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Swinging towards Intelligent Transport Systems: Globally and in India

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***Abstract*- Traditionally, road infrastructure has been designed to maximize mobility and economic efficiency at the cost of safety, particularly, for non-motorized road users, who are the most vulnerable. Changes are now required to optimize the movement of people and freight with road safety in mind. Global road traffic injuries kill more than 1.2 million people every year and have huge impact on health and development of societies. Without significant intervening changes road transportation system the dreadful figures of accidents, globally, are likely to increase dramatically. Developed countries have developed and/or adapted techniques depending on their geographic, cultural, socio-economic and environmental background. Most of the traffic crashes are well predictable and also preventable. Evidences suggest that interventions are effective at making roads safer. Developed countries have already implemented interventions and correspondingly achieved reduction in fatalities. Death rates in high-income countries are among the lowest in world. Intelligent transportation systems (ITSs) are the best solution to above mentioned problems. ITS has been proved and established route to solve or at least minimize traffic related problems. This paper highlights a review of development of ITS across the world. ITS is still a new concept in developing countries.**

***Index Terms* -ITS, Electronic Toll Collection (ETC), Connected Vehicle (CV), Connected Automated Vehicle (CAV), Driverless Cars.**

I. INTRODUCTION

Globally, every year 1.3 million people are killed and tens of million injured in road accidents. Moreover, 90% of casualties occur in low-and-middle income countries and the contribution of high income countries is only 06%. The number of road fatalities declined by overall 42% between the period 2000-2013 in 32 countries participating in International Road Traffic and Accident Database (IRTAD).These countries are all developed countries of the world. Greatest reduction were achieved in Spain with more than 70% and Portugal with almost 70%.

There has been less success in saving lives among vulnerable road users – pedestrians, cyclist and motorcyclist than among car users. During 2000-2013, deaths for car users reduced by 54%, whereas decrease were only 36% for pedestrians, 35% for cyclist and 22% for motorcyclist. According to WHO data, road traffic injuries rank one among four causes of death for children above the age of five. It is number one killer for children aged 05 – 17.

In the year 2011, UN General Assembly proclaimed 2011-2020 the UN Decade of Action for road safety in a land mark resolution agreed by 100 countries. The goal of Decade of Action, mandated by UN and endorsed by more than 100 governments, is to “Stabilize and Reduce” from a 2010 base line, the forecasted level of road fatalities by 2020. Meeting this goal could save up to 5 million lives and prevent up to 50 million serious injuries [1].

An important metric for economic growth of any country is its increased vehicle ownership. The direct effect of increased vehicle ownership is acute traffic congestion. India has seen increased vehicle ownership and associated traffic snarls in her metropolitan cities and towns. The variety of vehicles on Indian roads include: two, three, four wheelers, trucks, buses, motorcyclist, cyclist, human or animal pulled carts, in addition a large number of pedestrian population complicates the problem. Unlike developed countries the traffic is mostly heterogeneous and non-lane based. Economy-induced automobile usage is further complicated by influx of rural population in to urban area and makes enormous demand for transport infrastructure, in an overloaded region. World Bank report suggests that, in India, the economic losses incurred because of congestion and poor roads are as big as $ 4 billion per year.

II. DEFINITION OF INTELLIGENT TRANSPORT SYSTEMS

ITS is the application of computer, electronics and communication technologies and management strategies in an integrated manner to provide traveler information to increase safety and efficiency of the road/surface transportation system. These system involve vehicles drivers, passengers, road operators and managers all interacting with each other and environment, and linking with the complex infrastructure system to improve safety and capacity of road system. Without significant intervening changes to road transportation system the dreadful figures of accidents, globally, are likely to increase significantly. ITSs are the best solution to above stated problems.

ITS has been proved an established route to solve or at least minimize traffic related problems. It encompasses vehicles, infrastructure, communication, passengers, drivers and operational system. Developed countries have developed and/or adapted systems and techniques depending on their geographic, cultural, socio-economic and environmental background. They have integrated various components of their system in to interdependent system.

III. GLOBAL PERSPECTIVE & PLANS

Global road traffic injuries kill more than 1.2 million people per year and has huge impact on health and development of societies. They cost governments up to 3% their GDP. Despite this huge and mostly preventable human and economic losses, action to mitigate this global problem has been insufficient. The number of road traffic deaths globally has plateaued at 1.25 million per year. This is a good news and shows that the number of countries initiate efforts and take measures to make roads safer. There is a rapid pace of motorization in low-and-middle income countries. Progress has been made by government and non-government organizations in implementing processes which are effective such as: (1) Improving road safety regulations, (2) Managing speed around critical points, (3) Harmonizing data collection and (4) Rolling out minimum standards on vehicle safety. road safety. The above mentioned measures have been adopted under the Decade of Action for road safety. In addition World Health Organization (WHO) is to monitor the situation on yearly basis through its Global Status Report on to Decade of Action, international efforts for road safety have been increased with adoption of the 2030 Agenda for sustainable Development in September 2015 by the United Nations. The 17 Sustainable Development GOALS (SDGs) and their 169 targets are intended to balance economic, social and environmental dimensions of sustainable development, and stimulate action over the next 15 years in the critical areas. They include two targets that are related to road safety. In this agenda goal of reducing road traffic deaths and injuries by 50% by 2020 has been set. But, unfortunately, these efforts do not seem sufficient. Globally, in past three years, there has been 16% augmentation of new vehicles. Much more is needed to be done to minimize the deaths and destructions on world's roads in order to achieve the targets for road safety in Sustainable Development Goals. While much progress has been made in past decade, now it is a challenge to go past the current region of plateau in road deaths and march towards measureable declining phase.

Most of the traffic crashes are well predictable and also preventable. Evidences suggest that interventions are effective at making roads safer. Developed countries have already implemented interventions and correspondingly achieved reduction in road deaths. It has been reported that the number of road traffic deaths has remained constant since 2007 despite increase in global motorization and population and predicted rise in deaths. Interventions to improve road safety are preventing increase in road crashes, which otherwise would have occurred. The African Region continues to have highest road traffic deaths. In European Region, among its high income countries, road traffic death rates are lowest. They have been successful in achieving and sustaining reduction in death rates, despite increase in motorization. Roads have to be designed taking in to consideration the need of all road users. Making walking and cycling safer is also important to support reduced carbon emission and increased physical activity. Implementation of safety standards for infrastructure and vehicles are also important in reducing traffic injuries. Less than half of countries implement minimum standards on vehicle safety. These standards are absent in many of the large-and-middle income countries that are major car manufacturer. With the launch of the Sustainable Development Goals, road safety is receiving increased international attention and is included in two of its goals. The UN World Forum for Harmonization of Vehicle Regulation is the primary global body responsible for the development of passenger car safety standards. These regulations include both "crash-worthiness" (providing protection when an accident occurs) and "crash avoidance" (preventing a collision from occurring at all). Traditionally, road infrastructure has been designed to maximize mobility and economic efficiency at the cost of safety, particularly, for non-motorized road users, who are the most vulnerable. Changes are now required to optimize the movement of people and freight with road safety in mind. International Road Assessment program (iRAP) safety assessment use road assessment data to provide star ratings for roads: five star indicates safest roads and one star the least safe. Less than 20%of roads are three star or better for pedestrians in most regions of world. 50%of roads in America, Europe and Western Pacific Region are three star or better for vehicle occupants.

Ninety percent of road traffic deaths occur in low-and-middle income countries. These countries account for 82% of world's population. They account for only 54% of world's registered vehicles. 68 countries have seen rise in number of road traffic deaths since 2010 of which 84%are low or middle income countries. Death rates in high income countries in Western Pacific Region (such as Australia) are among the lowest in the world. For every person that dies in road traffic crash there are at least 20 others that sustain non-fatal injuries. These injuries can have considerable impact on quality of life and carry with them significant cost. Between 2010 and 2013 there was a 27 % growth in number of motorized two wheelers globally. In low-and-middle income countries motorcyclists comprise a large proportion of those injured or killed on roads. World's 10 most populous countries account for almost 4.2 billion people and 56% of world's road traffic deaths. Past three years (2010-2013) have seen 16% increase in the number of registered motorized vehicles this growth is highest in emerging economies. In 2014 alone there was a record addition of 67 million new passenger cars on world's road.

