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INTELLIGENT TRANSPORTATION SYSTEMS (ITS): BEST APPROACH AND THE WAY FORWARD

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Abstract
Transportation is a complex, large-scale, integrated, open system (CLIOS) that interacts directly with contemporary societies' social, political, and economic aspects. The mobility and conveyance of people, freight, and information are fundamental to economic and social activities such as commuting, manufacturing, distributing consumption of goods, or supplying energy. Transportation Systems are the support and driver of this mobility. They are composed of infrastructures, modes, and terminals. It enables the socio-economic life of individuals, institutions, and corporations, as well as Governments. With nearly 1.25 million deaths a year on transportation worldwide, a need exists for counter-measures to reduce the number and severity of crashes. A wide range of technologies and techniques are now available to vastly improve the performance of transportation systems to eliminate transportation crashes. Still, we have been slow to implement them. This paper provides a state-of-practice summary of intelligent transportation systems (ITS) to solve the current transportation systems and traffic management practices in eliminating road crashes. Intelligent transportation systems (ITS) and their components have been discussed, followed by best practices of ITS. Finally, the paper gives the future scope in ITS to make it more user-friendly and accessible. It highlights the conclusions extracted from the studies of different systems.

Keywords: Intelligent transportation systems, Intelligent transportation Technologies, Traffic congestion, Traffic management.

1. Introduction
Transportation is a complex, large-scale, integrated, open system (CLIOS) that interacts directly with contemporary societies' social, political and economic aspects. The mobility and conveyance of people, freight, and information are fundamental to economic and social activities such as commuting, manufacturing, distributing consumption of goods, or supplying energy. Transportation Systems are the support and driver of this mobility. They are composed of infrastructures, modes, and terminals. It enables the socio-economic life of individuals, institutions, corporations, and governments [1, 2].

1.2 Basic Philosophy of Intelligent Transportation Systems (ITS)
The intelligent transportation system (ITS) is a system that capitalizes on leading-edge information technology (IT) to support the comfortable and efficient transportation of people and goods. It aims to achieve a quantum leap in the safety, transport efficiency, and comfort of road traffic, contributing enormously to the solution to today's motorized society. These problems range from

urban traffic problems, such as traffic accidents and congestions, to environmental and energy issues. Intelligent Transportation Systems (ITS) supports comfortable and flexible movement in intermodal transportation systems (encompassing road, rail, air, and marine transport). Its ultimate goal is to create a more livable society, as encapsulated in the phrase, "ITS for a livable society" [3, 4 and 5].

Traffic Management Centre (TMC) is the vital unit of Intelligent transportation systems (ITS). It is mainly a technical system administered by the transportation authority. All data is collected and analyzed for further operations and control management of the traffic in real time or information about local vehicles [6, 7, 8, 9, and 10]. Well-organized and proficient operations of Traffic Management Centre depend on automatized data collection with precise location information than analysis of that data to generate accurate information and then transmitting it back to travelers. Let's understand the entire process in a more detailed way. Moreover, by delivering technologies and systems that add real value in response to user needs, intelligent transportation systems (ITS) contribute to creating wholly new industries and markets [11]. Fig. 1 shows using information from transmitters built into or along a road to the cars on it. The system works to help avoidance from dangers like a missed stop sign or signal or a dangerous intersection.

