Chapter 3

INTELLIGENT TRANSPORT SYSTEMS

3.1 INTELLIGENT TRANSPORT SYSTEM (ITS) (June-2022)

An **intelligent transportation system (ITS)** is an advanced application which aims to provide innovative services relating to different modes of transport and traffic management and enable users to be better informed and make safer, more coordinated, and 'smarter' use of transport networks.

Intelligent Transport Systems (ITS) are the control and information systems that use integrated communications and data processing technologies for the various purposes.

⇨ **Purposes/Objectives of ITS:**

- improving the mobility of people and goods
- increasing safety, reducing traffic congestion and managing incidents effectively
- meeting transport policy goals and objectives – such as demand management or public transport priority measures.
- Make transportation system more efficient, secure, and safer through the use of information, communications and control technologies.
- Improve the attractiveness of public transport.
- Tackle rising congestion which increases travel times and industry costs.
- Reduce the environmental impacts of transport.
- Save energy, reduce carbon foot print
- improve traffic flow by reducing congestion
- quickly detect incidents and appropriately respond to them
- improve air quality by reducing pollution levels locally and minimizing travel delay
- improve safety by providing advance warning before potential crash situations
- minimize the impacts of environmental, highway and human factors that contribute to accidents

Some of these technologies include calling for emergency services when an accident occurs, using cameras to enforce traffic laws or signs that mark speed limit changes depending on conditions.

ITS is defined as systems in which information and communication technologies are applied in the field of road transport, including infrastructure, vehicles and users, and in traffic management and mobility management, as well as for interfaces with other modes of transport. ITS may improve the efficiency and safety of transport in a number of situations, i.e. road transport, traffic management, mobility, etc. ITS technology is being adopted across the world to increase capacity of busy roads and reduce journey times.

With the conception of smart city transmuting cities into digital societies, making the life of its citizens easy in every facet, Intelligent Transport System becomes the indispensable component among all. In any city mobility is a key concern; be it going to school, college and office or for any other purpose citizens use transport system to travel within the city. Leveraging citizens with an Intelligent Transport System can save their time and make the city even smarter. Intelligent Transport System (ITS) aims to achieve traffic efficiency by minimizing traffic problems. It enriches users with prior information about traffic, local convenience real-time running information, seat availability etc. which reduces travel time of commuters as well as enhances their safety and comfort.

The application of ITS is widely accepted and used in many countries today. The use is not just limited to traffic congestion control and information, but also for road safety and efficient infrastructure usage. Because of its endless possibilities, ITS has now become a multidisciplinary conjunctive field of work and thus many organizations around the world have developed solutions for providing ITS applications to meet the need.

➪ **ITS : Key Drivers and Tools :**

- Information technology
- Communications technology
- Mobile Apps
- Cloud computing
- Sensors
- Cameras
- GPS
- Digital radio RFID (Radio Frequency Identification)

➪ **Intelligent transport technologies are:**

- car navigation;
- traffic signal control systems;
- container management systems;
- variable message signs;
- automatic number plate recognition,
- speed cameras to monitor applications, such as security CCTV systems,
- automatic incident detection or stopped vehicle detection systems,
- parking guidance and information systems;
- weather information; bridge de-icing (US deicing) systems;

➪ **Application areas of Intelligent Transport System**

The entire application of ITS is based on data collection, analysis and using the results of the analysis in the operations, control and research concepts for traffic management where location plays an important role.

Here sensors, information processors, communication systems, roadside messages, GPS updates and automated traffic prioritization signals play an imperative role in the application of various systems:

Applications of ITS :

1. Real-time parking management
2. Electronic toll collection

3. Emergency vehicle notification systems
4. Automated road speed enforcement
5. Speed alerts
6. RFID in freight transportation
7. Variable speed limits
8. Dynamic traffic light sequence
9. Collision avoidance systems

Traffic Management Centre (TMC) is the vital unit of ITS. It is mainly a technical system administered by the transportation authority. Here all data is collected and analyzed for further operations and control management of the traffic in real time or information about local transportation vehicle.

Well-organized and proficient operations of Traffic Management Centre depends on automatized data collection with precise location information than analysis of that data to generate accurate information and then transmitting it back to travelers. Let's understand the entire process in a more detailed way.

Data collection: Strategic planning needs precise, extensive and prompt data collection with real-time observation. So the data here is collected via varied hardware devices that lay the base of further ITS functions. These devices are Automatic Vehicle Identifiers, GPS based automatic vehicle locators, sensors, camera etc. The hardware mainly records the data like traffic count, surveillance, travel speed and travel time, location, vehicle weight, delays etc. These hardware devices are connected to the servers generally located at data collection centre which stores large amounts of data for further analysis.

Data Transmission: Rapid and real-time information communication is the Key to proficiency in ITS implementation so this aspect of ITS consists of the transmission of collected data from the field to TMC and then sending back that analyzed information from TMC to travelers. Traffic-related announcements are communicated to the travelers through internet, SMS or onboard units of Vehicle. Other methods of communications are dedicated short-range communications (DSRC) using radio and Continuous Air Interface Long and Medium Range (CAILM) using cellular connectivity and infra-red links.

Data Analysis: The data that has been collected and received at TMC is processed further in various steps. These steps are error rectification, data cleaning, data synthesis, and adaptive logical analysis.

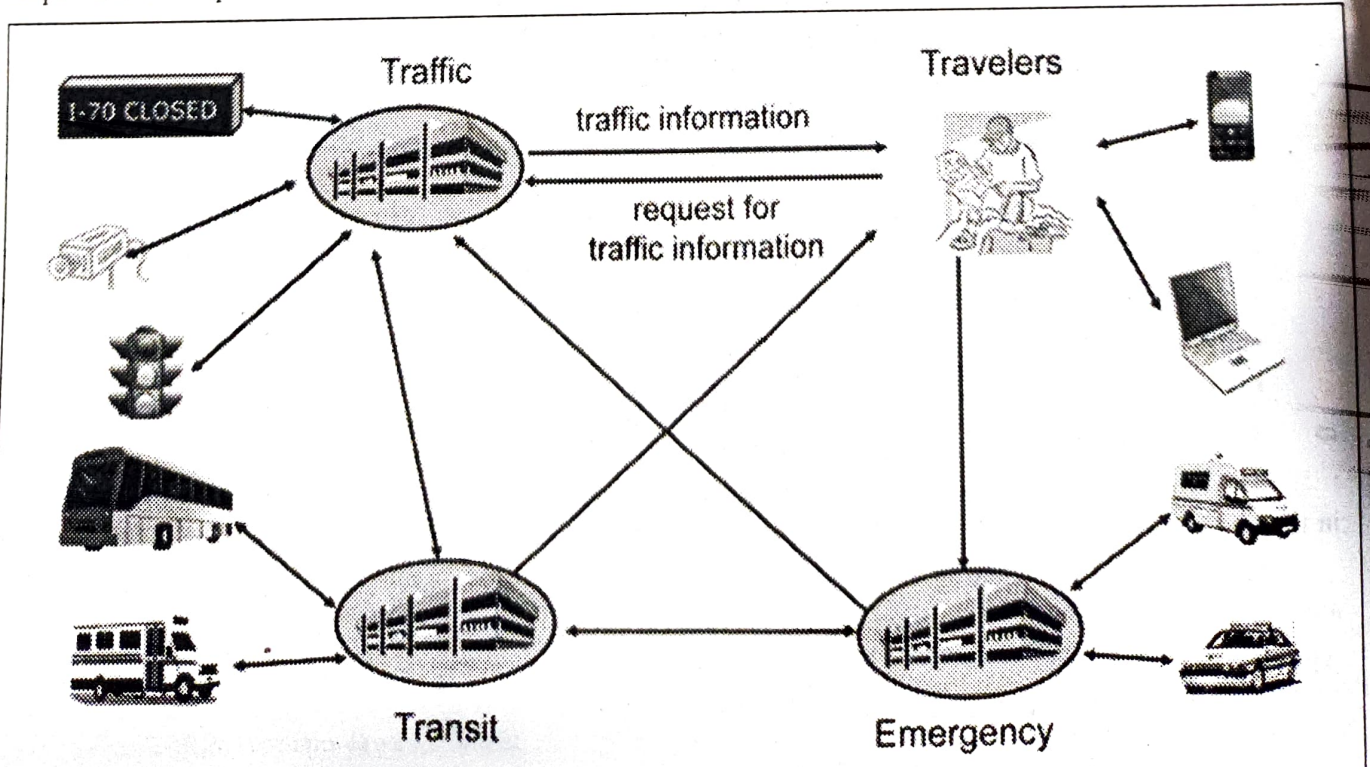

Fig. 3.1 Working of ITS

Inconsistencies in data are identified with specialized software and rectified. After that data is further altered and pooled for analysis. This mended collective data is analyzed further to predict traffic scenario which is available to deliver appropriate information to users.

