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A RESEARCH ON INTELLINGENT TRANSPORTATION SYSTEMS WORLDWIDE

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Abstract —*In over two decades, intelligent transportation systems (ITS) have redefined our transportation systems- buttressed their performance, augmented their security, and increased the choices for the travellers. These days, the traditional methods used for controlling the traffic i.e. deploying traffic lights, traffic signs, traffic policemen are getting obsolete day by day. In the era of technology and smart systems, transportation systems should be made intelligent. ITS involves a large number of breakthroughs and therefore this paper focuses on those we believe to be most relevant. The main purpose of the paper is to study the major achievements attained across the globe in this area and also suggest some possible directions towards future research.*

Keywords- *Intelligent Transportation Systems (ITS); ITS Techniques; Traffic control; Safe Transportation; Transportation Systems; Smart systems*

I. INTRODUCTION

Over last few decades, the transportation sector worldwide is becoming saturated with vehicles, and not new ideas and revolutionary transport systems. The impact of this highly dense situation is traffic congestion, unpredicted delays, and fatalities. In fact, according to WHO, road injury still ranks ninth in the leading causes of death globally. [15]

Though several solutions such as dispatching authorities (police, fire brigade, civil protection, health services, etc.) to assist people and subside the traffic, safety belts, helmets and air bags, to curb the problems were introduced, we still haven't made any significant progress in delivering safe and fast transport to the people everywhere. Moreover, building more roads to reduce traffic congestion is not the "right" solution because it's very expensive, causes considerable environmental impact, and requires a large space, which is an important limitation within urban areas. So, with the help of vigorous developments in microcontrollers, sensors, and wireless connectivity, the vehicle should be transformed into a computer on wheels.

Since ITS is dependent on results from a variety of other research activities in electronics, control, communications, sensing, robotics, signal processing and information systems, it increases the problem's complexity and calls for an exhaustive research approach. The multidisciplinary, multifaceted field that is ITS requires knowledge transfer and cooperation among different research areas.

In this work we give an overview of the state-of-the-art ITS found globally and study the order of ITS in India. To fulfil that objective the paper is organised as follows. Section 2 reviews the major types of ITS and presents several examples of real systems. Finally, section 3 discusses the need for ITS in a developing country that is India.

II. MAJOR TYPES OF ITS

To study every advance of ITS is beyond the scope of this paper; therefore, in this section the six major ITS categories are comprehensively studied and exemplified by some existing systems.

A. Advanced Traffic Management Systems (ATMS)

Advanced Traffic Management Systems are an important progress in intelligent transportation systems that have significantly improved traffic service quality and reduced traffic delays. In ATMS, we have a better means to manage traffic, implementing roadway incident control strategies from one central location, and to respond to traffic conditions in real time.

The three main elements of ATMS are:

- Collection data team -- monitor traffic conditions;
- Support systems -- cameras, sensors, semaphores, and electronic displays help to manage and control traffic in real time;
- Real-time traffic control systems -- with the help of previous two elements, they can change semaphore, send messages to electronic displays and control highway access. [1]

For example, an ATMS technology that has been installed in metro Atlanta is Georgia NaviGAtor. Georgia NaviGAtor operates with a series of traffic cameras, changeable message signs, ramp meters, and a traffic speed sensor system. Additionally, a portion of the system receives traffic flow information from floating car data gathered by

anonymously tracking cell phones. Moreover, with the new traffic information, Georgia Department of Transportation (GDOT) officials can now monitor and report traffic conditions on hundreds of miles of roadway south of Atlanta from Interstate 285 southward beyond the Macon area. [2]

ATMS also aids Advanced Travellers Information Systems which are discussed in next sub-section.

Another aspect of traffic flows that ATMS efficaciously counters is the light rush-hour flow in the opposite direction of a highway. Barrier transfer machines, also known as zipper machines or road zipper, relieve traffic congestion during rush hours by creating extra lanes in the direction of heavy travel. These extra lanes are called zipper lanes.