IV. HISTORY & PRESENT STATUS OF ITS IN DEVELOPED COUNTRIES

A. History of ITES in JAPAN

As per the new strategy of Japan, the cabinet office issued the declaration to be the world's most Advanced IT Nation, in June 2013. The ITS efforts in Japan include the following fields:

1. Advances in Navigation Systems
2. Electronic Toll Collection
3. Assistance for Safe Driving

4. Optimization of Traffic Management
5. Increasing Efficiency of Road Management
6. Support for Public Transport
7. Support for Pedestrians
8. Increasing Efficiency in Commercial Transportation
9. Support for Emergency Services

Area Traffic Control System was the first ITS implementation in Japan. It was started in 1970 in Tokyo. It coordinated timings of traffic light signals at 100 intersections with 200 vehicle detectors. It has been reported that there was reduction in travel time savings in man hours and gas consumption. The total savings stood at 5.7 times the installation cost. After Tokyo nationwide installation of traffic control centers started in a series of 5 year projects.

The **Comprehensive Automobile Control System (CACS)** was developed in 1973-78.it directed the vehicles to their declared destination. The CACS included following subsystems:

1) Route guidance subsystem
2) Driving Information Subsystem
3) Traffic Incident Information Subsystem
4) Route display board subsystem
5) Public service vehicle priority subsystem

Japan is pioneer in vehicle based navigation systems. The **Advanced Mobile Traffic Information and communication System (AMTICS)** was developed by Japan Traffic Management and technology Association with National Police Agency during 1989-91. It is an Integrated Traffic Information and Navigation System which displays information gathered at 74 cities of Japan. The major benefit of the system was its ability to display, in real time, not only vehicle's current position and route but also information on traffic congestion roadwork and parking [2].

The **Road Automobile Communication System (RACS)** was developed by Highway Industry Development Organization under supervision of Ministry of Construction during 1984-1991. In 1990 RACS and ATMICS were integrated to develop Vehicle Information and Communication System (VICS). It was a program which included government organizations, police, academic organizations and private industries.

VICS was implemented in the year 1996 in Tokyo and Osaka. Now it is used all over Japan. VICS is an information and communication system, which processes road traffic information at VICS centers. This information is transmitted by radio waves, infrared beacons and FM multiplex broadcasting for display in three formats: text, graphics and maps on navigation systems and other on board devices. VICS operates 24 hours a day, 365 days a year [3].

The **Universal Traffic Management System (UTMS)** has been implemented by National Police Agency since 1993. Drivers are given real time traffic information and guidance information. Two way infrared beacon are used for monitoring and communication purposes.

Automated Highway System was developed with support from the ministry of construction in 1995. The aim was driver automation. It was to be achieved through communication between vehicle and highway infrastructure. During 2nd world congress, in 1995, the AHS was demonstrated, which had features like partial automated driving, collision avoidance and incident warning system. A sizeable population in Japan uses toll roads. **Electronic Toll Collection (ETC)** was started in 1995. ETC enables non-stop automatic toll collection at tolls using wireless communication between systems toll booth and onboard vehicle terminals. Up to end of 2013 over 44million onboard units had been set up. 24 nationwide expressway and public road management companies use a single nationwide ETC system. Every day, nearly 7.1 million vehicles use ETC. Hence, congestion, at toll booths, has been almost eliminated in Japan. ETC also helps in reducing CO2 emissions.

In June 2013, Cabinet office issued the Declaration to be the World's Most Advanced IT Nation. Japan's new IT strategy aims to make IT a vehicle for Japan's growth strategy. IT is a main driving force in achieving sustainable growth and development. The goal of IT strategy is to strive to realize world's safest, most environment friendly and most economical road traffic society. In Japan development and commercialization of advanced driver assistance technologies and automated driving systems will be promoted. Based on this, a subcommittee for road traffic was established in October 2013. Public-Private ITS Initiative and Roadmap was released on March 2014. To further develop ITS in Japan and to contribute to national goal of reducing traffic accident fatalities, automated driving will be set as challenge. This challenge will be pursued through coordination of government, academia and industries. In 2010, ITS World Congress was held in Tokyo. Many ITS specialists attended the congress. It was an opportunity to showcase Japanese government-academia-industry initiatives to the world.

B. Current ITS Trends in JAPAN

1. ***Universal Traffic Management System (UTMS)***: It uses information communication technology with two way communication between individual vehicles and traffic management system using infrared beacon. UTMS helps to enhance the safety and smooth flow of traffic and results in reducing pollution. Main applications of UTMS include followings.

    a) Advanced Mobile Information System (AMIS). At the end of 2013 all prefectures in Japan adopted AMIS.

    b) Fast Emergency Vehicle Preemption System (FAST): At the end of 2013, 15 prefectures adopted FAST.

    c) Public Transport Priority System (PTPS): At the end of 2013, 40 prefectures adopted PTPS.

2. ***Infrastructure-to-vehicle (I2V) Cooperative Driving Safety Support System (DSSS)***: The National Police Agency (NPA) of Japan is promoting adoption of DSSS. Level 1 systems were adopted in Tokyo and Saitama prefectures in 2006-07. This type of systems use roadside equipment to detect possibly dangerous situation in road traffic environment and supplies this information to drivers via audio warnings or display on onboard devices. In 2010, Tokyo and Kanagawa prefectures introduced several level2 systems that use infrared beacons as communication devices at intersections that are prone to accidents.

3. ***Smartway project***: As a part of Smartway project, the adoption of next generation ITS services, (called spot service) has been promoted from 2007. It is a next generation road system that incorporates existing services such as VICS, ETC, as well as other services using advanced ITS. From 2011 various ITS services were started throughout Japan. Spot services were mainly concentrated on expressways. The Road Bureau of Ministry of Land, Infrastructures and Tourism (MILT) established 1600 ITS spots. On inter-city expressways these spots are 10 to 15 KM apart, while on inner-city expressways they are 4 KM interval. Spot services include basic services like dynamic route guidance, safe driving support and ETC in an all-in-one package. The ITS Green Safety Showcase started to resolve traffic problems through cooperative ITS. Following activities are included in it.

    a) ***ITS spot services***: In 2013 ITS World Congress held in Tokyo, participants experienced dynamic route guidance, safe driving support and ETC .They rode a demonstration bus along metropolitan expressways.

    b) ***Traffic Smoothing in Expressway road segments:*** Traffic smoothing through Infrastructure-to-vehicle and vehicle-to-vehicle coordination was demonstrated to participants. Vehicles were fitted with adaptive cruise control (ACC) or cooperative adaptive cruise control (C-ACC) that helps in automatically change vehicle speed and distance between vehicles.

    c) ***Tokyo Bay Aqua Line***: Here participants experienced traffic information services which sends information from ITS spots to smart phones and expressway parking.

4. ***Advanced Cooperative mobile communication and ITS spot services***: A model road passes through safety vehicle project. The road bureau of MILT has encouraged development popularization of ASVs from 1991. ASVs are based on DSSS. DSSS is a modern technology which is promoted by collaboration of industries, academic institutes and government. Fifth ASV promotion plan began in 2011. ASV technology promotes use of collision damage mitigation brake devices to alert the driver for unstable driving behavior and Electronic stability control (ESC).

5. ***Probe data***: This is the information collected by individual vehicles such as its position and speed. This information is collected by wireless technology and helps in traffic management. Here vehicles are used as sensors which collect information about traffic environment. Modern navigation systems have been developed by automakers that uses probe data. The utilization of probe data helps in increasing the volume of accessible traffic information. Thus more refined services are possible with the use of probe data. NPA combined information obtained from existing road side sensors with probe data to develop technology which generates enhanced traffic information. This enhanced traffic information is capable of enhancing efficacy of traffic signal control system. In 2013 two prefectures have started projects to implement more precise traffic signal control system using probe data. ITS spot services also allow probe data to be collected by vehicles. The Road Bureau of MILT plans to carry out initiatives which uses probe data from large number of vehicles (big data analysis) to use the road network intelligently. Thus it can identify the causes of congestion and accidents and use that information to develop congestion and traffic safety measures.