Traveler Information: Travel Advisory Systems (TAS) is used to inform transportation updates to the traveling user. The system delivers real-time information like travel time, travel speed, delay, accidents on roads, change in route, diversions, work zone conditions etc. This information is delivered by a wide range of electronic devices like variable message signs, highway advisory radio, internet, SMS, automated cell.

➪ **Advantages of ITS :** **(Dec.-2021)**

- Reduction in stops and delays at intersections.
- Improvement in safety
- Speed control & improvement.
- Travel time improvement.
- Capacity management.
- Incident management.
- offers a range of convenient and affordable transport options making best use of infrastructure

➪ **Types of ITS:**

ITS covers and improves almost all the aspects of Transportation engineering. There are many subsidiaries of the Intelligent Transportation System out of which most important and widely used all over the world to solve the traffic and transportation problem are as follows:

- Advanced Traveler Information System (ATIS)
- Advanced Traffic Management System (ATMS)
- Advanced Public Transportation System (APTS)
- Emergency Management System (EMS)

(i) Advanced Traveler Information System (ATIS)

Advanced Traveler Information System (ATIS) implements a wide range of technologies, such as internet, telephones, cellular phones, television, radio, etc. to assist travelers and drivers in making informed decisions regarding trip departures, optimum routes, and available modes of travel. ATIS provides the drivers both en route and pre-trip information which is advantageous in many ways. Pre-trip information availability enhances the self-belief of the drivers to use freeways and allows commuters to make better-informed transit choices. En route information and guidance saves travel time, helps a traveler avoid congestion, can improve traffic network performance.

(ii) Advanced Traffic Management System (ATMS)

Advanced Traffic Management System (ATMS) is used by traffic police department and traffic regulation authorities as a tool to manage and control traffic by monitoring the flow of traffic and making appropriate decisions in a timely manner. Traffic management systems optimize the movement of vehicles, by using real-time information to intervene and adjust controls such as traffic signals to improve traffic flow.

(iii) Advanced Public Transportation System (APTS)

Advanced Public Transportation System (APTS) is concerned with increasing operational efficiency of all public transportation modes and increasing ridership by making the transportation system more reliable. With the help of APTS the way public transportation systems operate is transformed, and the nature of the transportation services that can be offered by public transportation systems is changed.

(iv) Emergency Management System (EMS)

Emergency Management System (EMS) is the newest research field in intelligent transportation system. EMS is mainly concerned with the application of different intelligent transportation system technologies to

develop a transport system which can provide help in the emergency conditions.EMS can provide great help in reducing the fatality rate in the accidents.

Table 3.1 Intelligent Transportation Services

Title	Services
Traveler Information	Pre-trip Information, on-trip driver information, on-trip public transport information, personal information services, and route guidance and navigation
Traffic Management	Transportation planning support, traffic control, incident management, demand management, traffic regulations, infrastructure maintenance management.
Vehicle Systems	Vision Enhancement, automated vehicle operation, longitudinal collision avoidance, lateral collision avoidance, safety readiness, pre-crash restraint deployment.
Commercial Vehicles	Commercial vehicle pre-clearance, vehicle administrative processes, automated road side safety inspection, commercial vehicle on-board safety monitoring, commercial vehicle fleet management
Public Transport	Public transport management, demand responsive transport management, shared transport management.
Emergency Management	Emergency notification and personal security, emergency vehicle management, hazardous materials and incident notification
Electronic Payment (EP) Safety	Electronic financial transactions, public travel security, safety improvement for vulnerable road users, intelligent junctions.

3.2 SMART VEHICLES

In past few years, Driving the car in crowd or on highways environments increasing lot of difficulties. Due to the drivers restless driving or some silly mistake serious accidents happened, it causes human lives. While driving, the person is to drive must be relax, comfortable, no confusions in mind, compatible with all car features. Human life effected mostly due to in proper driving or not following traffic rules. Manual car driving also make person tired on long route.

Smart Car innovation overcomes all such types of difficulties and makes driving smart, safe and efficient. Smart car have such features which minimizes human efforts and make traveling comfortable. Smart car made driving and traveling on long route with ease and safe.

There are various research is going on to overcome all these driving related issues. The smart car concept is innovated by Google named "Google Self Driving car". It is fully automated smart car which is driven automatically. Rider just needs to give functioning order through their mobile phone software design for these systems only and the car itself came and pick and drop driver to their requested destination. This is now in service in Europe, USA and many other foreign countries. This smart car includes fully customized functionalities which follows all the rules and regulation of traffic system and all driving safety measure.

- **Features of smart cars :** **(June-2022)**

1. Biometric car lock and car ignition : This system enables the security of the car by bio-metric reorganization for car access. To start the car by pressing a button and that button has fingerprint analysis. The users and owner of the car all have their finger print recorded in the system. The limitation is that if system is failed or malfunction one could access the car. Whole system should be change either which will be costly. Another point can we should not forget if any injury happen to recorded finger then that person will not be able to access the car

2. Lane detection and changing : The lane detection and change is major concern about move around the road. The sensors attach around the car that will detect distances of vehicles around car based on that

lane change operation is happen. But is that system laser sensors are used whose range is limited and accuracy problem is there which may lead to wrong detection and in result of that accidents may happen which cause human lives.

The car will detect the obstacle or pedestrian through the IR sensor and alert the system according to that automatically breaks will apply to slow down the car. Major drawback is IR sensors range is very less and some amount of moisture on the sensors will lead to the deactivation.

Similarly, ***Adaptive cruise control system*** used in cars in which radar is used in place of sensors. The radar attached in front of the car detect speed and distance of car from ahead car accordingly slow down or speed up the car. Limitation of the system that it very complex and affect the car performance also.

3. Night vision camera : This camera provide clear and negative image in whole dark black road. It will increase driving safety and reduces chances of accidents. Increases a vehicle driver's perception and watching distance in darkness or poor weather beyond the reach of the vehicle's headlights.

4. Intelligent Speed Adaptation (ISA), also known as Speed Alerting, being the system that monitors vehicle speed and the local speed limit on a road and warns the driver when the vehicle is detected to be exceeding the speed limit.

5. Ultra-classic Airbags : Ultra-classic airbags help stop cars when accidents threaten. The friction in the bags helps to stop the car or slow it down.

To prevent accidents, today there are more versions of airbags including seatbelts, airbag, knee airbag, curtains airbag and underneath airbag. As a result, the car won't dip when you hit hard brakes. It also helps passengers stay intact in their safety belts.

- **Pioneering Technologies For Next-Generation Smart Vehicles :**

1. Vehicle-to-Cloud Connectivity (V2C) :

Clouds are being positioned as the best-in-class infrastructure (servers, storage arrays and network modules) for effectively and efficiently hosting a variety of platforms. Integrated development environments (IDEs) and rapid application development (RAD) tools. System takes full advantage of various sensors and real time connectivity with cloud, which have been integrated with the vehicle. Servers analyze data through complex data analytic algorithms and suggest any upcoming service requirement, navigation, apps, etc.

2. Vehicle-to-Vehicle Connectivity(V2V) :

This is the real-time exchange of decision-enabling data among vehicles. Such kinds of dynamic data exchange at a critical point and place offer ample opportunities for significant improvements, especially on the vehicle safety aspect. By interchanging valuable vehicle data regarding its speed, direction, position, and location dynamically, the much-anticipated V2V communication capability enables vehicles to sense any impending threats and hazards with a 360° view and visualization of vehicles in synchronization with other vehicles' position.

