INTELLIGENT TRANSPORTATION SYSTEM- A CRITICAL REVIEW

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ABSTRACT

Phenomenal growth in road traffic and vehicle population coupled with inadequate arterial road network has stretched the capacity of the arterial system almost to the limit. Any significant augmentation of capacity in near future does not appear very bright due to shortage of funds. Economic growth has brought about spurt in vehicle ownership, which together with fast pace of urbanization has created tremendous growth in urban traffic. The increasing traffic on city roads has created congestion along urban roads, which is leading to increase in vehicle operating costs, delays, air and noise pollution. The traffic congestion is, to a great extent, responsible for the increased accident rates. The relief from traffic congestion through the construction of highways has only been temporary, because new commercial and residential growth follows the path of the project. The traditional solution has been to construct more and larger highways. However, due to the high financial, social, and environmental costs of such projects, that is no longer seen as a viable option .Several solutions have emerged to solve this problem, but the concept of "Intelligent Transportation system" appears to be the most attractive one. In this paper historical and theoretical background of ITS, technology and potentials of ITS technologies, Inter-disciplinary Programs of ITS (ATIS, AVCS, ATMS, CVO, APTS, ARTS) and possible applications of ITS in India are discussed.

INTORDUCTION

The emphasis on heavy industry after independence started a process of urbanization creating surpluses for the development of other sectors of economy. By the end of 1990, the process of urbanization has gained significant momentum. Today, India 's urban population is the second largest in the world after China. Over the last fifty years, while the countries population grew by 2.5 times, the urban population has grown by 5 times. As per census 2001, 30 percent of the country's population is living in the 3700 towns and cities. Around 12 percent of this population lives in 4 mega cities only (*1*).

The steep growth in the number of people live in urban area has led to proliferation of commercial activities, Greater job opportunities and comfortable living. This economic growth has brought about spurt in vehicle ownership, which together with fast face of urbanization has created tremendous growth in urban traffic. This growth has been putting transport sector under severe strain, causing congestion and its consequences.

It is unlikely to solve these problems simply by building more roads or enhancing the capacity of the existing roads, because new highway construction cannot cope with the congestion due to increased traffic load. Innovative efforts are clearly needed on wider range. Among other alternatives ITS appears to be the most attractive one.

Intelligent Transportation System, in most general terms, connects use of IT tools in transport operation. A number of short-term and long-term programs have been initiated world wide particularly in USA, Europe and Japan for building Intelligent Road Transport Systems to improve safety and efficiency (*2*). ITS enables the driver to plan their journeys in a much better and coordinated manner by providing them with real time information on road traffic and weather conditions through a communication system which links individual users with a central control room. The ultimate objective of ITS is to upgrade and ultimately, automate the Navigation system through in-vehicle instrumentation which ensures auto route guidance, speed and headway control, etc. In its present form ITS is being largely exploited for electronic toll collection, improved traffic management, assisting public transportation and enhancing efficiency of road management.

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INTELLIGENT TRANSPORTATION SYSTEM

ITS is the integrated application of advanced information processing and communications, sensing, display, and control technologies to surface transportation – both in the vehicle and on the highway (*3*).

- To use the available capacity more effectively, promote more efficient use of the existing highway and transportation network ;
- To make significant improvements in mobility, highway safety, and productivity by building transportation systems that draw upon advanced electronic technologies ;
- To decrease the environmental costs of travel.

Potential advantages of ITS

- Collect and transmit information on traffic conditions and transit schedules, allowing travelers to avoid hazards and delays before and during trips.
- Decrease congestion by reducing traffic incidents, clearing them more quickly when they occur, rerouting traffic flow around them, and automatically collecting tolls.
- Improve the productivity of commercial, transit and public safety fleets with the use of automated tracking, dispatch
- Assist drivers in reaching desired destinations with in-vehicle navigation system and provide for their personal safety and security in route with collision avoidance and distress signaling technologies.

Cost of ITS technologies

The total investment for research, development, testing, and deployment of ITS technology is just over $34 billion for the 20 years period. The cost to the individual to purchase the vehicle technology was estimated to be around $800 to $1000 per vehicle (*5*).

Various ITS Technologies

- Advanced Traveler Information Systems (ATIS)
- Advanced Public Transportation Systems (APTS)
- Commercial Vehicle Operations (CVO)
- Advanced Traffic Management Systems (ATMS)
- Advanced Vehicle Control Systems (AVCS)
- Advanced Rural Transportation System(ARTS)

The details of each technology are presented in subsequent sections.