6. ***Other initiatives***: Japan recognizes automated driving as a growing technology. It will be pursuing its implementation as said in the Declaration to be World's Most Advanced IT Nation. In area of wireless technology the **Ministry of Internal Affairs and communication (MIC)** is responsible for allocation of new frequencies and their use. It forms policies for technical standards considering the usage of radio waves and interference with other wireless systems. it allocated part of 700 MHz band, freed up due to switchover to digital terrestrial television, for the introduction of DSSS to achieve safe road traffic environment. From April 2013 these systems are available nationwide. In 2013 a detailed testing on 79 GHz band

radar system was done. These systems have high resolution to detect smaller object such as pedestrian. Validation of their performance has been completed. Use of 700MHz is ill suited for DSSS. In US and Europe researchers use 5.9GHz band for I2V and V2V communications. Hence this consideration for ensuring future extendibility of services for international harmonization is needed. Japanese Ministry for Economy, Trade and Industry initiated a project to investigate and research on green vehicle technologies. These technologies are aimed at significant energy saving and CO_2reduction. The project also initiated initiatives to increase social receptivity of new technologies that have already been established and whose installation in individual vehicles is achievable within known timeframe. To improve social receptivity of state-of-the-art truck platoon driving among audience, a platoon driving demonstration of three trucks, separated by four meter distance, moving with the speed of 80 KM per hour was broadcasted in the World Congress at Tokyo in 2013.

C. United States of America

USA's interstate highways are one of its greatest achievements but it has fallen behind many European and Asian nations in application of ITS technologies to improve the safety and mobility of automobiles. America's outdated surface transportation system is beginning to impact its international competitiveness and quality of life of its citizens. The U.S. Department of Transportation coordinates ITS research activities in country through its **Research and Innovative Technology Administration (RITA)**. It combines cutting edge research with technology transfer and aims to improve the country's transportation system.

Research on the application of control and information technology to surface transportation began in 1950s and 1960s in United States, including automatic control of automobile and electronic route guidance. In late 1980s a coalition of private, public and academic organizations convinced the Congress to legislate support for comprehensive program in Intelligent Vehicle Highway Systems (renamed Intelligent Transportation System or ITS in 1994) to reflect a broader mission, including all parts of public transportation and intermodal connections.

The USDoT has long been a leader and strong supporter of research, development, adoption, and deployment of ITS around USA. For more than two decades, USDoT has provided leadership to the US's national ITS program. During this period USDoT has collaborated with ITS Joint Program Office (JPO) and other modal Partners. Through this work USDoT has responded to new transportation systems, the need of users, advancements in technologies, and evolvement of relationship between private and public sector organizations. Thus it has periodically refined the direction of federal ITS program.

*IEEEUSA has made following **recommendations to the federal Government** (IEEEUSA recommendations to federal govt).*

(1) Continue to support federal cooperation among public and private stake holders in pursuit of national transportation research program. Key research objectives should include improvement of transportation productivity, safety and efficiency through use of ITS.

(2) Fully fund the USDoT's Connected Vehicle (CV) research program to advance V2V and V2I communications. This should enable America's roads and highways, to function as a truly integrated system of connected vehicles and infrastructure.

(3) Ensure that the availability of licensed wireless spectrum for safety of critically connected vehicle application is not jeopardized by compelling commercial use.

(4) Incentivize broad deployment of ITS tools and strategies that improve mobility, efficiency and safety on all modes of surface transportation.

(5) Promote research on enabling technologies that will support future automated driving capabilities and conduct independent evaluation of ITS impact on traffic congestion, vehicle safetyand energy consumption and emission control.

*Some **US-ITS initiatives of special focus** are as following*:

(1) ***Telephonic Data Dissemination Scheme 511***: It is a nationwide scheme to disseminate current information about travel conditions, allowing travelers to make better choices: choice of time, choice of mode of transport, choice of route etc.

(2**) *IntelliDrive^{SM}* :** It is a multimodal initiative based on wireless communication technology. It enables communication among vehicles, infrastructure, and passengers' personal communication gadgets. It presents an interesting possibility by proposing to equip every car with an in-vehicle probe. The presence of probe in every vehicle on roadway would dramatically increase accuracy of probe-based data applications.

(3) ***Next Generation 9-1-1*:** It is focused on extending present emergency 9-1-1 system to establish emergency communication service using all forms of communication technologies.

(4) ***Cooperative Intersection Collision Avoidance System***: This initiative is a partnership among US DoT, automobile manufacturers, and state and local departments of transportation targeting at development of an optimized combination of autonomous vehicle, infrastructure and cooperative communication systems that can solve intersection crash problems.

(5) ***Congestion initiative***: Congestion is created by various natural and traffic related problems such as bad signal coordination, weather conditions, organization of events, capacity problems, traffic incidents, and business activities. Metropolitan areas implement following strategies to mitigate urban congestion problem:

(a)**Tolling:** payment for use of roads

(b) **Transit:** use of fast public utilities such as trains, buses etc.

(c) **Telecommuting:** enabling work from alternate locations and staggered hours of working.

(d) **Technology:** use of modern technology to reduce congestion.

(6) ***Integrated Corridor Management System***: This system collaborates multiple organizations within US-DoT to identify, test, and deploy technologies and techniques to develop an interconnected system cross network travel management.

(7) ***Clarus Initiative***: This initiative aims to give clear, accurate and relevant information about accidents, events, weather, road repairs and delays to users. This initiative will collaborate private and federal weather forecasting agencies and industries.

(8) ***Emergency Transportation Operation*****:** This initiative has three major areas of action: Traffic Incident Management, Traffic Management for Planned Special, and Emergency Transportation. Operation for Disaster management through integration of modern technologies.

(9) ***Electronic Toll Collection (ETC)*****:** It first appeared in early 1980 in USA. It was result of an agricultural research project. This project used transponders and receivers to track the movement of livestock. It was realized that this technology could be used to vehicle tracking and payment processing. ETC technology first appeared in Dallas and Louisiana in 1989. They used Amtech's 128 bit read-only technology. It permits efficient and cost effective collection and processing of highway tolls. The cost of collecting a toll manually is roughly 10 times higher than the ETC cost. After the establishment of two ETC system three states formed the E-Z pass **Inter Agency Group (IAG)** in 1990. This group of states adopted ETC on large scale in 1993. This was the largest contiguous area of interoperable ETC system. The system adopted by IAG was not interoperable with systems in Louisiana or Texas. Soon after IAG implemented ETC system, the next major step forward occurred, when California issued the Title 21 tolling standard in 1993. It created an open standard using 915MHz. This standard is used at all tolling facilities in state. The aim is to ensure interoperability throughout California. The only adopter of this standard is Colorado [4]. By 2007 out of 4113 toll collection lanes 3501 (85%) had ETC capability [5]. Moves to make existing US schemes (E-Zpasses, Sunpasses, fastrack etc.) interoperable through multi-protocol tags and readers and by video tolling are gaining momentum. Replacement of fuel duty by Vehicle Miles Traveled is also proposed.

(10) ***Traffic Management Software (TMS)*****:** TMS technology is not much prevalent in US as it is in Europe but is becoming more popular nowadays. It accounts for 90% of signal control systems in US. In future adaptive/ real-time TMS may be used for effective capacity improvement, congestion/ delay reduction and emission reduction. TMS compiles information received from VDC devices and equipment throughout arterial network. It implements one of several methods for coordinating and managing signals and signs accordingly. Advanced TMS packages produce significant benefits with respect to stop/delay, travel time saving and emission reduction. Advanced TMS packages using Split, Cycle, Offset, Optimize, Techniques (SCOOTS) and Sydney Coordinated Area Traffic System (SCATS) first came into practice in UK and Australia in 1970s. The Federal High Way Administration (FHWA) has consistently supported research and development to provide transportation agencies access to minimal management software package for minimal or no cost. In 1986 FHWA developed McTras Highway Capacity Software. It included functionality such as static optimization of signal timing on arterial roads. In 1990, FHWA sponsored development of Real-time TRaffic Adaptive Signal Control System (RT-TRASC). In 2005 FHWA introduced ACS-Lite which provides adaptive control capabilities for closed-loop system. Software was developed in partnership with Siemens.

Traffic control systems can be of three types: time-based signal control, interconnected control, and traffic adjusted control. Time-based signal control allows fixed, pre-defined signal control plans. The Architecture of latter two types are of three varieties: three-distributed computation level (closed loop), two-distributed computation level and central control. Signal timing plans are stored at the level of local controller. The controllers are connected by wired or wireless techniques. Simple signal coordination techniques analyze stored traffic data for the network and output is a pre-timed (time-of-day (TOD) or day-of-week (DOW)) plan. SCOOTS and SCATS are traffic responsive plans which can be selected for traffic adjusted control. These plans are based on optimization algorithms, but this optimization is not performed dynamically.