This vehicular interaction results in issuing appropriate advisories to drivers to take counter measures proactively and pre-emptively, to completely avoid or to mitigate the intensity of crashes. There are specific sensors and GPS systems collaboratively working to arrive at accurate data (latitude, longitude, etc.) to make cars self-, surroundings- and situation-aware.

The vision for V2V connectivity is that eventually each vehicle on the road will be able to connect and communicate with one another beneficially. The data that are getting generated and transmitted in time facilitates the production and delivery of next-generation applications for enhanced safety. The much-anticipated V2V communications will come handy in drastically reducing fatal and even minor accidents on the road.

3. Field Oriented Control (FOC) :

Field Oriented Control is one of the methods used in variable frequency drives or variable speed drives to control the torque (and thus the speed) of three-phase AC electric motors by controlling the current. With

FOC, the torque and the flux can be controlled independently. FOC provides faster dynamic response than is required for applications. There is no torque ripple, and smoother, accurate motor control can be achieved at low and high speeds using FOC.

The torque of an induction motor is at a maximum, when the stator and the rotor magnetic fields are orthogonal to each other. In FOC, the stator currents are measured and adjusted so that the angle between the rotor and stator flux is 90° to achieve the maximum torque. FOC also known as vector control, and provides better efficiency at higher speeds than sinusoidal control. It also guarantees optimised efficiency even during transient operation by perfectly maintaining the stator and rotor fluxes.

4. Geofencing :

Geofencing is a feature in a software programme that uses the global positioning system (GPS) or radio frequency identification (RFID) to define geographical boundaries. It allows an administrator to set-up triggers so when a device enters (or exits) the boundaries defined by the administrator, an alert is issued. Many geofencing applications incorporate Google Earth, allowing administrators to define boundaries on top of a satellite view of a specific geographical area. Other applications define boundaries by longitude and latitude or through user-created and Web-based maps.

Geofencing gives complete flexibility and solutions in setting-up real time alarms to inform of unauthorized vehicle movements and other exceptions. The geofencing system allows setting-up a series of geographic zones together with the time based rules of when vehicles should be inside or outside each zone.

5. Electronic Braking System (EBS) :

Electronic activation of the EBS braking components reduces response and build-up times in brake cylinders. This in turn reduces braking distance by several meters, which can be decisive in some situations. The integrated ABS function ensures driving stability and steerability throughout the braking procedure.

6. Kinetic Energy Recovery System :

A kinetic energy recovery system (often known simply as KERS,) is an automotive system for recovering a moving vehicle's kinetic energy under braking. The recovered energy is stored in a reservoir (for example a flywheel or high voltage batteries) for later use under acceleration.

7. Sensors :

In the broadest definition, a sensor is a device, module, or sub-system. Its purpose is to detect events or changes in its environment and send the information to other electronics, frequently a processor. A sensor is always used with other electronics, whether as simple as a light or as complex as a computer.

8. System for Automated Parking :

Some vehicles are already equipped with the Parktronic systems and can identify parking spaces themselves and independently take appropriate actions in order to park. To simplify and expand the possibilities of autonomous parking, it is necessary to create an infrastructure connecting a car.

- **Self-driving Cars :**

A car that operates on obeying commands is the next asset you want to acquire. Imagine having free hands which you can use on anything while running your errands.

Google and Audi successfully tested this technology on their cars, which means it promises more incredible things. The self-driving car uses ultrasounds, lasers and radar to gather information about the driving experience.

If there are objects ahead, the car avoids them automatically to avoid collisions. In doing so, you only need to give commands and bum! You get to your destination.

If you want comfort alongside a drive, a self- driving car will give you that. This car reads road signs, gets to traffic lights and finds alternative routes faster than a human can.

It's an intelligent technology you can't wait to have yet as it saves you lots of hassle. Driverless cars will reduce many highway accidents caused by distracted drivers. Imagine having to spend fewer hours in traffic?

Self-driving cars can drive close to each other and act as a unit. As more space is not used up, they reduce congestion on the roads.

- **Augmented Reality Cars :**

Commonly referred to as AR, this system uses in-car displays to relay information on enabled dashboards. If a car is fast approaching and you are almost on a head-on collision, AR comes into play.

By showing a red box when you get too close to a car, the car alerts that all is not well. It also gives arrows to show the best route to take down the road.

All this happens to help you stay focused on driving. The future is bright for car lovers with augmented reality cars in mind of top car companies.

These cars are projected to use GPS systems to detect an object through the windshields. Augmented reality cars relay information on the windscreens then give suggestions to the driver.

For instance, they can tell the model of the car ahead of you, how slippery the road is, and how wide the road is. Consequently, you can decide how to maneuver the road.

AR dashboards will not only provide data on windshields but also facilitate inspection of car machinery like engines. They will then offer possible steps to fix any problem found.

3.3 FUELS OF FUTURE

Direct combustion of fuel for transportation accounts for over half of greenhouse gas emissions and a significant fraction of air pollutant emissions. Because of growing demand, especially in developing countries, emissions of greenhouse and air pollutants from fuels will grow over the next century even with improving of technology efficiency. Most issues are associated with the conventional engines, ICEs (internal-combustion engines), which primarily depend on hydrocarbon fuels. In this contest, different low-polluting vehicles and fuels have been proposed to improve environmental situation.

Some vehicle technologies include advanced internal combustion engine (ICE), spark-ignition (SI) or compression ignition (CI) engines, hybrid electric vehicles (ICE/HEVs), battery powered electric vehicles and fuel cell vehicles (FCVs). Fuel cell vehicles using hydrogen, can potentially offer lower emissions than other alternative and possibility to use different primary fuel option

A ***fuel cell vehicles*** fed by pure hydrogen are a "zero emission vehicle", in fact the only local emission are water vapour. But in this case it is important to consider the full fuel cycle or "well-to wheels" emissions (fuel production, transport and delivery emissions). Primary source for hydrogen production is crucial for the environmental performance of vehicles. Hydrogen produced from renewable energy (i.e. wind or solar power connected with electrolysis process) and used in fuel cells can reduce significantly emissions. Recent studies concerning alternative fuels have been identified the fuel cell vehicles, using hydrogen, as the most promising technology with reference to fuel cycle emissions.

In order to develop technologies in ultra-low-carbon vehicles, European Commission considers three principal power train:

- alternative fuels to burn in combustion engines to substitute gasoline or diesel fuel include liquid biofuels and gaseous fuels (including LPG, CNG and biogas);
- Electric vehicles;
- Hydrogen fuel cell vehicles.

⇨ **Biofuels :**

Biodiesel or biogas vehicles are seen as an element on the path towards energy independence from fossil fuels and relief from unstable oil prices.

The two most common types of biofuel are ***bioethanol*** and ***biodiesel***. Biofuel can be produced from plants (i.e. energy crops), or from agricultural, commercial, domestic, and/or industrial wastes (if the waste

has a biological origin). Biofuels are transportation fuels such as ethanol and biomass-based diesel fuel that are made from biomass materials. These fuels are usually blended with petroleum fuels (gasoline and distillate/ diesel fuel and heating oil), but they can also be used on their own. Using ethanol or biodiesel reduces the consumption of gasoline and diesel fuel made from crude oil, which can reduce the amount of crude oil imported from other countries. Ethanol and biodiesel are also cleaner-burning fuels than pure gasoline and diesel fuel.

Ethanol is an alcohol fuel made from the sugars found in grains such as corn, sorghum, and barley. Other sources of sugars to produce ethanol include :

- Sugar cane
- Sugar beets
- Potato skins
- Rice
- Yard clippings
- Tree bark

Biomass-based diesel fuels include biodiesel and renewable diesel. They are both called biomass-based diesel fuels because they are mostly produced for use in diesel engines, but they can also be used as heating fuels. Both fuels are made from biomass or materials derived from biomass, but they differ in how they are produced and in their physical properties. Biomass-based diesel fuels can be used in diesel engines without modifying the engines.

⇨ **Fuel cells :**

- Fuel cells and batteries convert chemical energy into electrical energy and are very useful forms of galvanic cell.
- A galvanic or voltaic cell is an electrochemical cell that converts chemical energy into electrical energy through the redox reactions that occur within the cell.
- Galvanic cells that are designed to convert the energy of combustion of fuels like hydrogen, methane, methanol, etc. directly into electrical energy are called fuel cells. One of the most successful fuel cells uses the reaction of hydrogen with oxygen to form water.