ADVANCED TRAVELLER IFORMATION SYSTEMS (ATIS)

ATIS is defined as system that "acquires, analyze, communicate and present information to assist surface transportation travelers in moving from a starting location to their desired destination" (*6*).

Objectives of ATIS

- To get the real time data for enhancing the traffic operation.
- To assist the drivers during the operational bottleneck, inclement weather conditions and natural disasters.
- To make significant improvements in mobility, highway safety and productivity.

The following technologies are required for implementation of ATIS (*7*):

- On-board displays of maps and roadway signs.
- On-board navigation and route guidance system.
- Systems to interpret digital traffic information broadcasts.
- On-board traffic hazard warning system.

ATIS address technologies to assist travelers with planning, perception, analysis and decision making to improve the convenience and efficiency of travel. Communications technology, architecture and interface standards that will enable two-way, real-time communication between vehicles and a management center are required. They include radio data communications, cellular systems, roadside beacons used in conjunction with infrared or microwave transmission or low powered radio signals and satellite communications. Software to format the collected data for effective use by commercial vehicle operators and operators of transportation management systems is necessary. A number of critical human factors issues and must also need to investigate for developing graphical interface for drivers

Potential advantages of ATIS

Advanced traveler information systems provide drivers with information on traffic jams, operational bottlenecks (construction and maintenance activities, lane closure etc..) , congestion, inclement weather conditions and natural disasters, occurrence of accidents along certain routes and suggests the best alternative route to be taken. ATIS provides information about restaurants, tourist attractions and the nearest service stations and rest shops. It also provides information that assists in trip planning at home, at work and during journey also. ATIS can include on-board displays that replicate warning or navigational roadside signs when they may be obscured during inclement weather conditions.

ADVANCE (*8, 9*), FAST-TRAC (*10, 11*), and TRAVINFO (*12*) are the applications of ATIS technologies in USA. Features of ADVANCE are detailed below for the demonstration of working principle involved in ATIS. ADVANCE (Advanced Driver and Vehicle Advisory Navigation Concept) is aimed at reducing traffic congestion in Chicago suburban area. The ADVANCE system uses smart cars and smart highways to reduce congestion and improve safety for all drivers in the project area.

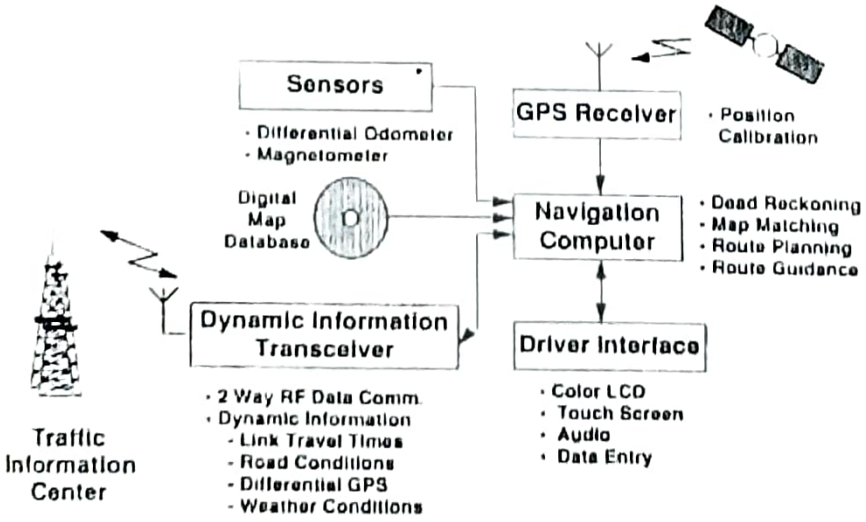

Figure 1: In-vehicle system of ADVANCE

The ADVANCE system consists of four functional elements

1. Mobile Navigation Assistant (MNA) -- performs and displays in vehicle navigation and route guidance and generates travel time reports for transmission to the traffic information center (TIC).
2. TIC -- Performs the data processing display and interface functions for overall system control
3. Radio Frequency Communication Network -- Provides two-way radio data communication between MNA and TIC.

4. Traffic-related Functions (TRFs) – the ADVANCE traffic related data and analytical functions at the TIC.

A functional diagram of the in-vehicle system is shown in Figure 1.