Advanced traffic signal control techniques are of two types: traffic responsive or traffic adaptive. In this technique real-time optimization of traffic network is performed. Adaptive systems do not select from menu of signal timing plans, rather they make more complex adjustments. RHODES and Optimized Policies for Adaptive Control (OPAC) are adaptive traffic Models. TSP and EVP are available as applications in an advanced TMS package. In comparison to Europe, the US market for Advanced Traffic Management Software is underdeveloped. Processing of complex real-time information on large arterial network will become feasible with the innovations and implementation of wireless technologies and decrease in price of bandwidth. Successful TMS deployment provides travel tine savings and increases the efficiency of existing road supply by smoothing traffic pattern and decreasing congestion. In this capacity, in future TMS may effectively develop as substitute to road building [4].

(11) ***Emergency Vehicle Preemption (EVP)and Transit Signal Priority (TSP)***: EVP was originally created in 1970s and used strobe light system to communicate with signal controller.

(12) ***Highway Data Collection***: This data collection technology can be divided into two categories namely sensor-based and probe-based data collection. Sensor-based technologies are traditional methods of Highway data collection. Examples of these technologies include camera, inductive loops and other direct measurement technologies. Probe-based data collection relies on in-vehicle devices that are non- static. Probe data detection devices can be vehicle-mounted or hand held devices brought in to car. Inductive loops have become the primary highway data collection device since their inception in 1960s. Their detection accuracy is as high as >97%. But they are highly invasive (need to be embedded in pavement) and cost of installation is higher than cost loop itself. Other sensor technologies have been proposed to compensate the weakness found in loops. A comprehensive examination of major sensor technologies was performed by Cheung and Varaiya. The sensor based technologies in a mature state. Probe-based technology is relatively new. The first devices of this type began to appear in mid 1990s and are only recently being utilized actively for highway data collection. Probe HDC devices require no infrastructure investment and in case of mobile phones utilize existing cell towers. The collection of data has no value of its own. Rather, what is important is using data collected in such a manner to help manage congestion or provide real-time traveler information. HDC is intermediate in nature and used to provide input to other ITS applications. Technologies that complement the HDC market could include variable message signs, 511sytem, emergency vehicle preemption or general traffic management software. Probe-based technology represent an important element of future direction of HDC.

There are three main probe-based models that have gained traction in the HDC market. They are described as cellular model, owned and operated model and contract carrier model. One major issue concerning probe data is its accuracy. Unless this accuracy improves, sensor will continue to dominate market. Probe data will remain as a complement to loops rather than a clear substitute.

Google:On October 28th 2009 Google entered in to navigation business. The product is based on turn-by-turn navigation, through Google maps application on their Android Mobile Operating System. The application sends GPS location data to Google. This poses interesting question into how the HDC market will evolve. This has the potential to provide Google with millions of probes. How Google will capitalize on the collection of data on a global scale in such important sector of economy?

(13) ***Vehicle Detection and Data Collection*****:** Arterial traffic account for more than half of all vehicle miles of travel in USA and majority of total person-hours of congestion in urban areas. Arterials are differentiated from Highways, by presence of intersections. The presence of intersections increases the complexity of collection and interpretation of data accuracy. Arterial Traffic Management Centers (TMCs) use collected data for signal coordination, whereas Highway TMCs are focused on processing and disseminating data to provide en-route traveler information.

The framework of USDoT ITS strategic plan (2015-19) is built around the ITS program priorities of realizing CV implementation Advancing Automation (AA). The first priority of realizing CV implementation is based on huge progress made around design, testing and planning for CV to be deployed across the nation. The ITS strategic plan will continue to delve in this direction and expand its present program to include planning and support for adopters and agencies responsible for deployment. The second priority of advancing AA enables the ITS program to enter into this cutting-edge field of research, development, and adaptation of automation related technologies as they emerge. There are six program categories: (1)CVs (2)AA (3) Enterprise data (4) Interoperability (5) Emerging capabilities and(6) Deployment support. ITS JPO aims to focus its activities on above mentioned program categories. The vision statement of strategic plan is," Transform the way society moves". It aims to guide the ITS program and the USDoT in finding the way to integrate transportation services with a range of other public institutions and services. The mission statement of ITS strategic plan is,"Conduct research, development and educational activities to facilitate the adoption of information and communication technology to enable society to move more safely and efficiently". There are five strategic themes (1) Enable safer vehicles and roadways. (2) Enhance mobility. (3) Promote innovation (4) Support transportation system information sharing [6].

From 1980 to 2006 the total number of miles traveled by automobiles in US increased by 97%, but over the same period, the total number of highway lane miles grew just by 4.4%. Hence, over twice the traffic in the country was traveling on essentially the same roadway capacity.

Cities throughout America have developed smart transportation applications such as Street Bump and SFpark. Car pooling and dynamic ride-sharing reduce congestion and pollution and commuter cost. Zipcar (Avis) claims to be world's leading car sharing club, covering the United syates, Canada, the UK, Spain, Austria and France, offering more than 30 makes and models of self-service vehicles on the hourly or daily basis to people who don't want to own a car, or occasionally need a second car. It is a subsidiary of Avis Budget Group. A Zipcar can be availed on website by free-of-cost Application. You get a card which unlocks the vehicle [7]. Drive Now (BMW/ Sixt) operate in Europe and San Francisco. Uber (Google) and Lyft have turned dynamic ridesharing into successful business.

*Waze:*It is owned by Google. Waze users drive with its application open on their phone to contribute, mapping and other road data in background mode, but they can be proactive by sharing reports on accidents or disruption on roads, and gas prices at gas stations, benefitting other drivers [8]. Road network change on both short-term and long-term basis due to accidents, road works and road buildings. Keeping road network data base up-to-date is time consuming and expensive in absence of waze. Its application and use are free of cost.

In Oct. 2014 waze launched its ‘connected people’ program with a number of city partners who agreed to share data in Boston, Los Angeles, Miami, and New York in USA. There is 2way information exchange. Authorities provide their road traffic and transport data which Waze aggregates and makes available to users who in turn update and supplement the data by crowd sourcing. This aggregated and updated data can be used by city Traffic Management Centers (TMCs) as well as by users of application.

Moovit: It is a public transport version of Waze. Its free transit planner shows live arrival and departure time. It is available in more than 500 cities including New York, Los Angeles and other parts of world [9, 10].

D. EUROPE

Mainland Europe’s ITSs work under Road Transport Informatics (RTI). RTI works on two programs: Road Infrastructure for Vehicle Safety in Europe (DRIVE) and PROgram for European Traffic with Highest Efficiency and Unprecedented Safety (PROMETHEUS). DRIVE comes under the control of Commission of European Communities (CEC). PROMETHEUS is a part of European

Research Coordination Agency (EUREKA) an industrial research initiative involving 19 countries and European vehicle manufacturers. Primary goal of the PROMETHEUS is system development and DRIVE works on human behavior issues and implementation of systems in Europe.

Public-private partnership programs focusing on specific safety applications of ITS technologies are eSafety, INVENT and PReVENT.

***INVENT program focuses on eight specific projects*:**

(1) ***Detection and Interpretation of Driving Environment***: Through the use of laser and radar sensors and video image processing and communicating the information to road users is given.

(2) ***Anticipatory Active Safety***: Automatic detection of crossing cyclist and pedestrian and thereafter warning drivers. Supporting drivers in lane changing and turning maneuvering.

(3) ***Congestion Assistance*:** Regulation of speed, maintenance of safe distance and detection of potential obstacle through automatic cruise and headway control.

(4) ***Driver Behavior and Human Machine Interface*:** Measures the driver’s reaction and responses to new systems and improve human-machine interface.

(5) ***Traffic Performance Assistance***: Vehicle based data collection and analysis of traffic state, and communicating to upstream vehicles.

(6) ***Network Traffic Equalizers*:** Use of dynamic route guidance and navigation systems to track traffic data and choosing optimal route to destination.

(7) ***Traffic Management in transport and Logistics*:** Intelligent route planning systems for deliveries, optimized courier services taking into account mobility of customers and duration of trip, guarantee of precise delivery time.