The Fuel Cell Electric Vehicle (FCEV) combines hydrogen and oxygen to generate an electric current and water is the only byproduct.

$$\text{Hydrogen} + \text{Oxygen} = \text{Electricity} + \text{Water Vapour}$$

$$2H_2\,(g) + O_2\,(g) \rightarrow 2H_2O\,(l)$$

Fuel Cell Electric Vehicle (FCEV) engines are similar to the conventional internal combustion engines because they also rely on a constant supply of fuel (hydrogen) and oxygen.

⇨ **Advantages of FCEV :**

- FCEVs produce much smaller quantities of greenhouse gases and none of the air pollutants that cause health problems.
- Fuel cells emit only heat and water as a byproduct and are far more energy-efficient than traditional combustion technologies.
- FCEVs do not need to be plugged in for charging, like battery-powered EVs.
- There is a wide availability of resources for producing hydrogen.

⇨ **Disadvantages of FCEV:**

- The process of making hydrogen needs energy, often from fossil fuel sources, which raises questions over hydrogen's green credentials.

- Handling of hydrogen is a safety concern because it is more explosive than petrol.
- These vehicles are expensive and fuel dispensing pumps are scarce.

When ***hydrogen*** is used as a fuel in fuel cell electric vehicles (FCEVs), the only vehicle emission is water. When hydrogen is used in an internal combustion engine, the emissions are water, some nitrogen oxides, and some trace chemicals mostly as a result of using lubricants. Although CO_2 emissions are absent from vehicle emissions when hydrogen is used as an LDV fuel, varying amounts of GHGs are emitted during hydrogen production.

The two major challenge areas are the following:

- Making low-cost hydrogen with low GHG emissions.
- Building the hydrogen infrastructure will be a large, complex, and expensive undertaking. Hydrogen-fueling stations would have to be available before FCEVs can be sold.

3.4 GIS- FOR TRANSPORTATION (Dec.-2021)

The focus of most transportation professionals in the urban areas of the world has shifted from the construction of new highway facilities to maximizing the utility of existing infrastructure, and the development of new public transport facilities and capabilities. At the same time, a renewed focus has emerged on using technology effectively to make urban centers more efficient, livable and sustainable. These trends have produced two overlapping initiatives: intelligent transportation systems (ITS) and the concept of smart cities. It is clear that GIS technology will play an ever increasing role in both initiatives. As a platform to integrate and fuse vast amounts of information, GIS has already come to play a significant role in a large number of ITS systems.

Geographic Information System (GIS) are becoming more widely used in transportation planning agencies, especially among metropolitan transportation organizations. In many developed countries, highway maintenance management is becoming a critical issue. Many more authorities are now able to use GIS for Highways and transport management, due to falling costs and GIS increasing overfriendliness. GIS offer transport planners a medium for storing and analyzing data on population densities, land uses, travel behavior, etc. The most important objectives for using GIS are map/display and data integration. Agencies must identify potential issues that can be addressed through a GIS application more efficiently and effectively, and more economically than with prevailing methods.

A fundamental requirement for most transportation GIS is a structured road network. Additional information concerning general topography, land cover and land use is pertinent to the consideration of the impact of construction. The lack of appropriate data for GIS remains a chronic problem. GIS describes a world in terms of longitudes and latitudes and other projection systems consisting of a hierarchical structure of graphical objects. The typical GIS represent the world as a map.

The major requirements and issues surrounding GIS management technology are building and maintaining a database, selecting and upgrading hardware and software, using the technology to solve problems, funding, networking, providing access, and others. Standard GIS functions include thematic mapping, statistics, charting, matrix manipulation, decision support system, modeling and algorithms and simultaneous access to several databases.

The main advantage of using GIS is its ability to access and analyze spatially distributed data with respect to its actual spatial location overlaid on a base map of the area of coverage that allows analysis not possible with the other database management systems. The main benefit of using the GIS is not merely the user-friendly visual access and display, but also the spatial analysis capability and the applicability to apply standard GIS functionalities such as thematic mapping, charting, network-level analysis, simultaneous access to several layers of data and the overlayment of same, as well as the ability to interface with external programs and software for decision support, data management, and user-specific functions.

Potential applications for GIS in transportation planning include the following : (June-2022)

- highway maintenance,
- traffic modeling,
- accident analysis,
- route planning
- environmental impact assessment of road schemes.
- Executive information system.
- Pavement management system.
- Bridge management.
- Maintenance management.
- Safety management.
- Transportation system management (TSM)
- Travel demand forecasting
- Corridor preservation and right-of-way
- Construction management
- Hazardous cargo routing
- Overweight/oversize vehicles permit routing.

Its graphical display capabilities allow not only visualization of the different routes but also the sequence in which they are built, which allows the understanding of the logic behind the routing network design. The interaction between the transportation system and its surrounding environment makes the GIS technology ideally suited for hazardous material, routing design, risk analysis, and decision making. GIS can also be integrated with sophisticated mathematical models and search procedures to analyze different management options and policies.

Some of the applications of GIS in Transportation planning are described as under:

➪ **Planning :**

Transportation agencies face an enormous challenge in keeping their infrastructure operating smoothly and efficiently. The world's leading travel demand forecasting packages are integrated with GIS technology, helping transportation professionals conduct the complex analyses required to plan the transportation systems of the future. Increasingly, transportation planners are integrating land-use, environmental, and greenhouse gas considerations, along with energy consumption factors, into their planning processes. In doing so, they have discovered that GIS can bring all these factors together in the type of comprehensive planning models that will be required to help effectively plan the future.

➪ **Design :**

Transportation engineers are discovering the advantages of integrating GIS into their design processes. By bringing imagery, elevation, and environmental information into the CAD environment, engineers can continue working with familiar software while gaining access to important GIS data. Design files can be brought into a GIS and linked to financial software for better labor and materials and total project cost estimation. With these types of capabilities, GIS is an essential component of the engineering information systems of the future.

➪ **Traffic Engineering :**

Congestion management programs can be most suitably developed in a GIS environment. GIS based congestion management systems can start with the highway base maps and attribute databases used for long range transportation planning in urban areas. These regional base maps will provide the framework for identifying and monitoring congestion from a regional perspective. Additional more detailed base maps and databases can be developed to manage congestion in real time in critical corridors.

Traveller Information System:

These systems were one of the first applications in ITS, and were designed to provide the public with current information on traffic conditions and alternative travel options. Such systems brought together information from various sensors and automated systems to provide a single source of up-to-the-minute travel information and choices. It combines information on real-time traffic speeds along with travel options (and a journey planner) for public transport, car sharing, bicycling and parking availability into a single application which is widely used by locals and tourists alike.

Safety Management

The analysis of accident data coupled with roadway features and characteristics, traffic volumes, bridge inventory and other data and the geographical presentation of this information in GIS environments will be very useful to develop safety management system. Inventory files such as traffic signals, narrow bridges and railroad crossings could be analyzed more efficiently using GIS.

Bridge Maintenance

A major benefits derived from GIS use will be in obtaining bridge information through general query capability. Example includes bridge condition surveys, sufficiency ratings, functionally deficient bridges, posted capacity distribution, clearness etc. Through relational database, bridge maintenance engineers could access important information like average daily traffic, as well as system and functional classification from planning and research maps.

Routing analysis of hazardous materials

GIS is an ideal environment for routing analysis of hazardous materials because this requires overly of many highway network attributes as well as other databases (e.g. demographic, topographic, weather etc.) on individual road segments in order to properly characterize accidents and consequence to population and environment.

Environmental Management

Transportation infrastructure management requires careful consideration of the environment. GIS is uniquely capable of assisting transportation professionals in understanding these issues and selecting the most environmentally sensitive solutions. With GIS, you can understand the impact of land-use decisions and evaluate smart-growth alternatives. GIS integrates environmental factors with land-use, housing, and employment density analysis to help communities address growth issues.

Construction Management

When integrated with construction management and financial software, GIS can help track the performance of one or multiple infrastructure projects. GIS makes a wealth of information, such as schedules, estimates, and contracts, easily available from a spatial interface. For project tracking, GIS can help organize all relevant information, from survey data, soils, and geotechnical studies to planning, environmental studies, and engineering drawings. Having quick and easy access to data during construction can greatly increase efficiency and reduce time spent searching for needed information.