The MNA includes wheel speed and compass sensor as well as GPS receiver that provide accurate position and time data for the navigation function. A key function of the MNA is to compute travel time reports as the car is driven through the links in the highway system. With position and time measurements supplied by the navigation centers, the MNA calculates the time it takes to transfer each link in the highway grid as the vehicle moves to its destination. The beginning and end of each link is signaled when the vehicle makes a turn at an intersection or when it moves over designated highway-embedded sensors. These maneuvers define the vehicles known position related to the stored digital highway map. The calculated link transfers time is immediately compared with a value for a normal travel time for that link, stored in the vehicles computer memory. If the traverse time deviates from normal by a specified amount then the measured transfers time is transmitted to the TIC.

TIC collects and analyses hundreds or thousands of such reports in periods of 30 minutes or 60 minutes. The result is an accurate and gives current picture of traffic congestion and link travel times throughout the entire highway network. This data on current traffic conditions is broadcasted to all operating ADVANCE vehicles in the area to use in preparing route-guidance instructions appropriate to each vehicle's current positions and planned destination. A CDROM disk drive is provided for mass data storage. Traffic Information Centre is shown in Figure 2.

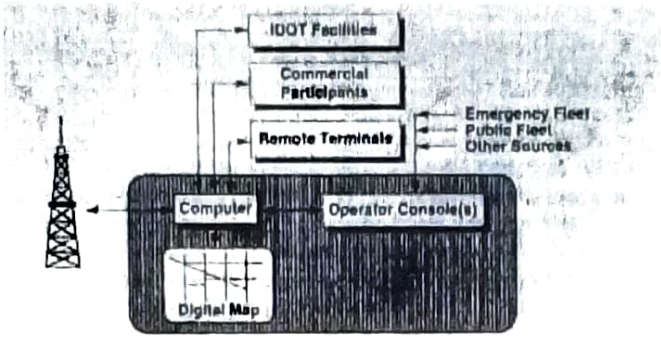

Figure 2: Traffic Information Centre of ADVANCE

The driver interface is a 5.7-inch color liquid crystal display (LCD) with a touch screen and dedicated set of hard keys. The driver interface is shown in Figure 3.

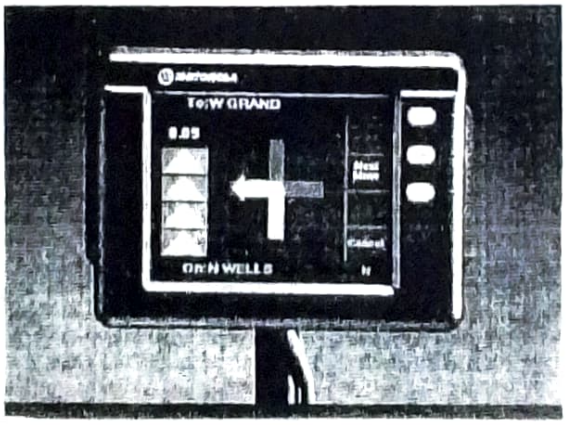

Figure 3: Driver Interface of ADVANCE

ADVANCED PUBLIC TRANSPORTATION SYSTEMS (APTS)

APTS is defined as the ITS subsystem that "encompass the application of advanced electronic technologies to the deployment and operation of high occupancy, shared-ride vehicles" (*6*).

Objectives of APTS are:

- To move increased number of travelers without constructing the additional highways;
- To provide effective means for alleviating urban traffic congestion;
- To move some of the travelers off the highways and into the buses, trains and subways.

The following technologies are required for implementation of APTS (*7*):

- Fleet monitoring and dispatch management.
- Real-Time displays at bus stops.
- Intelligent fare collection (using smart cards)
- Ride share and HOV information system.

GPS receiver for automatic vehicle location, two-way communications, in vehicle equipment, operation center software and displays, and a customer information network for transit system uses are essential components of APTS.

Potential advantages of APTS are listed below (*3*):

Dynamic routing and scheduling could be accomplished through on board devices, communication with a fleet management center and public access to a transportation information system containing information routes, schedules and fares. Automated fare collection could also be possible.

AUTOMATED VEHICLE LOCATION (*13*), SMART BUS (*14, 15*), and TRAVLINK(*16*) are the applications of APTS technologies in USA. Features of SMART BUS are detailed below for the demonstration of working principle involved in APTS. The SMART BUS project involves a significant upgrade to the transit system serving the Denver area. Smart Track AVL system based on GPS technology is the key technology.