(8) ***Traffic Impact, Legal issues and acceptance***: Evaluation of economic and business implications of new technologies as well as legal conflict.

***INVENT*:** This program works for improving traffic flow and traffic safety by development of novel Driver Assistance System (DAS), knowledge and information technology, solutions for more efficient traffic management and to prevent or minimize the severity of accidents.

***PReVENT*:** This program integrates various safety functions so that a safety belt is created around the vehicle. Using European Geostationary Navigation Overlay Service (EGNOS) and European satellite navigation system – Galileo a project named AGILE developed a global navigation satellite service in mobility sector. AGILE’s aim is to define a roadmap in order to bring into reality profitable applications based on EGNOS and Galileo. High quality positioning data, achieved through improvements in American GPS and Russian Global Orbiting Navigation Satellite System (GLONASS) enabled implementation of critical applications in areas where safety is crucial such as navigating trains, guiding cars and landing aircrafts.

***AIDE*:** This project was launched by the combined efforts of research institutions and universities of Europe. The project’s aim is to develop a model to predict behavioural effects of driver assistance and information systems. It created a methodology for evaluating safety benefits of adaptive human-machine interface. Adaptive integrated driver-vehicle interface was developed for road vehicles to enable safe integration of multiple IVIS and ADAS functions including nomadic devices. BITS project was designed to link ITS organizations and activities in Europe to those of China in order to implement ITS projects in Chinese cities. BITS was funded through EC ASIA Information Technology and Communication Program.

***CONNECT*:** This program was focused on uniting public authorities, road administrators and traffic information providers. Thus, to develop ITS in central and Eastern Europe. Austria, Czech Republic, Germany, Hungary, Italy, Poland, Slovakia and Slovenia were some of the contributors to this project that helped improve cross-border traffic and transport through use of ITS.

***DELTA*:** This project worked for integration of Dedicated Short Range Communication (DSRC) link as standard in-vehicle equipment by developing a standardized interface between CEN compliant DSRC units and in-vehicle electronics.

Digital Tachygraphy: This is a joint ERTICO- European Commission initiative to ensure free movement of EU vehicles in Central and Eastern European countries by informing national administration, law enforcement agencies as well as social partners about digital tachograph. The tachograph is a control device recording and storing drivers' activities and related data like vehicle speed, location, events and faults.

***eCall*:** Since 2007 attention has been given to develop eCall system and automatic dialing 112 – Europe's single emergency number in the event of serious event. The European Commission aims to have the system operational by 2015.This project is for developing automatic notification techniques of emergency situation on road to concerned crisis management services in order to enhance response speed. The technology involved manual calling and automated message transfer by sensors, which are activated by crash events such as airbag release. On this project future services such as pan-European eCall are based. This project calculated the benefits of eCall and also its effects on congestion, secondary accidents, rescue services and traffic management with reference to national economy.

***ETNITE*:** The project team worked for development of educational resources and increasing awareness of ITS among public and private sectors. It also worked for promoting e-learning methodologies. It put in concerted efforts to improve the quality of ITS training in Europe. It supported European industry by providing it state-of-the-art know how in ITS, developed, tested and spread awareness about Advanced Driver Assistance system (ADAS) for increased safety [1].

In past decade there have been substantial improvement in real time information available to user/passenger. This has led to significant enhancement in public transport. In cities like Prague, Budapest and Stockholm integrated payment systems are being developed which allow for rail-bus-metro integration. Full set of mobility solutions are now emerging including bike and car share and taxi systems in cities like Bremon, London and Lyon. In past decade Europe has led the way in development and subsequent popularity of bike share scheme across the world. From 2007, Velib scheme in Paris has grown to be the largest single bike share scheme in Europe (second largest in world). Cycle highways have been constructed in Copenhagen, several Dutch cities and also in London and Paris.

A few cities in Europe like Gothenburg, London, Milan and Stockholm have introduced road pricing to ease congestion. Road pricing schemes have shown evidences for long-term decreased demand. In Stockholm an average decrease in traffic volume of 22% was observed. In 2007, London observed 32% reduction in congestion.

ICT firms are the newest players in transportation sector. At the end of 2014 car sharing services in Germany had an estimated one million customers. Car manufacturers are currently investing considerable sums in R&D activities like "Connected Cars" and different models for (partially) automated driving. US began its self-driving car in 2009, leading the states of California and Nevada to adopt new legislations to allow such technology. In Singapore, the SMART project (Singapore-MIT Alliance for research and technology started in 2007) is about to implement the testing phase under real life traffic conditions on public roads. City Mobile2, a European project financed by the 7th EU legal framework program, which aims to contribute to harmonization of EU legal framework for development of validation and certification process for Automated Vehicles.

New opportunities for intermodal transport services are emerging as a result of platform strategies. Some platforms such as moovel and Quixxit enable integration of diverse services for users. 'moovel' started in Germany 2012 and extended to other European countries and North America. 'Quixxit' was launched in 2013 by Deutch Bahn. 'Smile' is a pilot project currently active in Vienna. Daimler, with car2go and BMW with DriveNow have been especially successful at reaching new user groups. Service providers such as Lyft, Uber, BlablaCar and Get-around are bringing change in technology-related and sharing economy based businesses. There is an increase in deployment of ICT in transportation.

One of the most significant element of ITS in Europe is **Real Time traffic Information (RTTI).** RTTI services provide users with information related to their journey such as: Traffic regulation (speed limit), recommended driving routes, estimated travel time and information about congestion and road work etc. There are growing number of applications where regulation has to ensure that privacy concerns are to be incorporated. Some of main examples are given below.

1. ***E-ticketing in public transport***: Electronic fare collection systems have developed significantly over past few years. They offer a large amount of advantage for both user and service provider. A chip card is used to pay for service.

2. ***Parking payments***: ICT is used to replace traditional vending machines for parking tickets. A variety of options exist which allow user to pay their parking dues more conveniently and city administrations to collect fees more efficiently with less chances of fraud.

3. ***Road user charges***: Tolling based on in-vehicle equipment is becoming increasingly common and is replacing the payment of road tolls through a stationary toll booth to facilitate a free flowing system.

4. ***Pay-as-you-drive Insurance***: Insurance offers to relate their car insurance premiums to actual driving behaviour of insurance holder. They take in to account things such as mileage and speeding. Previously, premiums were based on fixed categories to determine user's crash risk. Present systems allow tailor made precise calculation of user premiums.

5. ***Traffic data collection*****:** Traditional methods of traffic data collection used stationary sensors. Those methods posed no dangers to users' privacy. In new methods such as "Floating Car Methods" car owners on voluntary basis act as a probe. Thus traffic flows can be monitored by Global Navigation Satellite System (GNSS). This method can be used to determine passage time between two points. These systems pose different security challenges such as user tracking and user profiling [11].

The first EU-wide legal framework for ITS was created in July 2010 with adoption of Directive 2010/40/EU. The directive focuses on compatibility and interoperability of systems. It facilitates continuity of ITS services in Europe while member states have the freedom to invest in. Research projects on ITS system for smart safety and in emergencies are grouped in four clusters.

1. ***Advanced Driver Assistance Systems (ADAS)*****:** Use of in-vehicle system for sensing danger and assisting drivers to take actions.

2. ***eCall*****:** Use of in-vehicle emergency call (eCall) for emergency assistance for road accidents, improved accident reporting and faster response by emergency services.

3. ***Road and vulnerable systems***: Development of smart road restraint systems to reduce injuries to and death of vulnerable road users (pedestrians, cyclist and motorcyclist).

4. ***Cooperative systems for safety***: Innovative solutions for network management with regard to safety and hazard warning.

EU funded research projects on use of ITS to improve accessibility and multi-mobility have been clustered as follows:

1. ***Enabling Technology***: Interaction between technology and people for knowledge exchange and dissemination to enhance multimodal and integrated transport and accessibility.

2. ***Open data and interoperable systems***: Innovative technologies using freely available data and integrated interface to enhance sustainable transport.

3. ***Traveler information and traveler behavior*****:** Identifying user needs, developing and using intelligent solutions for urban trips, journey planning and travel information tools to orient traveler to sustainable solutions.

4. ***Cooperative Systems***: Improving and enabling data transmission between vehicle to vehicle (V2V), vehicle to infrastructure (V2I) and implementing communication systems to detect meteorological events and traffic congestion.