Transportation applications of GIS have become increasingly popular in recent years, so much so that they are now routinely referred to by the acronym GIS-T(Geographical Information Systems in Transportation).

3.5 GPS- FOR TRANSPORTATION

It is estimated that delays from congestion on highways, streets, and transit systems throughout the world result in productivity losses in the hundreds of billions of dollars annually. Other negative effects of congestion include property damage, personal injuries, increased air pollution, and inefficient fuel consumption.

The availability and accuracy of the Global Positioning System (GPS) offers increased efficiencies and safety for vehicles using highways, streets, and mass transit systems. Many of the problems associated

with the routing and dispatch of commercial vehicles is significantly reduced or eliminated with the help of GPS. This is also true for the management of mass transit systems, road maintenance crews, and emergency vehicles.

GPS enables automatic vehicle location and in-vehicle navigation systems that are widely used throughout the world today. By combining GPS position technology with systems that can display geographic information or with systems that can automatically transmit data to display screens or computers, a new dimension in surface transportation is realized.

A geographic information system (GIS) stores, analyzes, and displays geographically referenced information provided in large part by GPS. Today GIS is used to monitor vehicle location, making possible effective strategies that can keep transit vehicles on schedule and inform passengers of precise arrival times. Mass transit systems use this capability to track rail, bus, and other services to improve on-time performance.

Using GPS technology to help track and forecast the movement of freight has made a logistical revolution, including an application known as time-definite delivery. In time-definite delivery, trucking companies use GPS for tracking to guarantee delivery and pickup at the time promised, whether over short distances or across time zones. When an order comes in, a dispatcher punches a computer function, and a list of trucks appears on the screen, displaying a full array of detailed information on the status of each of them. If a truck is running late or strays off route, an alert is sent to the dispatcher.

Many nations use GPS to help survey their road and highway networks, by identifying the location of features on, near, or adjacent to the road networks. These include service stations, maintenance and emergency services and supplies, entry and exit ramps, damage to the road system, etc. The information serves as an input to the GIS data gathering process. This database of knowledge helps transportation agencies to reduce maintenance and service costs and enhances the safety of drivers using the roads.

Vehicle tracking :

In the transportation and logistics business, GPS or GPS technology today extends further than just a tool to help drivers to navigate from locations. GPS technology has fully transformed the transportation industry. They are mobile app developers that can hand you advanced GPS vehicle tracking systems that include business-effectual tools required by your business and customer needs.

From your smart mobile device, you can easily locate your vehicles, effectively plan drivers' assignments and manage costs. These features are ideal for running a successful transportation or logistics business without making so many calls or going through bulky reports to make decisions.

With GPS tracking technology, you can monitor vehicle speed, routes, engine start-up and shut down, idling and routes.

Intelligent Transport System (ITS) is an example of a GPS application. GPS can be applied in the following 3 fields of traffic engineering effectively due to its higher accuracy.

a. Automatic vehicle location

b. General fleet operation

c. Dynamic route guidance

The application also includes support to emergency vehicles (police search & rescue, etc) and for the monitoring of cars, taxis dangerous/hazardous or valuable cargos, trucks and railways. GPS can also be applied in the following fields, but yet not found effective compared to other positioning systems.

- Advanced Traffic Management System (ATMS)
- Advanced Traveler Information System (ATIS)
- Commercial Vehicle Operation (CVO)
- Advanced Public Transport System (APTS)

(a) Automatic Vehicle Location (AVL) :

AVL system, tracks the positions of a fleet of vehicles in a particular area and reports the information to a host via a communication infrastructure. GPS positioning system is more appropriate because the accuracy needed is of the order of centimeters. Determination of the location of each vehicle typically involves a transmission initiated by the mobile vehicle. In this system, the communication system transmits the actual location to the host server. The transmission contains a position report data packet, which includes the vehicles latitude and longitude derived using a GPS receiver installed in the mobile vehicle.

A generic distributed AVL system: In this system, the only location determination component is an on board GPS receiver. After receiving the reported position from the mobile GPS unit, the known route plus the position information will provide enough information for the host to obtain a rough estimate of location.

(b) General Fleet Operation :

The major benefit of positioning for fleet applications is that it makes it possible to send the closest vehicle to a dispatch point, with consequent saving of fuel and time. This can be used both for commercial vehicle operation and emergency vehicle management. The accuracy required depends on the size of fleet and total area being serviced. For fleet operation in metropolitan areas a wide area of coverage is sufficient. For interstate/inter-country fleet operations, a positioning system with global coverage satisfies the requirement. Hence positioning requirement for interstate/ inter-country fleet operation is better fulfilled by GPS.

(c) Dynamic Route Guidance :

A dynamic navigation system uses real time traffic information to assist users traveling on the road networks. This technique is also known as dynamic route guidance. The other sensors along with GPS receiver used for route guidance in a vehicle are described below:

The sensors those are used along with GPS for dynamic route guidance are as follows:

➪ ***Generic GPS Aided vehicle Navigation system :***

a. ***Odometer*** **:** It is a distance sensor that may be mounted singly or in pairs on to either the wheel or the transmission of the vehicle.

b. ***Magnetic Compass*** **:** It measures the heading of a vehicle. The most popular electronic compass technology for land vehicle application uses the flux-gate principle.

c. ***Tilt Sensor :*** It gives information about the pitch and roll angles of the vehicle. It may include one or more inclinometers.

d. ***Gyroscope :*** It measures the rate of change of heading of the vehicle

e. ***Digital Maps :*** These are used through GIS to relate mathematical coordinates to locations on the street segments and intersections. In turn, the stored coordinates of the map features provide a means in coordinate space, and hence allow the digital map to contribute the navigation function. Enroute guidance of vehicles is done using the position data received by a GPS receiver. Once the position is known, proper signals and instructions can be prepared for the driver after comparison of the position against the planned route. This planned route consists of a sequence of road segments stored by digitizing the map through GIS.

➪ **Benefits of GPS :**

- Higher levels of safety and mobility for all surface transportation system users.
- More accurate position determination to provide greater passenger information
- More effective monitoring to ensure schedule adherence, creating a transit system more responsive to transportation users needs.
- Better location information with electronic maps to provide in-vehicle navigation systems for both commercial and private users.
- Increased efficiencies and reduced costs in surveying roads.

3.6 NAVIGATION SYSTEMS

Navigation is a field of study that focuses on the process of monitoring and controlling the movement of a craft or vehicle from one place to another. The field of navigation includes four general categories: land navigation, marine navigation, aeronautic navigation, and space navigation.

It is also the term of art used for the specialized knowledge used by navigators to perform navigation tasks. All navigational techniques involve locating the navigator's position compared to known locations or patterns.

Navigation, in a broader sense, can refer to any skill or study that involves the determination of position and direction. In this sense, navigation includes orienteering and pedestrian navigation.

Land Navigation :

Navigation for cars and other land-based travel typically uses maps, landmarks, and in recent times computer navigation ("satnav", short for satellite navigation), as well as any means available on water. Computerized navigation commonly relies on GPS for current location information, a navigational map database of roads and navigable routes, and uses algorithms related to the shortest path problem to identify optimal routes.

Satellite Navigation service is an emerging satellite based system with commercial and strategic applications. ISRO is committed to provide the satellite based Navigation services to meet the emerging demands of the Civil Aviation requirements and to meet the user requirements of the positioning, navigation and timing based on the independent satellite navigation system. To meet the Civil Aviation requirements, ISRO is working jointly with Airport Authority of India (AAI) in establishing the GPS Aided Geo Augmented Navigation (GAGAN) system. To meet the user requirements of the positioning, navigation and timing services based on the indigenous system, ISRO is establishing a regional satellite navigation system called Indian Regional Navigation Satellite System (IRNSS).

(a) GPS Aided GEO Augmented Navigation (GAGAN) :

This is a Satellite Based Augmentation System (SBAS) implemented jointly with Airport Authority of India (AAI). The main objectives of GAGAN are to provide Satellite-based Navigation services with accuracy and integrity required for civil aviation applications and to provide better Air Traffic Management over Indian Airspace. The system will be interoperable with other international SBAS systems and provide seamless navigation across regional boundaries. The GAGAN Signal-In-Space (SIS) is available through GSAT-8 and GSAT-10.