A fully integrated SmartTrack system includes in-vehicle equipment, communications, operation-center software and displays, and a customer information network of transit system uses. An overview of the system is shown in Figure 4. In this system, each bus is equipped with a transit control head, an intelligent vehicle logic unit, and a radio communication system. The control head includes a display that shows clock time, schedule status, a notification of the bus being off- route, and text messages from the dispatcher. The control head also has 20 buttons that send pre coded, stored messages to the dispatcher. The control head is shown in Figure 5. The logic unit provides data and message storage. It also serves as an interface with the radio system and in-vehicle data functions such as GPS position data, Fare collection, passenger boarding and alarms.

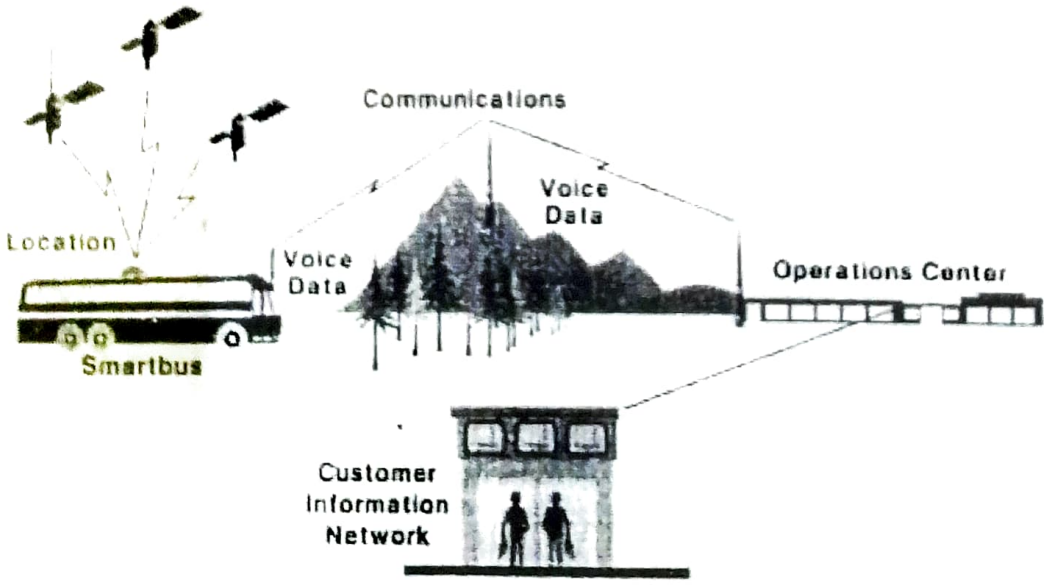

Figure 4: SmartTrack system overview

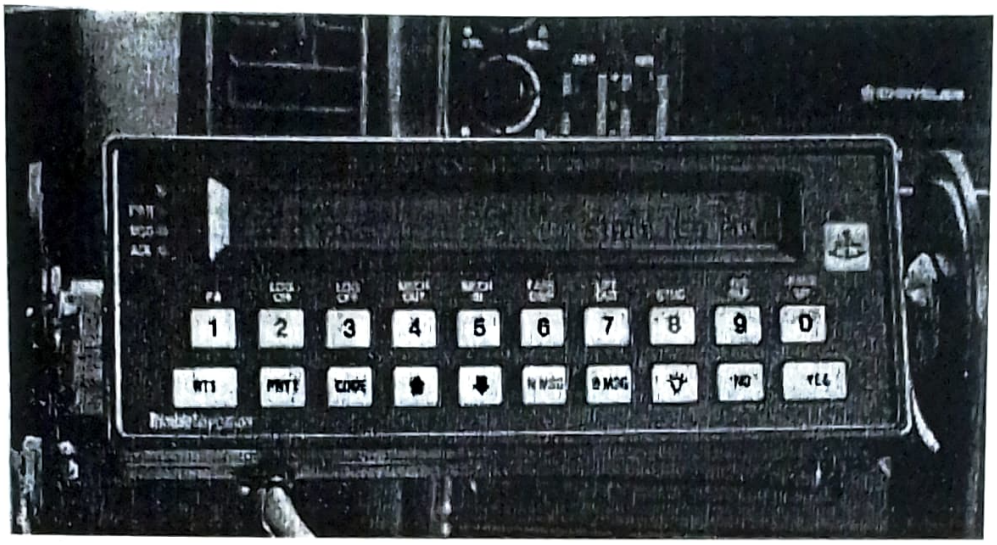

Figure 5: Control head

COMMERCIAL VEHICLE OPERATIONS (CVO)

The main focus of commercial vehicle operations (CVO) is on the specialized operations involved in long-distance heavy truck transport (*17*).