Energy efficiency is a key element of EU climate and energy policy to meet the target of 20% reduction in energy demand by 2020. Electrification of transport (electro-mobility) is a priority in EU research program [12].

During the ITS World Congress 2012 in Vienna, experts and public audience could experience the benefits of cooperative ITS (CITS). There was demonstration of cooperative mobility on public roads involving cooperative vehicles, cooperative road-side units and Vienna traffic management centre. In Jan 2013 new European projects like COMPASS4D with city pilots focusing on efficient intersection have started. Within COMPASS4D seven European cities (Bordeaux, Copenhagen, Eindhoven-Helmond, Newcastle, Thessaloniki, Verona and Vigo) are willing to further invest in road safety, energy efficiency and congestion reducing measures based on cooperative ITS during next 3 years. From 2015, a tri-nation driven corridor project (Vienna – Munich – Frankfurt - Rotterdam) and other national projects are currently discussed and developed. For taking advantage of cooperative ITS services like traffic data collection, analysis, traffic control and management. Currently traffic control and management in Europe rely on dedicated heterogeneous sensors and backbone networks, hard and software solutions ensuring high availability and integrity (e.g. traffic signaling and control in cities' section control on motorways). European DRIVEC2X project (2010-13) laid down foundation for rolling out cooperative systems in Europe [13].

The cooperative ITS technology has been developed within Research and Development (R&D) project and are evaluated in Field Operational Tests (FOTs). Majority of enabling technology is already standardized. Road operators in Germany, the Netherland and Austria have started joint deployment of cooperative ITS in Europe with partners from industry. It was planned that the roadside cooperative ITS infrastructure for initial services in cooperative ITS corridor (Rotterdam – Frankfurt - Vienna) will be installed by 2015. Communication between vehicle and infrastructure was established via short range communication (WiFi 802.11p,5.9GHz) or cellular network [14].

***ITS Demonstration activities in Europe*:**

*1. **Thessaloniki Pilot Site (Greece)***: The aim of this activity is to provide real time travel time for important routes of city through internet, mobile applications and Variable Message Sign (VMS). Travel time is estimated using CERTH-HIT. The detectors track MAC identities of Bluetooth equipped vehicles. A total of 45 Bluetooth detectors perform more than 3.6 million detections per week. The expected outcome is reduction of congestion on important routes and providing congestion information of alternate routes.
*2. **Patras (Greece)***: This system is similar to that of Thessaloniki. In future the Bluetooth devices are going to be integrated with central system, which will monitor their operation and also collect their data in central information system. This system will be able to communicate with other Traffic Management System (TMS) of Municipality of Patras.
*3**. Vienna (Austria)***: This site covers motorway intersection A3/A23-A4-S1 and the interface to urban road network in Vienna area will be of about 45 Km in length. These sections are operated by Austrian Highway Agency (ASFINAG). This site was used for demonstration of cooperative systems at ITS World Congress 2012. A23 is most heavily used motorway in Austria. The cooperative ITS service demonstration in Vienna include in-vehicle signage, hazardous location notification, traffic jam ahead warning, road work warning, park and ride information and floating car data.
*4. **Hungary***: This site is on Eurovelo-6 route. This is a free end user smart phone application. This application assist bikers in navigation. Eurovelo-6 is one of the most popular cross European cycle routes. Hungarian section is 470 Km long. It runs along Danube from Rajaka till Mohacs. The existing services and data base are utilized by Hungarian pilot KIRA (National transport information system and data base) KENYI (National Bicycle Road Data Base) and public transport module of KIRA.
*5. **Sofia***: This site of Dragicheo Roundabout is 1Km away from east part of town of Permik. It is heavily used by commuters. It is on Trans-European network E79, E871, A3 and A6 highway. Four Bluetooth sensors are installed on each entry/exit of roundabout. They are mounted on street light poles. Based on Bluetooth technology travel time and speed are estimated and stored on cloud. Subsequently, travel time are displayed on Google Map.
*6. **Romania***: This project focuses on Multimodal Traveler Information Services. The implementation is through Web-based journey planning application. It uses information from following modes of transport. (A)Public transport (B)Urban and inter-urban road transport(C)Railway and (D)Inland waterways. The services follow a corridor approach starting from Timisoara to Constanta. The application allows user to receive information about travel times on selected corridor at any time, using different modes of transport.
*7. **Emilia-Romagna***: This pilot project monitors Dangerous Goods (DG) transport flows passing through Bologna node. The sy stem detects and distinguishes between two types of traffic: DG traffic crossing the node and that which has its origin or destination at that node. Trucks carrying DG are recognized by orange panel they show as requested by ADR normative. Lower number identifies the substance that is transported while upper number is a key for threat they pose. The selection of this solution is to bridge the gap of complete absence of regional dangerous goods transportation management system [15].

***EU ITS Directives*:**

DIRECTIVE 2010/40/EU OF EUROPEAN PARLIAMENT AND OF THE COUNCIL of 7th July2010 on the framework for the deployment of ITS in the field of road transport and for interface with other modes of transport established a legal framework from EU commission to develop specifications to make ITS interoperable across borders. Directives include 24 areas for specifications to be developed. The six priority action areas are:

(a) The provision of EU-wide multimodal travel information service.
(b) The provision of EU-wide real-time traffic information services.
(c) Data and procedures for the provision, where possible, of road safety related minimum universal traffic information free of charge to users.
(d) The harmonized provision for an interoperable EU-wide e-call.
(e) Provision of information services for safe and secure parking places for trucks and commercial vehicles.
(f) Provision of reservation services for safe and secure parking places for trucks and commercial vehicles.

The delegated regulations on priority actions (b), (c) and (e) requires setting up of a single national access point and its associated "discovery/search and browse" functionality by each member state. This will facilitate those who are interested in accessing the data to find it all in one place. Data owners in public and private sectors will be requested to make their data accessible via national access point. Each national access point will offer a single window access to the road and traffic data of given territory/network and their corresponding description which are available for re-use by any potential user.
Public and/or private road operators and/or service provider will be required to share and exchange their dynamic/static road data via a national access points, if possible in DATEX II (CEN/TS 16157) or any machine readable format fully compatible and interoperable with DATEX II.

The Department for Transport (DfT) is planning to use the existing UK Government metadata search and discover facility that is part of data.gov.uk and which is already used in similar manner for discovery, view and download in the INSPIRE directive.
This is a metadata store, which references transport related data being hosted at local directories with comprehensive search and discover capabilities. The existing national access point is administered by the UK Cabinet Office and is available to whole UK public sector as well as private organizations that wish to register their metadata for access by third parties. Transport data sets are major part of metadata and are one of the most popularly viewed metadata records. The DfT has appointed Vehicle Certification Agency (VCA) for assessment of compliance to delegated regulations. VCA's status allow them to have close links with the UK Government and European policy formulation and enforcement of vehicle safety and environmental standards. DfT has also appointed ITS(UK) to assist with creating a comprehensive catalogue of who in UK collects, processes, publishes and adds value to the data listed in the related delegated regulation. ITS(UK) has links with similar organizations across Europe. It can bring the benefits, ITS can offer, in areas such as efficient management of network managing effects of congestion/pollution on the environment and improvement to road safety. UK has an important private sector dealing with traffic data and information services on a commercial basis. DfT has held extensive consultation with this sector, assisted by ITS(UK).
The ultimate aim of the European commission is to harmonize the deployment of ITS across Member States, and one of the ways it can be done is through interoperability. DfT and ITS(UK) have worked together on achieving their aims since work on the ITS Directive began in 2009. Current work on National Access Point represents continuation of this work. DfT's aim is that it will be easy-to-use, correct and accessible catalogue of what data is held and whom to contact in order to gain access to it.

***List of road safety-related events or conditions*:**

The events or conditions covered by the road safety related minimum universal traffic information service shall consist of at least one of the following categories:
(a) Temporary slippery roads; (b) Animal, people, obstacle and debris on the road; (c) Unprotected accident area; (d) Short-term road works; (e) Reduced visibility; (f) Wrong-way driver; (g) Unmanaged blocked of road (h) Exceptional weather condition.