Figure 1: A barrier transfer machine

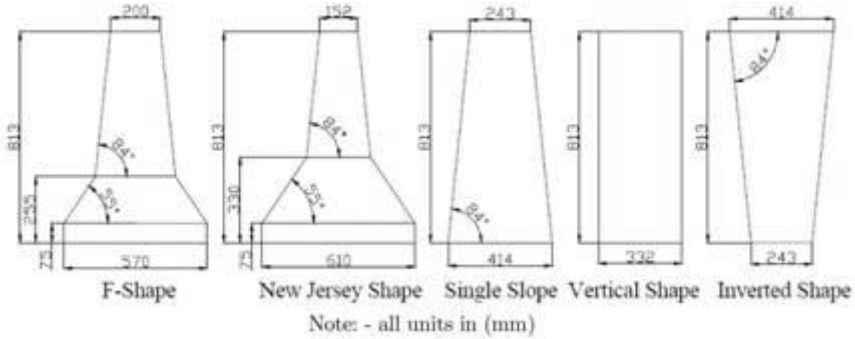

Figure 2: Typical shapes of concrete barriers [4]

B. Advanced Traveller Information Systems (ATIS)

Advanced Traveller Information Systems furnishes the travellers with information like locations of incidents, weather and road conditions, optimal routes, recommended speeds, and lane restrictions. With this system, travellers, from home, on work, or in stopping-place can decide the shortest and the fastest route to reach their destination as well as the aptest transport service to take. As said earlier, ATMS also provides traffic information that will allow drivers to make better-informed decisions regarding their driving times and routes, resulting in reduced traffic and shorter travel times. With such systems and technologies at their dispense, the traveller can also react to a dangerous situation in a faster, effective way.

ATIS can be delivered to the consumers via radios, computers, websites, cellular phones, television, or electronic billboards. These systems are connected to the Internet and are fed with data like traffic delays, accidents, the status of rush hours traffic, and alternative highways. They can be installed at public places like petrol pumps, gas stations, hotels, supermarkets, and parking lots.

Some of the advances in this category are the Smartraveller provided by the Australian Department of Foreign Affairs and Trade and the Google Maps.[5] Google maps provide real-time traffic information, satellite imagery of routes, estimated time of arrival by different transports, as well as alternative routes. Furthermore, the feature of downloading the map on the Google Map application of a particular area beforehand allows the users to navigate their routes without depending on the internet connectivity.

Washington State Department of Transportation provides a WEBFLOW32 system to obtain real-time information about the traffic conditions in Seattle, U.S. and is available on the internet. One can use WebFLOW32 to create traffic maps on your PCs running on Microsoft Windows XP, Windows Vista, Windows 7, and Windows 8 operating systems. These maps as similar to the ones you find on the WSDOT website, figure 3, and in the WSDOT regional traffic management centres. One can also see camera images, displays of variable message signs, and the status of the ramp meters. WebFLOW32 creates traffic maps by first downloading a small data file from the WSDOT Internet servers and then fills in a map that resides on your PC. [6]

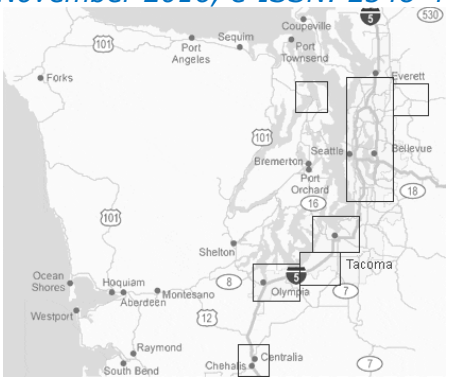

Figure 3: Washington State Puget Sound and Olympic Peninsula Cameras (Zoomed Out) [6]

C. Commercial Vehicles Operation (CVO)

Commercial Vehicle Operations (CVO) encompasses a range of industries, including service and repair vehicles, private buses and taxis, and trucks. These systems allow the management of all the vehicles while controlling speed and stopping-place times, facilitating collection and distribution, besides fulfilling the destination.