(b) Indian Regional Navigation Satellite System (IRNSS) : NavIC :

IRNSS is an independent regional navigation satellite system being developed by India. It is designed to provide accurate position information service to users in India as well as the region extending up to 1500 km from its boundary, which is its primary service area. IRNSS has operational name of **NavIC** (acronym for **Nav**igation with **I**ndian **C**onstellation).

IRNSS will provide two types of services, namely,

1. Standard Positioning Service (SPS) which is provided to all the users and
2. Restricted Service (RS), which is an encrypted service provided only to the authorized users.

The IRNSS System is expected to provide a position accuracy of better than **20 m** in the primary service area. The main goal behind designing the Indian Regional Navigation Satellite System (IRNSS) is to provide accurate position information services to assist in the navigation of ships in Indian Ocean waters.

NavIC based trackers are compulsory on commercial vehicles in India and it is planned to become available in consumer mobile phones shortly. India becomes 4th Nation to have its own navigation system: IRNSS Is India's Own GPS!

The IRNSS system comprises a space segment, ground segment and user segment.

Space segment :

The constellation consists of 8 satellites. Three of the eight satellites are located in geostationary orbit (GEO) at, approximately 36,000 km above earth surface. Remaining five satellites are in inclined geosynchronous orbit (GSO).

Ground segment :

Ground Segment is responsible for the maintenance and operation of the IRNSS constellation. The Ground segment comprises:

- IRNSS Spacecraft Control Facility (IRSCF)
- ISRO Navigation Centre (INC)
- IRNSS Range and Integrity Monitoring Stations (IRIMS)
- IRNSS Network Timing Centre (IRNWT)
- IRNSS CDMA Ranging Stations (IRCDR)
- Laser Ranging Stations
- IRNSS Data Communication Network (IRDCN)

User segment :

The User segment mainly consists of:

- Single frequency IRNSS receiver capable of receiving SPS signal at L5 or S band frequency.
- A dual frequency IRNSS receiver capable of receiving both L5 and S band frequencies.
- A receiver compatible to IRNSS and other GNSS signals.

Figure specifies the radio frequency interface between space and user segments. Each IRNSS satellite provides SPS signals in L5 and S bands.

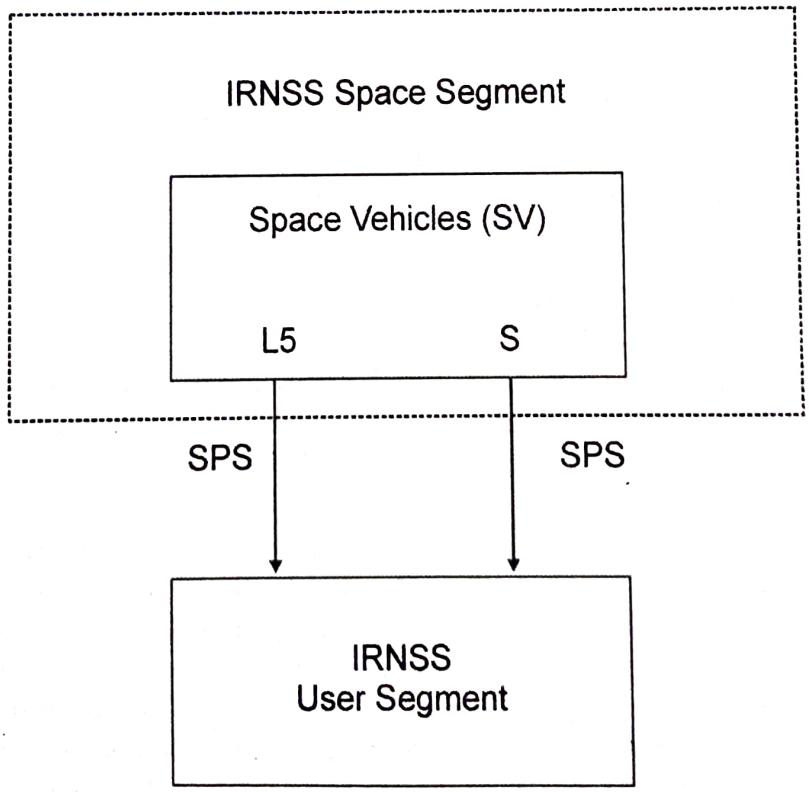

Fig. 3.2 IRNSS Space segment interface with User segment

➪ **Some applications of IRNSS are :**

- Terrestrial, Aerial and Marine Navigation
- Disaster Management
- Vehicle tracking and fleet management
- Integration with mobile phones
- Precise Timing
- Mapping and Geodetic data capture
- Terrestrial navigation aid for hikers and travellers
- Visual and voice navigation for drivers

➪ **Terrestrial Navigation :**

Terrestrial navigation is applied to all techniques that are based on terrestrial sightings and/or measurements; however, radio navigation systems are not included. Terrestrial navigation comprises dead reckoning, visual navigation, and some other generic position fixing techniques. These methods are applied in land, maritime, and aeronautic applications.

It is the method of navigation used by mariners that uses landmarks as reference points, ship's stability, fuel consumption and ship's speed along with tides and currents. This is the opposite of celestial navigation, which plots positions in relation to the stars.

➪ **Instruments for terrestrial Navigation :**

- ✓ Odometers — distance measurement
- ✓ Laser ranging — Time of arrival/pulses, – Continuous waves
- ✓ RF techniques, radar (radio detection and ranging)..... Time of arrival/pulses – Continuous waves
- ✓ Sonar (sound navigation and ranging) — time of arrival / pulses
- ✓ Barometer — measure altitude
- ✓ Radar Altimeter — measure altitude
- ✓ Doppler sensors
- ✓ Accelerometers and Gyroscopes
  - Gyroscopes measure angular rotation rate
  - Accelerometers measures non-gravitational acceleration
- ✓ Compass - measure direction of magnetic north

3.7 TRAFFIC SAFETY MANAGEMENT :

India ranks high when it comes to number of accidents on the road. However, in the recent years, improvement has been seen in this area. With the rapid increase in the number of vehicles on the road, the traffic conditions are under a lot of pressure. Therefore, road safety is one of the most serious public health issues in our country. It has an impact on everyone, whether one drives a vehicle, walks or rides a cycle.

Road Safety is a multi-sectoral and multi-dimensional issue. It incorporates the development and management of road infrastructure, provision of safer vehicles, legislation and law enforcement, mobility planning, provision of health and hospital services, child safety, urban land use planning etc. In other worlds, its ambit spans engineering aspects of both, roads and vehicles on one hand and the provision of health and hospital services for trauma case (in post-crash scenario) on the other. Road safety is a shared, multi-sectoral, responsibility of the government and a range of civil society stakeholders. The success of road safety strategies in all countries depends upon a broad base of support and common action from all stakeholders

Road safety refers to the measures which must be adopted by everyone while using roads. These safety methods are meant for reducing the risk of accidents and injuries or causalities on the road. These rules must be followed by all users of roads including pedestrians, cyclists, motorists, and bus and truck drivers. Safety methods also relate to the construction, layout of roads as well as traffic regulation systems. So, we can summarize that ***road safety involves***:

(i) the design of roads and highways;
(ii) laws pertaining to traffic and vehicles;
(iii) systems of traffic safety and control;
(iv) driver education;
(v) school students' education;
(vi) mass education;
(vii) traffic regulation and road safety signs;
(viii) vehicle design; and
(ix) motor vehicle safety inspection and maintenance.

⇨ IMPORTANCE OF ROAD SAFETY :

Road Safety

Some of the ***major causes*** of road accidents are as follows.

(i) Lack of highway safety
(ii) Drunken driving
(iii) Driving in an exhausted state for long hours
(iv) Using cell phone while driving
(v) Over speeding or rash driving
(vi) Driving in wrong lanes
(vii) Turning without giving signal
(viii) Overtaking from wrong side

It can be seen that road safety is a collective responsibility. Therefore each one of us has to take steps required of us.