Objectives of CVO

- To improve productivity, safety and regulation of all commercial vehicle operations;
- To introduce no-stop-needed handling of the routine administrative tasks.

The following technologies are required for implementation of CVO (*7*):

- Automated vehicle Identification (AVI)
- Weigh in Motion (WIM)
- Automatic Vehicle Classification (AVC)
- Electronic toll Collection (ETC)
- Automated Vehicle Location (AVL)
- Two-way Communications (TWC) between fleet operator and vehicles
- Automatic Clearance Sensing (ACS)

Transponder, weigh station computer, GPS receiver, trip data packet, gateway computer, a set of road side readers and driver communication subsystem are the components of CVO technologies.

Potentials Applications of CVO

Automatic toll collection, road use calculation, permit acquisition, vehicle weighing (3). Such automation can save time, reduce air and noise pollution and increase reliability of record keeping and the fee collection. Faster dispatching, efficient routing and more timely pickups and delivers will be made possible and this will have a direct effect on quality of service.

ADVANTAGE I-75 (*3*) and HELP (*17*) are the two applications of CVO technologies in USA. Features of ADVANTAGE I-75 are detailed below for the demonstration of working procedure involved in CVO. ADVANTAGE I-75 is a public-private organization along inter state 75 corridor, running from Florida to Michigan State, with an extension into Canada. Its objective is to reduce congestion, increase efficiency and enhance safety.

Trucks entering the I-75 corridor at any point will be required to stop at the first weigh station they encounter, where AVI reader reads out the truck identification number and credentials stored in the transponder. This information is read into the weigh station computer and check. the trucks weight, its configuration, weigh station identification and time of day is recorded

in the trucks trip data packet. The trip data packet, a small formatted database is forwarded to the next weigh station for pre clearance authorization. Weigh station computer sends all these data to various weigh stations about the incoming trips and other details. Trucks can continue on their trip without any need to stop at additional weigh stations. Advantage I-75 weigh station AVI reader layout is shown in Figure 6.

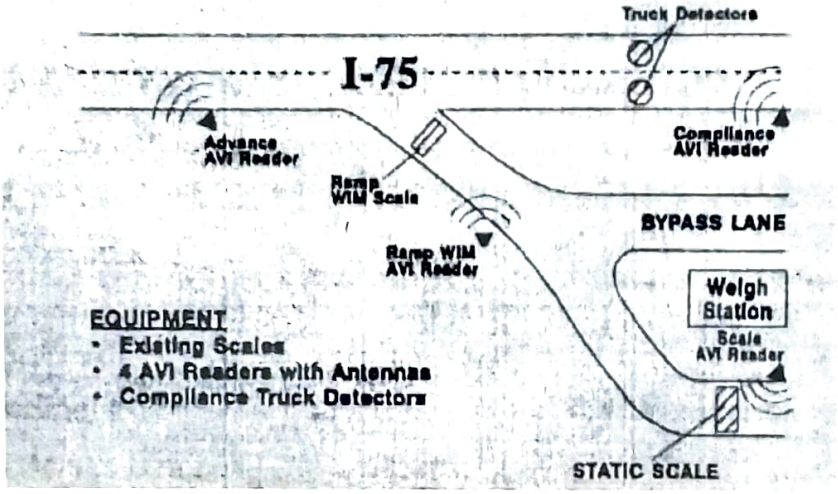

Figure 6: ADVANTAGE I-75 weigh station AVI reader layouts

ADVANCED TRAFFIC MANAGEMENT SYSTEMS (ATMS)

ATMS is defined as "an array of hardware and software components designed to the monitor, control and manage traffic on street and highways" (*5*). The concept of ATMS evolved from the idea of applying emerging computer and communication technology to both the traffic management system and highway vehicles as an integrated system (*17*).

Objectives of ATMS are

- To respond dynamically to actual traffic condition, for avoiding massive traffic delay
- To have highway surveillance for early detection of incidents
- To increase efficiency of highway use by enhancing the traffic operation

The following technologies are required for implementation of ATMS (*7*):

- Traffic management centers in major metropolitan areas to gather and report traffic information.
- Sensors including magnetic loops and machine vision systems that provide current information on traffic flow to the TMC
- Variable message signs that provide current information on traffic conditions to highway users and suggest alternate routes
- Programmable, directional traffic signal control systems
- Automated dispatch of service and emergency vehicles to accident sites

Advanced detection technology, such as image processing systems, automatic vehicle location (AVL) and identification (AVI) techniques are the components of the ATMS. New traffic models need to be created, including real-time dynamic traffic assignment models, real-time traffic simulation models and corridor optimization techniques. Artificial Intelligence (AI) and Expert System can be applied for incident detection.