Information provided on the road safety-related events or conditions shall include following items:
(a) Location of event. (b) Category of event and if appropriate, short description. (c) Driving behavior advice.
Member states are required to report to the commission by Oct 2015 information regarding their national access point and independent assessment body for compliance to services related to priority action (c) and (e).

E. ITS in United Kingdom

ITS (UK) was created in 1993. The scope of transport and mobility issues that ITS addresses has grown significantly. The involvement and future of ITS(UK) and its members has continued to grow helped by success of London2006 congress. ITS industry has made remarkable progress since early days of 1970s and 80s. These developments have been driven by revolutions in communication, data capacity, and computer processing capabilities.
The way people describe what they do has developed from road/automobile communication systems in Japan(1984), and the road transport informatics and integrated road transport environment in Europe(1988) and the Intelligent vehicle-highway system in US(1991), through Transport telematics(1992), to Intelligent Transportation Systems(1994) and connected cooperative and mobility systems and services of today. All are synonymous to ITS. "Now ITS may be called Integrated Transportation Services. May be ITS stand for Integrated Transportation Services?" [16].
"Topics such as big data, smart cities, cyber security, and financial transactions as well as Connected and Automated Vehicles (CAV) are all part of what ITS is becoming" [17]. ITS(UK)'s International Director Richard Harris of Xerox was inducted in to the Hall of Fame during 2015 ITS World Congress in Bordeaux. He was also awarded 2015 Lifetime Achievement Award by ERTICO-ITS Europe.
Dart charge free flow tolling system: This system at Dart Ford crossing is providing time saving of 90 minutes per week for commuters. The system uses automatic number plate recognition technology to identify vehicles using the crossing. Latest statistics show that journeys across the Thames at Dart ford are now up to 56% faster than before the toll booths were removed. This is despite traffic volumes have grown by around 4% compared to last year.

Funding for UK driverless car research:Efforts to develop fully autonomous vehicle technologies in the UK have been increased following launch of a 11 million Euro Pounds research program by Jaguar Land Rover and the Engineering and Physical Sciences Research Council. Funding has been awarded to five different projects under the 'Towards Autonomy – Smart and Connected Control' program, with research due to take place across ten UK universities and at TRL. Research will be taken up into topics including transition between human control and automated systems, use of radar and video sensing to interpret the external environment, and how data from intelligent infrastructure, drivers and automated vehicles can be used to aid interaction.

***Warning system for dangerous road condition*:**INRIX has developed a new system which harnesses data from connected cars and weather prediction to warn drivers of potentially dangerous road conditions. 'INRIX Road Weather' has been made available for automakers, mobile application developers and public sector agencies. The system is capable of delivering updated alerts to drivers about road conditions every 15 minutes, providing details like type of precipitation, surface condition and visibility levels. The system uses a broad set of public and private data sources, real time vehicle sensor data and forecast modelling technology for Global Weather Corporation (GWC).

***Scottish journey planner received accolades*:**A mobile journey planner application received recognition at the 2015 Scottish Transport Awards. It was used by spectators at GlasgowCommonwealth Games. Tavelin Scotland was presented with the 'Excellence in technology and innovation' award for the application. The application was developed by ITS(UK) member Trapeze. During Glasgow Commonwealth Games, the application offered over 1.4 million personal journey plans to 480,000 users visiting 13 games venues. The application was launched in 2010. The venue-based technology is now used to provide better public transport information for travel to hospital sites including the new Queen Elizabeth hospital campus in Glasgow.

***Drivers kept informed through Motorway Roadwork*:**The Airscan system developed jointly by ITS(UK) member Colas and Iknamia is providing travel time information to motorist. The motorist use diversion routes while road works are there on the M3, where highway England is currently delivering 22km Smart Motorway Upgrade. The system uses anonymous Wi-Fi and Blue tooth signals transmitted by visible devices in passing vehicles. It uses portable sensors to collect journey time information on these diversion routes. This information is then relayed to Variable Message Signs (VMS). Road users are advised in advance of potential delays. The system is under trial so that drivers are better informed. They have improved experience and thus risk to road workers get reduced. Traffic management teams are also issued Bluetooth Low Energy tags. The tags can be used to monitor their location. The system will continue to operate on diversion routes on M3 Smart Motorway Project and will be rolled out across all other Highways.

Project for Air Quality research: Through their Government backed project in Manchester, transport authorities could provide live information about air quality to road users. They could introduce automated traffic management. The yearlong 'SimpifAi' research will find out how Transport for Greater Manchester's (TfGM) Urban Traffic Control team can benefit from the collection of additional data to improve traffic flows in real time and reduce airborne pollution. The project is being delivered by TfGM's research and development consultancy KAM futures, the university of Huddersfield, BTand system solution company INFOHUB. Government has funded a grant of 160,000 Pounds. The project SimplifAi is due to run until September 2016. Once complete it will be subjected to review, and decision will be taken on how the findings can change future traffic management policies both in Manchester and across country. The project will collect data related with average traffic speed, wind speed, temperature, nitrogen dioxide emission and route geography.

***AGD systems helps Cyclist stay on track*:** Cyclist safety has not been on focus of ITS industry. However this perception is now speedily changing. Road authorities are turning towards innovative ITS solutions in order to make roads safer for all categories of vulnerable road users. Now, there are systems available to detect exactly where cyclists are located in road environment. Thus traffic management is adjusted to provide maximum safety for cyclist. Recently, AGD systems has witnessed more demand to safely detect cyclist on cycle lanes and roads. AGD has been doing this with its TOUCAN crossing solution. This solution is focused on increasing safety of cyclist and pedestrian moreover improving traffic flow over a decade. With the help of FMCW radar technology, AGD can accurately determine where the cyclist is coming from, the direction they going and monitor when they are expected to leave the junction. One of the application is to provide an early demand at crossing when cyclist are approaching a junction from a designated cycle path. AGD's 318 radars are deployed on existing signal infrastructures monitoring the cycle routes.When cyclist approach towards a junction, they are tracked by the 318 radar from up to 150 meters. When they enter two meter zone, the radar clocks detection and crossing demand is created. As soon as the cyclist reaches crossing, the crossing phase is signaled active, thus cyclists' waiting time is significantly reduced. There is no need of cyclist to try to cross the junction in live traffic that makes cycle routes safer.

***Self-driving pods in Milton Keynes*:** The future came closer, when the transport system catapult brought the build stage of their LUTZ pathfinder self-driving vehicles project to a close in Sept. 15. This announced the beginning of autonomous system phase at a public event in Milton Keynes. The first of the three "pods" was presented before commuters outside Milton Keynes station. This was to acclimatize Milton Keynes citizens for sight of vehicles sharing the pathway with them in coming months.The Automotive Council has made provision for an event that would trial small two-seater "pods". These pods are capable of operating in pedestrian areas. The Automotive Council awarded the project of running of LUTZ Pathfinder to newly launched Transport System Catapult. The Catapult appointed RDM to design and manufacture three pods. RDM is Coventry-based automotive innovative expert. After the completion of build process, the electric powered two-seater vehicle were equipped with sensors and navigation technology developed by the University of Oxford's world-leading Mobile Robotic Group. Findings from LUTZ Pathfinder will be used in the larger-scale UK Automotive program. This program will trial a fleet of 40 self-driving pods with seven 'regular' road based cars in Milton Keynes and Coventry. The pods will have a maximum speed of 24Km/h. A recent report by the Intelligent Transportation Society of America found that ITS including autonomous cars , could achieve a 2-4% reduction in oil consumption and related greenhouse gas emissions each year over the next decade.

***Connected and Autonomous Vehicle (CAV) Technologies*:** Today's society is facing problems of urbanization, congestion and aging population. CAV technologies offer various solutions. CAVs can communicate with their environment, such as roadside infrastructure like traffic lights and other vehicles. CAV technologies offer better use of road space, reduced congestion, fuel consumption, emission and provide more convenient journey time. CAVs will make driving easier. The driver will be able to choose whether they want to be in control or hand over the driving to vehicle itself. Thus drivers will be allowed to to safely use the journey time which way they wish from reading a book to surfing the web, watching a film or just chatting face to face with other passengers. Human error is an important factor in 90% of accidents. Failing to view properly, misjudging others' movements, being distracted by external events, reckless driving, speeding are some of the most common causes of accidents.

Automated vehicles will not be prone to such mistakes. With various sensors CAVs will uninterruptedly monitor their surroundings. They will abide by all traffic laws. Hence CAVs can provide dramatic economic, environmental, and social benefits.