The most prominent segment of CVO is- motor carriers. Motor carriers fall into three general classifications: "common", "contract" and "private." A common carrier is a business that carries goods for-hire, serving the general public or other businesses at established rates. A contract carrier also carries goods for hire, but on a contract basis, for specific customers. A private carrier is a unit that serves the internal transportation needs of an organisation (e.g., the truck fleet for a supermarket chain). [7]

CVO also includes Freight Management Systems. FMS are used in logistic and cargo shipments and delivery through transportation that includes sea, land, air, tug and barge and rail services. Primarily, FMS is used for reducing congestion, pollution and noise, but it also raises mobility and customer value. With the growth of e-commerce and e-business systems, FMS and CVO provides a timely operation while being economical.

CVO systems use different ITS technologies to increase safety and efficiency of commercial vehicles and fleets. Moreover, the ITS technologies increase the speed of goods delivery, patient transport and reduction of costs operation. [1] These systems include the technologies for travellers' information, traffic management, vehicle control management, such as:

- Automatic Vehicles Identification: Ordinarily long range RFID is used for AVI because they are convenient, secure, and contribute to the environment.
- Automatic Vehicles Classification: AVC provides information about classes of the vehicle which are important for traffic operation.
- Automatic Vehicles Location: AVL are used for tracking vehicles by placing a GPS module inside the vehicle.
- Pedestrian Movement Detection
- Board Computers
- Real Time Traffic Transmissions

D. Advanced Public Transportation Systems (APTS)

Advanced Public Transportation Systems intend to improve the efficiency and operation of the most common way of commutation: public transport. Intelligent and smart systems in them for more efficient and safer travel are the need of the hour. Previously mentioned technologies in ATMS and ATIS are used to acquire route information, schedules, the cost of running, weather, to determine accidents or mishaps in routes, to estimate time of arrival, etc.

Such public transports usually include buses and trains, but some high-end technologies gave rise to Maglev. Derived from 'magnetic levitation', Maglev, a combination of superconducting magnets and linear motor technology, realises super high-speed running, safety, reliability, low environmental impact and minimum maintenance. It is a transportation method that uses magnetic levitation to move vehicles without touching the ground. With maglev, a vehicle travels along a guideway using magnets to create both lift and propulsion, thereby reducing friction to a great extent and allowing very high speeds. Maglev trains move more smoothly and more quietly than wheeled mass transit systems. They are relatively unaffected by weather. The power needed for levitation is typically not a large percentage of its overall energy consumption. The Shanghai Maglev Train, also known as the Transrapid, is the fastest commercial train currently in operation and has a top speed of 430 km/h (270 mph). [8]

APTS includes the automatic payment systems like Smart Cards which have a stored amount that can be used to draw tickets from Automatic Ticketing Machines; Automatic Vehicles Location determining the geographic location of a vehicle along with its speed which can be used to predict the arrival and departure of various transit systems. It also includes Automatic Passenger Counters, to monitor customer service and trip costs.

E. Advanced Vehicles Control Systems (AVCS)

We cannot build roads and highways to decrease traffic congestion; it is not only hazardous to environment but also not feasible. Advanced Vehicles Control Systems aid in managing the traffic, ensures safety of the drivers and passengers, and considerably reduce the congestion on highways.

One such example is the Safe Road Trains for the Environment (SARTRE) project. It aims to encourage a step change in personal transport usage by developing of environmental roadtrains called platoons. Systems will be developed facilitating the safe adoption of road trains on un-modified public highways with interaction with other traffic. A scheme will be developed whereby a lead vehicle with a professional driver will take responsibility for a platoon. Following vehicles will enter a semi-autonomous control mode that allows the driver of the following vehicle to do other things that would normally be prohibited for reasons of safety; for example, operate a phone, reading a book. [10]

Figure 4: A roadtrain [10]

Apart from these, there are automatic vehicles like the one developed at the Ohio State University Centre for Intelligent Transportation Research (CITR). This vehicle demonstrated advanced cruise control, automated steering control for line keeping and autonomous behaviour, including the automated stopping and lane changes in reaction to other vehicles. It was also equipped with image processing computer, graphical status display computer, vehicular control computer, angular rate gyro, radar signal processing components, and interface electronics. [11] Such smart vehicles are a step to counter the dangerous situations, especially for the elderly drivers.