Potential advantages of ATMS

- Work in real time

- Respond to changes in traffic flow
- Quick detection of congestion, accidents and other incidents
- Dynamic traffic signal controls
- Rapid recovery of the incident zones

GuideStar (*18*), MAGIC (*17*) and Intelligent Corridor System (*19*) are the applications of ATMS technologies in USA.Features of MAGIC are detailed below for the demonstration of working procedure involved in ATMS. MAGIC (Metropolitan Area Guidance and Control), is a major project in New Jersey, USA on the inter state 95 (I-95) North East corridor. The MAGIC project is designed to reduce traffic congestion, there by reducing total vehicle emissions in the corridor.

MAGIC includes a variety of system components that monitor highway conditions, support traffic management, and advise travelers, as shown in Figure 7.

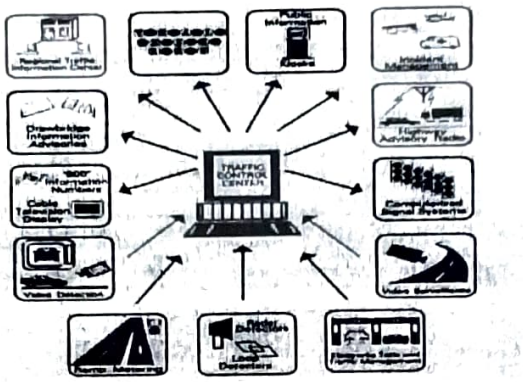

Figure 7: MAGIC system components

The traffic control center (TCC) will be the command center of the magic system. The TCC will receive the data from array of sensors installed along the highway corridors in the system. A master computer will process and control displays of highway and traffic conditions and other relevant data. Computer software will assist in incident detection. Expert systems will be developed to present recommended actions for alternate routing or other actions to alleviate traffic congestion. The TCC will control the dissemination of signals to variable-message signs, high way advisory radio, and other means to support incident management.

ADVANCED VEHICLE CONTROL SYSTEM (AVCS)

AVCS Combine sensors, computers, and control system in vehicles and in the infrastructure to warn and assist drivers or to intervene in the driving task (*6*).

Objectives of AVCS

- To improve traffic flow by reducing congestion, commuting time and accidents;
- It enhances personal mobility, safety and increase comfort of highway travel;
- To create more environmental responsible transportation system.

The following technologies are required for implementation of AVCS (*7*):

- Adaptive cruise control, which slows a cruise –controlled vehicle if it gets too close to a preceding vehicle.
- Vision enhancement system, which aid driver visibility in the dark or in adverse weather
- Lane departure warning systems, which help drivers, avoid run- off- the-road crashes.
- Automatic collision avoidance system, that is, automatic breaking upon obstacle detection.

- Automated highway system (AHS), automatically controlled vehicles in special highway lanes to increase highway capacity and safety.

Magnetic sensor to keep the vehicles in the center of lane, network computers to coordinate the flow of traffic, digital radio to communicate with others vehicles and TMCS, forward looking sensors to detect dangerous obstacles and other vehicles ahead, and video displays to inform the driver about the operation of vehicle are the required components of AVCS (*3*).

Potential advantages of AVCS

- Improve operating effectiveness – Increase throughput of people, goods, and vehicles and improve operations in adverse weather.
- Improve transportation service – provide a full range of services, reduce travel time, and improve travel reliability.
- Improve user desirability -- Improve safety, enhance personal mobility, increase comfort of highway travel, provide user -friendly service and reduce insurance costs, and ensure affordable cost.
- Improve community Desirability -- Reduce land use, property impact, reduce need for emergency support and reduce construction disruption
- Improve state transportation agency desirability -- provide a basis for long-term upgrade to major highways, enable smooth transition, Enable smooth installation, enable practical operation, provide better cost/ benefit ratio, and integrate with and support transits operations.
- Provide societal Benefits -- strengthen the nation's economy, support national emergencies, reduce fuel consumption, and reduce pollutants from vehicles.

AUTOMATED HIGHWAY SYSTEM (AHS)

AHS is defined as "specially equipped highway lanes, on which vehicles are controlled automatically" (*23*).