▪ Collective Responsibilities :

Role of Government and Public Sector

(i) Develop stricter road safety polices
(ii) Generate funds for road safety awareness
(iii) Stricter enforcement of rules by government
(iv) Building better roads and highways

Role of General Community

(i) Acceptance of road safety rules, regulations and policies
(ii) Participation in road safety awareness drives to enhance people's knowledge about road safety

Role of Education Sector

(i) Inclusion of road safety modules in school curriculum
(ii) Impart road safety education with the help of experts in this area
(iii) Impart effective driver training for learners as well as existing drivers

Role of Media

(i) Communicate road safety messages through print and electronic media
(ii) Support road safety initiatives through responsible and objective reporting

Role of Health Professionals

(i) Strengthen trauma facilities in our country.

(ii) Organize workshops for saving the lives of people in road accidents.

- **Improvement in Infrastructure -guidelines**

(i) Adopt effective and safe traffic management measures while planning and designing infrastructure. For example, government approved road design, design of over bridges, road signages, etc.

(ii) A Road Safety Authority should be installed both at national and state level.

(iii) An appropriate policy and framework based on the Safe System approach should be adopted to guide safe road infrastructure design.

(iv) The Indian Roads Congress (IRC) Codes of practice need to be updated regularly, based on local research. Application of the IRC Codes should be mandatory.

(v) Installation of road signages must be done in accordance with the IRC Codes.

(vi) Safety performance of roads and their design standards should be evaluated continually.

(vii) Road safety consultants should be independent, which is common practice internationally.

(viii) A pool of safety auditors should be created both at a national and a state level.

(ix) Rating of road safety auditors and contractors should be conducted in regards to their level of experience and expertise.

Design of Roads

In India the road networks are nearly 5,472,144 KM. The roads are designed only by keeping in mind all safety aspects but accident rate of the roads accidents are merely increased as to the extent. Designs of roads are divided as three types:

1) Road junctions

2) Road maintenance

3) Inadequate visibility

Roads design depends on the basis of location of the road, traffic congestion, Hospital areas and educational institutions, road dividers and road junctions.

Vehicle Technology **(June-2022)**

Speed of the vehicle is most dangerous think for the accidents. Considering technical factors, speed of the vehicle, vehicle size and capacity, any motor vehicle should be designed because one of the major reasons for accidents is vehicle design. To make motor vehicles accident free motor vehicles, it should be designed in such a way that it can be controlled by motor vehicles even before the accident occurs. To ensure safe public vehicles, it has been suggested to the governments of all states that;

a) The width, height and length of vehicles,

b) The size, nature and condition of wheels and tyres,

c) Brakes,

d) Lamps and reflectors,

e) Warning devices,

f) The inspection of vehicles,

g) Regulating the particulars exhibited on vehicles and the manner in which such particulars shall be exhibited. These all should be standardized and strictly implemented.

Recommendations for vehicles are:

a. Harmonization of vehicle regulations with the UN ECE Regulations should be pursued while the process must take in consideration the road traffic situation of India.

b. The opportunities to develop enhanced regulations for buses, commercial vehicles, and motorcycles, should be reviewed and understood.

c. It should be possible, by the appropriate assigned body, to cancel vehicle registrations should the vehicle not meet applicable safety regulations.

d. A vehicle rating program should be finally defined, i.e. rating programs should be scientifically examined to benefit the Indian market, and get support from all stakeholders, with an aim to help buyers of vehicles to make informed purchase decisions.

e. Incentives to promote safety beyond basic regulations should be considered.

- **Hurdles in Road Safety**

(i) Negligence by civilians

(ii) Pathetic condition of roads

(iii) Unsafe vehicle design

(iv) Violation of road safety standards

(v) .Lack of emergency services

(vi) Defects in highway designing

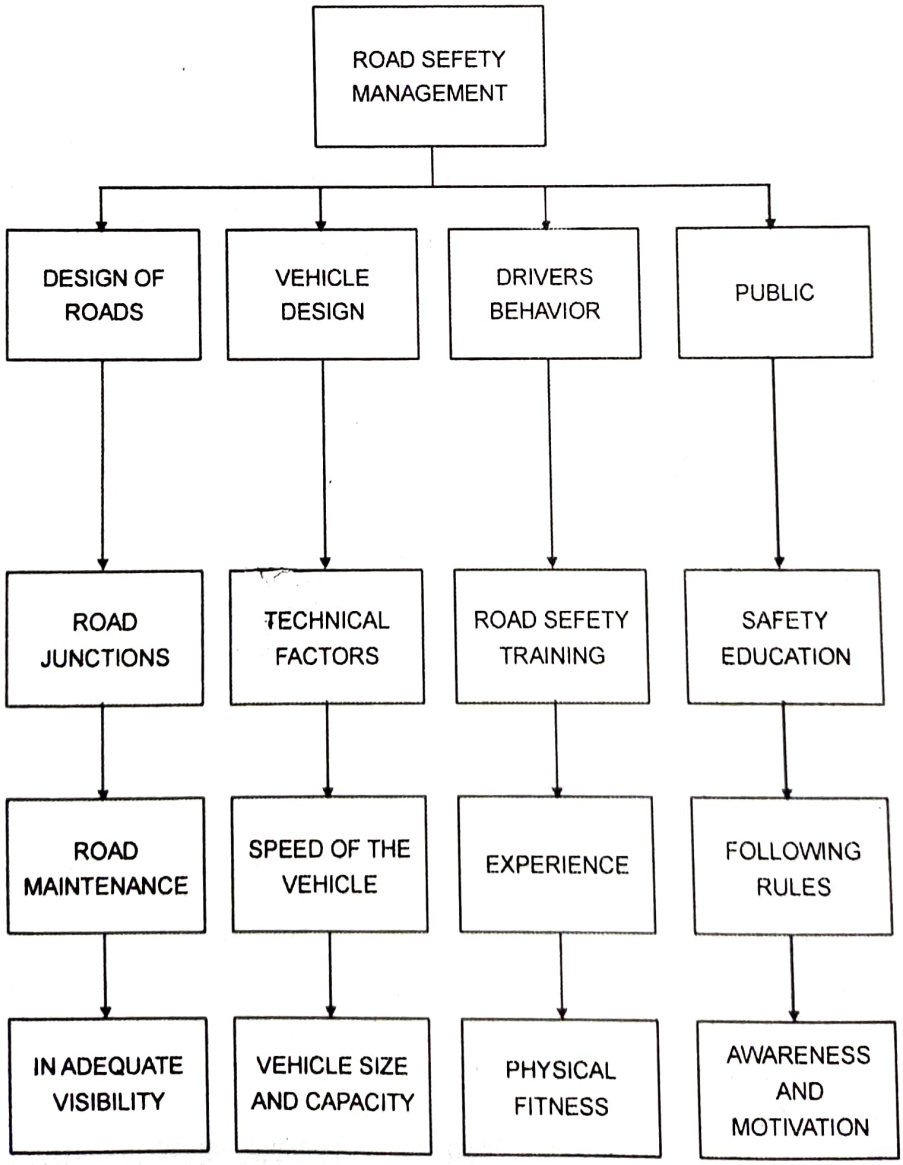

Fig. 3.3 Approach for Road safety management

National Road Safety Policy(2010) **(Dec.-2021, June-2022)**

The National Road Safety Policy outlines the policy initiatives to be framed/taken by the Government at all levels to improve the road safety activities in the country. Broadly, it aims

- To promote awareness about road safety issues.
- To establish a road safety information database.
- To ensure safer road infrastructure by way of designing safer roads, encouraging application of Intelligent Transport System etc.
- To ensure fitment of safety features in the vehicles at the stage of designing, manufacture, usage, operation and maintenance.
- To strengthen the system of driver licensing and training to improve the competence of drivers.
- To take measures to ensure safety of vulnerable road users.
- To take appropriate measures for enforcement of safety laws.
- To ensure emergency medical attention for road accident victims.
- To encourage human resource development and R&D for road safety.
- To strengthen the enabling legal, institutional and financial environment for promotingroad safety culture in the country.

