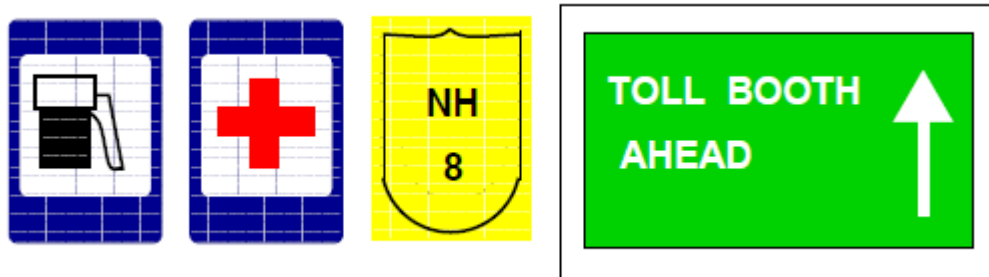


Figure : Examples of informative signs (route markers, destination signs, mile posts, service center information etc)

INTELLIGENT TRANSPORTATION SYSTEM (ITS)

1. intelligent transportation system are advance application without embodying intelligence as such, aim to provide innovative series relating to different modes of transport and traffic management and enable various user to be better informed and make safer, more coordinated and smarter use of transport networks.
2. The goal of intelligent transportation system is to improve the effectiveness, efficiency and safety of the transportation system.
3. Long range planning of the development of ITS technologies depend in the part of knowledge of which technologies are more effective. The benefits of the ITS are as follows:

[A] SAFETY:- typical measure include overall number of crashes and changes in crash, injury, fatality rates and measure vehicle speed, speed variability or changes in the number of violation of traffic safety law.

[B] MOBILITY:- typical measure include the amount of delay and variability of travel time.

[C] CAPACITY OR THROUGHPUT:- Capacity is measure by the maximum number of person or vehicle per hour at a point. Throughput is the number of person, goods or vehicles traversing a roadway section per unit time.

[D] CUSTOMER SATISFACTION:- Measure related to satisfaction include the amount of travel in various modes, modes of choice and quality of service as well as volume of complaints or compliments received. Typical result reported for customer satisfaction with a product awareness, expectation of benefits, product use, response, realization of benefits.

[E] PRODUCTIVITY:- Measure includes operational efficiency and cost saving.

[F] ENERGY AND ENVIRONMENT:- The measure of effectiveness include the changes in emission level and energy consumption. specific measure for fuel use and emission level includes kilogram or tons of pollutants for carbon monoxide, hydrocarbon, volatile organic compound