Components of AHS

- Automated Highway --Is the instrumented highway, on which magnetic nails are installed in the center of highway lane that are one inch in diameter by four inches long, appearing at three feet. They assist in providing feed back to vehicles to maintain lateral (steering) and longitudinal (speed & spacing) controls.
- Automated Vehicle – Six magnetometer sensors, mounted to the front and rear bumpers of each vehicle, and radar sensors mounted to the front send the data to an on-board computer, which keeps the vehicle in the centre of its lane. The computer interpret signals received from other vehicles and road side sensors and issues command's to the car's actuators (i.e., steering, braking and throttle mechanisms)
- Transportation Management Centers (TMCs) – Monitor traffic flow via roadside cameras and by inductive loop detectors and collect information about collisions, road closures, and emergency notifications, and inform it to all vehicles

Working of AHS

1. Vehicle System Check Point -- A Vehicle transponder relays a signal to road sensors locale in the validation lane, furnishing them with the status of all onboard computer system. If all systems are functioning correctly, control of the vehicle is assumed by the system. It is shown in Figure 8.

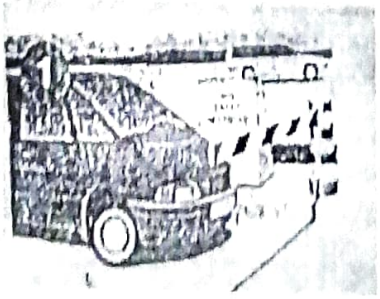

Figure 8: Vehicle System Check Point

2. In vehicle navigation systems -- Notes drivers destination point, distance between vehicle and all necessary information regarding AHS. It is shown in Figure 9.

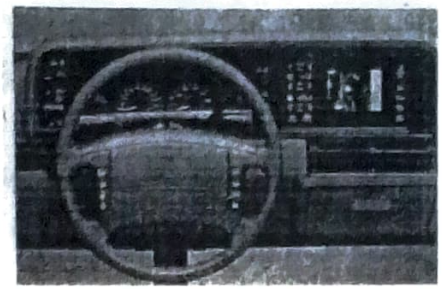

Figure 9: In vehicle navigation system

3. Automated Highway System -- Then vehicle entered into an AHS lane and control of vehicle is taken by the system until the driver's destination is reached. Control is then returned to the driver. It is shown in Figure 10.

Figure 10: Automated Highway Systems

4. At destination – upon reaching the destination, signal is emitted advising the driver to resume manual control transponder in car sends signal to other cars, which creates a space so it can exit. It is shown in the figure 11.

Figure 11: At destination

Demo '97 of AHS (*24, 25*)

This operational test was conducted on a 12 km, HOV segment of interstate 35 located near San Diego, USA. On the test track magnetic nails are buried along the center of the road at 1.2m apart. 8 cars are traveled in close coordination under fully automated longitudinal and lateral control. Cars maintained a fixed spacing of 6.5m between them selves at all speeds. During maneuvers like acceleration and declaration, spacing was maintained with accuracy within 10 centimeters. The platoon moves as a unit during acceleration, deceleration, and changing lanes, and avoiding obstacles like a "highway train "with vehicles linked. The cars communicate to each other 50 times each second.

ADVANCED RURAL TRANSPORTATION SYSTEM (ARTS)

ARTS address applications of ITS Technologies to rural needs.

Objectives of ARTS

- To Provide Safety On Rural Roads

- To Provide Traveler information and emergency services
- To respond rapidly to incidents

The following technologies are required for implementation of ARTS (*7*):

- Route guidance
- Two-way communications
- Automatic vehicle location
- Automatic emergency signaling
- Incident detection
- Road way edge detection

Potential advantages of ARTS are listed below (*3*):

Applications of ARTS technologies can address the needs of rural motorists who require assistance in extreme conditions such as weather, public works, and special events ARTS could address long-term issues including construction zone assistance, transit applications, inclement weather trip avoidance and assistance route information for tourists, and traffic control.