3.8 e-TICKETING :

(Dec.-2021, June-2022)

An **electronic ticket** is more efficient method of ticket entry, processing and marketing for companies in the airline, railways and other transport and entertainment industries. An e-ticket (electronic ticket) is a paperless electronic document used for ticketing passengers, particularly in the commercial airline industry. Virtually all major airlines now use this method of ticketing.

e- ticket for air transport provides the following details :

- An official ticket number (including the airline's 3-digit ticketing code, a 4-digit form number, a 6-digit serial number, and sometimes a check digit)
- Carriage terms and conditions (or at least a reference to them)
- Fare and tax details, including fare calculation details and some additional data such as tour codes.
- A short summary of fare restrictions, usually specifying only whether change or refund are permitted but not the penalties to which they are subject
- Form of payment
- Issuing office
- Baggage allowance

e-ticketing in Indian Railway :

The Indian Railway Catering & Tourism Corporation Ltd., (Irctc Ltd) a PSU of Ministry of Railways have developed a system for advance booking of Rail tickets through Internet. The Web site for online booking is ***www.irctc.co.in.*** Booking procedures are simple and user friendly.

Indian Railways offers cashless ticketing option to its customer through internet ticketing on IRCTC website for booking reserved tickets. More than 58% of the train accommodation is reserved through e-ticketing. IRCTC also provides option for purchasing Season Tickets for suburban train services on Western and Central Railways. Facility for purchasing unreserved tickets through mobile phone is available for Pan India stations. Further Automatic Ticket Vending Machines dispensing unreserved tickets using smart cards are provided at over 1000 locations all over the country.

E-Ticketing by IRCTC is helpful in protecting environment by saving paper. E-ticket holders are now permitted to travel without printout of ticket and can travel with SMS sent by ITCTC along with valid Photo ID proof in original.

E-ticketing is also helpful in saving environment by controlling pollution as people do not have to travel to Rail Reservation Offices to buy tickets. E-Tickets can be booked from the comfort of homes and offices. This not only saves air pollution but also Noise pollution.

Advantages of electronic ticketing :

- cheaper for the airline;
- no piece of paper to misplace
- as part of a well designed operation can reduce processing time
- Easy to keep records for business travel
- less chance of **ticket** theft.
- E-ticketing has streamlined some of the airport check-in process. Some airlines allow you to use a self-check-in kiosk, skipping the long line at the airline ticket desk.
- You can purchase and print e-ticket any time 24 hours a day
- You can pay for e-ticket with your credit card online without leaving your work place or home.

Disadvantages of electronic ticketing :

- If you have a system crash and don't back up appropriately can lose information.
- No souvenir ticket to paste in scrapbook
- Fear of change

3.9 SMART MOBILITY : (Dec.-2021, June-2022)

Urban mobility has been seen as an important engine for the growth and progress of modern cities. In smart cities, mobility refers not just to the movement within a city and the delivery of goods from one place to another destination, it also means technologies like citywide wireless communication and real-time monitoring of the traffic flow, as well as the flexible reactions to problems. In addition, mobility in smart cities is customized through the well-developed communication infrastructure.

Our cities are faced with rapid motorization. This has led to severe congestion, deteriorating air quality, increasing incidence of road accidents and a rapidly increasing energy bill. Walking and cycling have been rendered unsafe due to poor infrastructure and public transport has been inadequate. So far, urban transport planning has emphasized providing for the personal motor vehicle. Public transport systems have been planned in isolation with the result that a well-integrated multi-modal system has not come up. This has resulted in high cost facilities not giving the outcomes that were sought.

Ease of being able to move from one place to another is at the core of a "Smart City". Seoul, Singapore, Yokohama and Barcelona (all considered Smart Cities) have a sound transport system as the core of their "Smartness". The transport system emphasizes walking, cycling and public transport as the primary means for mobility with personal motor vehicles being actively discouraged. In fact, smart cities lay considerable emphasis on the walkability and cycling in the city. The pedestrian is given a place of prominence as every trip has a leg that involves walking. However, smart city need to look into the bottlenecks of road/rail networks also and wherever required underpasses, elevated roads, additional rail networks need to be put in place urgently.

Smart mobility includes, Intelligent mobility; Advanced traffic management system (ATMS), Parking management, ITS-enabled transportation pricing system

⇒ ***Measures to improve mobility :*** **(Dec.-2021, June-2022)**

- Intelligent mobility is one of the key aspects of a Smart City, towards which cities worldwide are starting the most interesting transformations, either through large structural investments, and low cost initiatives that act on social innovation and on raising public awareness. In particular, the interventions for a Smart mobility brought forward by the Cities concern:
- enhancement and efficiency of the system of public transport and a modernization of the related means of transport with vehicles that use low-emission combustion engines, electric or hydrogen motors, up to the introduction of driverless vehicles;
- promotion of the use by citizens of electric and hybrid vehicles, even with the installation of new charging columns (as required by the EU) and the activation of electric cars rental services, and the introduction of smart charging systems (vehicle to grid and vehicle to building);
- enhancing bike sharing, car sharing and car pooling policies;
- implementation of early warning systems for conveying traffic and of parking addressing systems and the management via smart phones of the access to restricted traffic areas and pay parking;
- digitalization of the public transport system with the introduction of smart palettes and panels with a variable message at public transport stops and applications dedicated to info-mobility that can provide useful information about urban lines, waiting times, possible criticalities and atmospheric disturbances directly to the users' smart phones;
- introduction of interchange parking spaces where to leave own car to continue with other lower environmental impact means;
- promotion and development of pedestrian traffic activating policies to encourage walking even through the retraining of the paths, the improvement of lighting and the introduction of dedicated signage;
- introduction of intelligent traffic lights taking real-time count of car flows as now happens in several cities in the United States;
- introduction of intelligent streetlights capable of automated modulating lighting according to the intensity of the transit and that, through a survey in real time of the detected data, are able to provide public administration useful information;
- realization, as in Netherlands and France, of solar photovoltaic cycle paths.
- Cycling is one of the, most cost efficient and environmentally sustainable mode for commuting in cities. Many cities across the world have given emphasis to it and developed the required infrastructure for promoting cycling. Also programs like bicycle sharing such as Velib in Paris can be promoted to decongest the CBDs.
- If cities are to be efficient engines of economic growth, it is important that goods are able to move from production centres to consumption centres at low cost and high speed. Therefore, a good freight movement system acquires importance.

Hence, improved mobility will involve a three pronged approach whereby there are:

1. Improvements in public transport – Metro Rail, BRT, LRT, Monorail, Trams etc.
2. Improvements in infrastructure of other motor vehicles – ring roads, bypasses, underpasses, elevated roads, improvements in the existing road ways
3. Improvements in infrastructure for walking, cycling and waterways

Smart traffic systems and routes that might bring many informational sources and possibilities, not yet used by crisis management. Examples are smart cars themselves. Their ability to communicate between themselves and environment allows us to collect data about traffic flow, obstacles on the road, road condition and so on. But they can also analyze those received data by themselves and adjust to the situation. Those are base abilities in the development of autonomous driving.

A contribution to individual safety for smart cars passengers is also the possibility of notification of predetermined mobile contacts and emergency call about the traffic accident. Therefore, even in the case of traffic accident in abandoned route, ended in the fall of passengers unconscious, there will be a help coming.

REVIEW QUESTIONS

1. What is Intelligent Transportation System(ITS) ? What are its purposes and applications? **(June-2022)**
2. Describe various Intelligent Transportation System(ITS).
3. Describe pioneering technologies for smart vehicles.
4. What is smart car ? Give features of smart cars. **(June-2022)**
5. Write short note on: Fuels of future.
6. Describe various applications of GIS in transportation engineering. **(Dec.-2021, June-2022)**
7. Describe role of GPS in transport system management.
8. Write a brief note on: Indian Regional Navigation Satellite System (IRNSS)
9. What is scope of traffic safety management ? Enumerate collective responsibilities of various segments of traffic safety management.
10. Give recommendations for infrastructure improvement and vehicle technology for traffic safety. **(June-2022)**
11. Write short note on: National Road Safety Policy(2010). **(Dec.-2021, June-2022)**
12. Give advantages and disadvantages of e-ticketing. **(Dec.-2021, June-2022)**
13. What is smart mobility ? Give measures to improve mobility. **(Dec.-2021, June-2022)**
14. Write the advantages of ITS. **(Dec.-2021)**