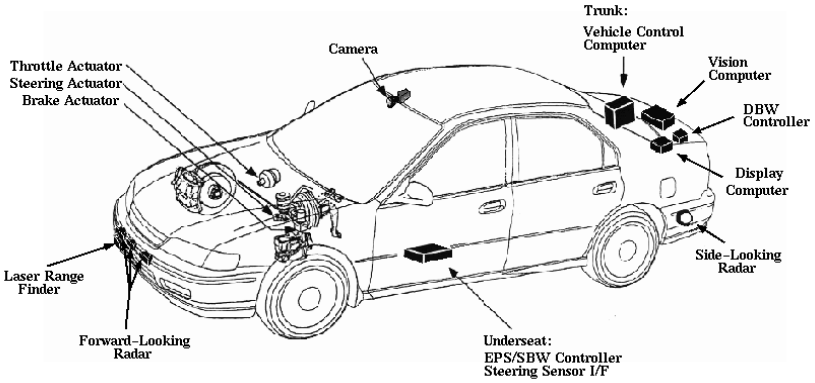

Figure 5: Ohio State University Autonomous Vehicle [11]

Clearly, self-driving vehicles will play a crucial role in improving transportation safety and accelerating the world's transition to a sustainable future. In fact, Tesla Motors and Google have made tremendous progress in this area with the advent of Tesla Cars and Google Self-Driving Car Project respectively. Tesla claims that, as of last month, all its cars will have the hardware needed for full self-driving capability at a safety level substantially greater than that of a human driver. While Tesla cars system will be further calibrated using millions of miles of real-world driving to ensure significant improvements to safety and convenience, Google's project has self-driven over 2 million miles. Both these projects connote noteworthy development in this sector of ITS. [16] [17]

Figure 6: Google Self-Driving Project [17]

F. Advanced Rural Transport Systems (ARTS)

ARTS technologies provide information about remote road and other transportation systems. For all round development of the country, it is very essential that the isolated areas are developed simultaneously with the metropolitan area. Examples include automated road and weather conditions reporting and directional information. This type of information is valuable to motorists travelling to remote or rural lands. There are many different types of dissemination methods including Dynamic Message Signs (DMS).

Figure 7: Dynamic Message Signs [12]

Another ARTS service provided by Office of Federal Lands Highway is Highway Advisory Radio (HAR). HAR is used in conjunction with other technologies such as Road Weather Information System (RWIS), Environmental Sensing Stations (ESS), Roadside Detection (RS-D), Closed Circuit Television (CCTV), pavement sensors, and other technologies that gather weather and roadway information. HAR can disseminate information about current roadway conditions, road closures, construction events, congestion, alternate routes, or any other valuable directions that may assist motorists. [12]

Effects of ARTS:

- Increase Passenger Throughput
- Increase Roadway Capacity
- Manage System Efficiency
- Reduce Local Demand

III. NEED FOR ITS IN INDIA

Some of the main issues in transportation systems in India are: an underdeveloped network, explosive urbanisation and growth, lack of resources for operation and maintenance, outdated and worn out assets and infrastructure and this is the main cause of accidents and environmental pollution. [13] The development of transport system is imbalanced in India i.e. there is heavy pressure on rail and road transport in certain regions. In metropolitans there is a lack of fast and adequate public transport system; this leads to explosion of personal transport (own vehicles).