ITS PROGRAMS OUTSIDE THE USA

EUROPE (*3*)

A number of programs underway in Europe to research, develop, and demonstrate ITS technologies. EUREKA, a $5 billion, 19-country program designed to simulate cooperative research and development among industries and governments in Europe. The following are ITS related programs:

- EUROPOLIS – a $150 million, 7 year research project to design automated road systems to develop technology to automate driver functions.
- CARMINAT – a 4 year research project to develop in- vehicle electronic navigation and communications systems.
- ATIS – an $8.5 million project, 5 year project to provide pre trip information on traffic condition.
- ERTIS – a $2.7 million, 3 year project to develop a common road information and communications system for motor carriers across Europe.
- PROMETHEUS – This stands for PROgraMme for European Traffic with Highest Efficiency and Unprecedented Safety. It is a $800 million, 8 year project. Its general objectives are to improve traffic safety, enhance vehicle operating efficiency, and reduce the adverse environment effects of automobile travel by using the latest advances in electronics and information technology in order to shape computer aided driving (19).
- DRIVE – This stands for Dedicated Road Infrastructure for Vehicle Safety in Europe. It is a $150 million, 3 year project. The goal is to improve road safety, promote transport efficiency, and reduce environmental pollution.
- ALI- SCOUT – Developed in the Federal Republic of Germany, is a route-guidance system.

JAPAN (*17*)

With its strong orientation toward advanced technology, Japan has led the world in applying advanced electronic technology to alleviate traffic congestion and make its surface transportation systems safer and more efficient. Some elements of this technology are described below.

- *Vehicle Information & Communication System (VICS)* – was organized to support the dissemination of traveler information such as current traffic conditions and guidance instructions.
- *Universal Traffic Management System (UTMS)* – This aims at to deploy an enhanced traffic management system.
- *Advanced Road Transportation System (ARTS)* – Objectives of ARTS project are an automated toll-collection system, a road alignment information system that alerts drivers of changes in the road direction ahead, a road surface-detection system that sense and provides information on road surface condition, such as surface water and ice, a surrounding

objects detection system, A vehicle headway control system, an automatic vehicle control system that provides automatic longitudinal and lateral control, a traffic flow guide/control system that guides or controls traffic flow, providing drivers with route-guidance instructions for minimum travel times in highway networks, based on current traffic conditions.

- *Advanced Safety Vehicle (ASV)* – ASV was initiated with the objective of designing, building, and testing a small number of prototype vehicles. The ASV project will develop automatic vehicle control system technologies in four functional categories: safety through warning and automatic intervention, damage reduction in the event of collision, and automatic accident warning to prevent multiple car collisions.
- *Super Smart Vehicle System (SSVS)* -- The SSVS project was initiated with the objective of exploring vehicle concepts for fully automatic driving in the future.

ITS IN INDIA

AITS India is an umbrella organization, which represents a broad spectrum of members including industry, government, consumer organizations, academic Institutions and research organizations, for encouraging the development and deployment of Intelligent Transportation Systems in India. AITS India also has strong links internationally with similar organizations including ITS America, ERTICO, VERTIS and ITS Asia-Pacific. AITS India can provide valuable insight into the latest global developments (*27*).

Some developments related ITS field in India is listed below:

- An effort has been made to develop an approach for ITS through the development of a computer model. The applicability of the model has been tested by taking the data of a study area consisting a portion of ring road in Delhi (*26*).
- Vehicle actuated signals has installed on Herbal Interchange in Bangalore
  - (*Bangalore Development Authority, Bangalore*)
- ITS technologies are likely to be implemented in Golden Quadrilateral Project (*Business Line ,The Hindu Groups Chennai*)

Probably, to implement ITS In India, when mixed traffic conditions exist, few prerequisites are essential. They are listed below:

- Segregation of slow moving traffic
- Training for all technical staff of concerned road authorities.
- Awareness to people about this technology
- Need to look a simple and robust system, which is cost effective and efficient, at the same time compatible with the present level of developments in related fields of developments in related areas of technology(2)

Some of the Applications of ITS technologies are:

- Vehicle actuated signals on urban arterials to handle the traffic dynamically.
- Visual inputs from cameras installed at vantage points for identification of Incidents.
- On expressways provide display of variable message signs for giving information to travelers.
- Use of inductive loop technology for detection of over dimensional or over loaded vehicle

SUMMARY

There is a need for application of electronic Information Technology in improving the efficiency of road transportation and safety on roads. Not much development in this field has taken place in India so far. Providing an efficient and safe traffic operation on this network will be crucial factors in the years to come. Similarly, growth in urbanization and employment opportunities offered by cities, spurt in vehicle ownership are going to tremendously influence urban transportation. ITS has to become an integral part of transportation planning exercise. There is a need to select technology, which is best suited to the needs of the country and at the same time is cost effective and efficient. This may require an inter-disciplinary approach to be

followed involving planning, operating and enforcing agencies, creation of substantial physical infrastructure, and considerable human resource development efforts.

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