***The Center for Connected and Autonomous Vehicles (CCAV)*:** In UK, CCAV is reaping the benefits of the expertise in industry, academia and other government bodies to develop a train of activities so as to ensure that UK is at forefront of CAV activity. Collaboration in must for unlocking innovation.
CCAV's activities include:
(1) Providing a single point for contact.
(2) Devising new strategy to inform decision makers for government investment in CAV and underpinning infrastructure.
(3) Ensure that the competition among the government funded R&D activities deliver government objectives for CAV.
(4) Reviewing and amending national and international regulations including liabilities.
(5) Amending regulations on vehicle use to promote safety. Also address the issues of data security, privacy and sharing to ensure protection of personal privacy against the insurers and OEMs.
Connected and autonomous vehicular technologies offer opportunities with significant social benefits. The UK government has recognized this opportunity in this fast growing and competitive global market. It has positively responded to signals from industry and has established CCAV to stay at forefront.

***Smart Cities Infrastructure Control through E-GNSS and advanced image processing*:** Exploitation of E-GNSS technologies and integration with other sensors represent a key element to enable urban R&D. It translates into real solutions for current and future cities. To address this need a consortium of six companies and a research institute: Teletel and Irida Lab(Greece), Bit-gear and Arriva(Serbia), ATI and ISMB (Italy) and ALPHA Consult (UK) are conducting Location Based Services (LBS) project relying on Galileo and EGNOS positioning and advanced image processing which is funded by GSA under H2020 frame work.
The potential services that GHOST is designed to provide encompasses:

1. Reporting street lighting anomalies and road deteriorations.
2. Monitoring public garbage completion level
3. Detecting double parking infractions or disabled parking occupied by unauthorized vehicles.
4. Moreover, advanced services such as bus lane and CC area violations are expected to be implemented in second stage.

GHOST system is composed of six main functional and communication entities: (a) Web portal data base (b) users(c) administrators (d) image processing servers (e) embedded devices (OBU) and (f) citizens as data collectors. Citizens use 3G or Wi-Fi to communicate with web portal.

Connected Vehicles: Machine-to-machine communication is the driving force behind so called 'Internet of Things'. This allows devices from washing machines to connected buses to send or receive information in real time without need for human intervention. The Scandinavia has been at the forefront of M2M revolution. Faltcom has been one of the leaders in M2M. Faltcom's units are in service, worldwide, giving data to business over 2G, 3G, and 4G mobile network. There are application ranging from New York City's connected bus stops to a platform for connected vehicles that can be integrated, managed and monitored via cloud. With accurate GPS tracking of bus routes, old fashioned time-tables are replaced by real time travel information delivered directly through customers' mobile phone. Faltcom communication platform has an open interface which can be easily interconnected with existing vehicles.

3M Company: This Company provides speeding related solutions. It is a diversified technology company which is working to reduce road deaths with a range of speed limiting products. The company's Home office type Approved Average Speed camera system track the speed of vehicles over a long period of time. It encourages motorist to drive at safer speeds. By using Automatic Number Plate Recognition (ANPR) over a section of road, the camera system makes a time, date, and location file for each vehicle. If the vehicle reaches next camera earlier than expected then a violation is clocked. 3M has created variety of products along with the Average Speed Camera system to tackle issues related with speeding [18].

***SSL Company*:** This Company is the holder of Queen's award for innovation. It was established in 1979. It delivers specialist systems for roadside use such as CCTV surveillance, safety critical Tunnel control system, Smart Motorway Control system and Message Sign controllers. Blue Truth is a low-cost Traffic Monitoring System which calculates actual and expected journey times. It identifies journey trends, and detects slow or queuing traffic, which is very important for controlling congestion, planning for new roads or determining effective public transport routes. The solar powered detectors, installed on existing infrastructures give information to the cloud via internet. The company provide products to intelligently synchronize traffic lights, set message signs or trigger CCTV cameras. They have the tool which is far superior to any conventional traffic monitoring systems [19].

V. ITS IN INDIA

India is a second most populous country in the world. It is a fast growing economy. Road congestion is a ubiquitous problem across her cities and towns. Building new infrastructures, discouraging growth of ownership of private vehicles and encouraging use of public transport are some of the long-term solutions to this problem. Government of India has committed Rs. 234,000 Cr. for urban infrastructure sector. Bus rapid transit, metro rail and mono rail are being built in different cities to encourage use of public transport system. With sudden growth of Information Technology sector, the cities like Delhi, Pune and Bengaluru have witnessed a steep rise in population. This has resulted in strong need for cheap and fast transportation for supporting fast growing economy. Meeting such growth with increased infrastructure is an infeasible solution because of space and cost constraints. The idea of Intelligent Transportation System (ITS) including intelligent management of traffic flow, informing commuters about road and traffic status can, up to some extent, mitigate negative impact of road congestion. However, replication of ITS solutions[i] used in developed countries cannot be applied directly in India. The Indian traffic is different from developed world. Indian traffic is generally non-lane based and disorderly with heterogeneous vehicles. Hence, there is a need for adaptation of existing solutions and techniques to Indian scenario. Significant R&D efforts are the need of hour. ITS is an interdisciplinary area. Sensors need electronics engineering background. If mobile sensors are used then it needs mobile computing knowledge. Analyzing sensed data needs techniques of signal processing. Communication among sensors and central traffic management authorities need wired or wireless networking background. Traffic classification and prediction algorithms need understanding about machine learning and statistical knowledge. Traffic signal management needs knowledge of transportation engineering. If research in ITS has to make an impact on society, collaboration and technology transfer is the need of hour.

***ITS Applications*:** Most important among numerous possible ITS applications is the Travel and Traffic management which includes applications like 1) Vehicle Classification 2) Intersection Control. 3) Incident Detection. 4) Condition Monitoring. 5) Revenue Collection. 6) Historical traffic data. 7) Congestion map and en –route driver information. 8) Public transport information. 9) Individual vehicle information. Etc [20, 21].

Players in ITS in India: Collaboration with public sector is indeed necessity for the domain of ITS. Laboratory test and simulations will never provide true picture of actual condition on road. Large scale video or GPS data available from traffic control authorities can be used by researchers in their work. List of key players in Indian ITS scenario includes government organizations like city traffic control authorities, academic institutes, start-ups and research laboratories.

Table 1: Research Players in India.

Sr. No.	Organization type	Detail
1	Academic Institutions	IISC Bengaluru, IIT Delhi, Chennai, Bombay and Kharagpur.
2	Private organizations	Mapunity, Logica, Kritikal, Embarg, iTrans, Traffline.
3	City traffic control authorities	Mumbai, Bengaluru, Chennai, Delhi
4	Research Laboratories	Microsoft, IBM, Alcatel, Lucent, Infosys.
5	City bus authorities with GPS Installed in buses	Bengaluru and Chennai.
6	Government R&D Lab	Centre for Development of Advanced Computing (C-DAC).

VI. CONCLUSION

Most of the ITS studies/developments are based in developed countries like Japan, US, UK, and other western countries. Most of the solutions are based on GPS and address the need of urban areas. In development of ITS solutions, integration of different modes of transportation is significantly needed. However, replication of ITS solutions used in developed countries cannot be applied directly in India. The Indian traffic is non-lane based, disorderly and with heterogeneous vehicles. Hence, there is a need for adaption of existing ITS solutions and technologies to Indian scenario. If research in ITS has to make an impact on society, collaboration and technology transfer is the need of hour. In ITS real time information is very important. GPS technology can help in this direction. In India development of ITS with heterogeneous vehicles on road should be considered and its installation and operating costs are inhibiting factors. New emerging technologies such as Zigbee, Wireless Sensor Network (WSN), and Vehicles in Ad-hoc Network (VANET) could be much helpful in this scenario. Use of Android based smart phones can be helpful in order to make ITS more user friendly because smart phones are most commonly used instrument in India and the world. ITS in India is still in its infant state, with decision-makers, key planners, NGOs and agencies are in process of understanding its potential. The development of and implementation of advanced technologies is vital for management and operation of ITS in India. The technologies include sensors, detectors, communication technologies and application of Global Navigation Satellite system (GNSS). At last cooperation between government, NGOs, academic research institutes and industries is indeed necessary.

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