Figure 8: Road Congestion

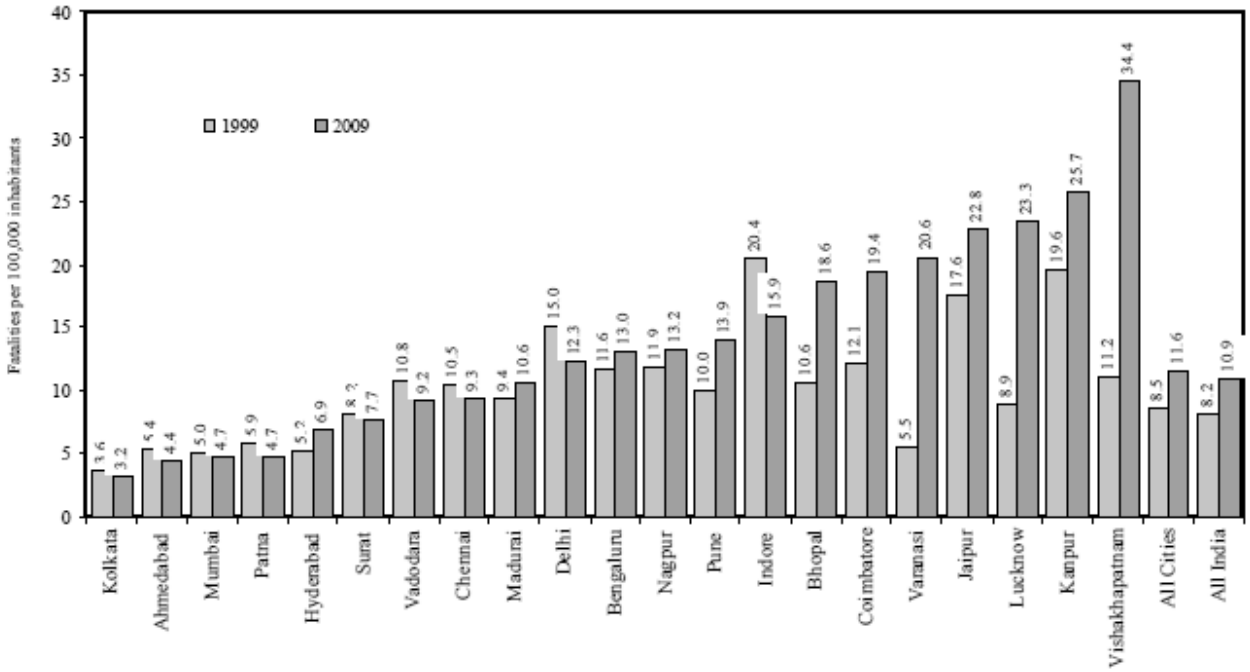

Figure 9: Road accident fatality risk in selected Indian metropolitan cities in the year 1999 and 2009 [14]

The problem of acute road congestion, rising air pollution, and a high level of accident risk faced by metropolitan cities of India is taking serious dimensions and worsening the people's quality of life. [14] Thus, a strategy is needed which will provide and promote sustainable high-quality links and contribute to congestion relief and environmental preservation.

Towards this objective, Ministry of Electronics and Information Technology Government of India has undertaken a few ITS sub-projects:

Sub project/ ITS technology	Likely End Users
Wireless Traffic Control System	Traffic police and local authorities
Second Generation Area Traffic Control System (CoSiCoSt- II)	Medium and large cities deploying ATCS
Real Time Traffic Counting & Monitoring System	Traffic Planners and development authorities
Intelligent Parking Lot Management System	Town planners & local authorities
Advanced Travellers Information System	General public and traffic planners
Intelligent Transit Trip Planner and Realtime Route Information	General public and traffic planners
Red Light Violation Detection System	Traffic police
Intelligent Traffic Congestion Management System using RFID	Traffic planners and development authorities

Table 1: ITS technology and Likely End Users [18]

Evidently, we are yet to make substantial progress in the field of Intelligent Transportation Systems. ITS is needed for ensuring safe, affordable, quick, comfortable, reliable and sustainable access for the growing urban and rural population to jobs, education, recreation and such other needs.

IV. CONCLUSION

The reliable, fast, and intelligent transport system with accurate safety warning systems is the need of the hour. Automated vehicles would be highly beneficial to not only combat fatalities but also become the proactive means of transportation in the future. Evidently, the field presents a promising area for future research, and the results constitute the starting point for everything the future has in store for us.

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