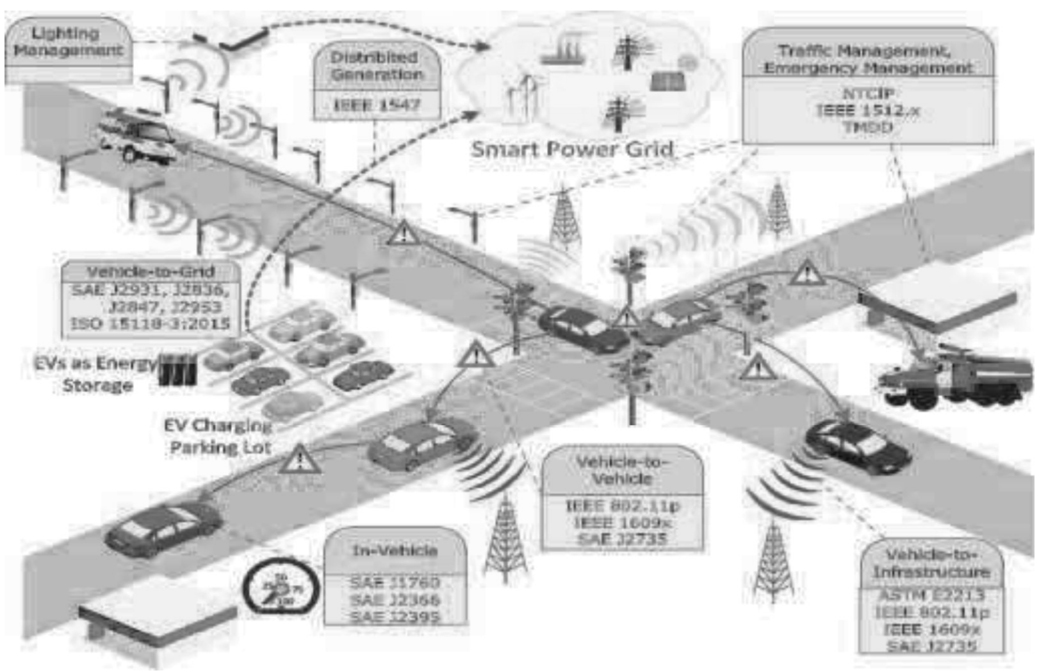

Fig. 1: Intelligent Transportation Systems (ITS) Data Collection

Intelligent transportation systems (ITS) intend to add information and communications technology infrastructure and vehicles to improve: - Safety, - Reliability, - Resource-efficient, - Quality of means of transport, - Climate environment friendly, - Seamless friendly for the benefit of citizens, economy and society, - To boost the competitiveness of transport. There should be a relationship between people, roads, and vehicles to achieve an Intelligent transportation system (ITS) [12].

1.3 Intelligent Transportation Systems (ITS) Goals and Targets

In order to realize its vision for the globe, guided by the theme of "Intelligent Transportation Systems (ITS) for a livable society," Intelligent Transportation Systems (ITS) world has set three first-step targets or goals, which are the realization of: -

(1) A zone with zero traffic fatalities

(2) A zone with zero traffic congestion
(3) A zone with a comfortable transportation experience [13].

1.3.1 How to achieve Intelligent Transportation Systems (ITS) Goals and Targets

The scenario ITS Japan envisions for transportation in the medium term is one in which: -

1) Safe and secure "intelligent transportation systems (ITS) zones" are constructed to reduce traffic fatalities to zero
2) Improved logistical flow and development of automated driving systems of logistical vehicles on limited stretches of road to reduce traffic congestion to zero on those sections
3) Commercialization of "Human navigation systems" makes the transportation experience more enjoyable in a "comfortable transportation zone."
4) A comprehensive intelligent transportation systems (ITS) platform is in place.

1.4 Why is Intelligent Transportation Systems (ITS) Important?

A wide range of technologies and techniques are now available to improve our transportation system's performance vastly. Still, we have been slow to adopt them. Information technology (IT) has transformed many industries, from education to health care to government. It is now in the early stages of transforming countries' transportation systems [14, 15, and 16]. Although many think that improving a country's transportation network means solely building new roads or repairing aging infrastructure, the future of transportation lies not only in concrete and steel but in the implementation of information technology (IT). Information technology (IT) enables assets throughout the transportation system — vehicles, buses, roads, traffic lights, message signs, and so forth — to become intelligent by embedding them with microchips or sensors and empowering them to communicate with each other through wireless technologies [17]. See Fig. 2. Intelligent Transportation Systems (ITS) is an established route to resolve or minimize traffic problems [18].

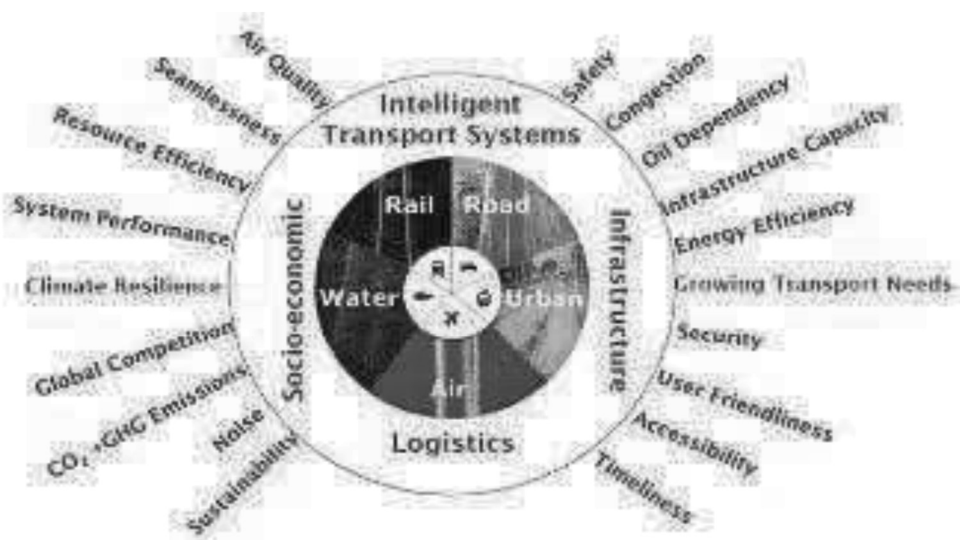

Fig. 2: Why Application of Intelligent Transportation Systems (ITS) [27, 53]

Intelligent transportation systems (ITS) refers to a set of Information and Communication Technology (ICT) based solutions, applications, and services applied in all areas of transport to achieve safer, more reliable and efficient transport journeys, thereby supporting sustainable economic growth and prosperity. When properly implemented, intelligent transportation systems (ITS) solutions have been a useful tool in supporting the delivery of policy objectives such as casualty reduction, crime reduction, traffic congestion, and carbon emission reduction. Other objectives such as increasing accessibility, informing travelers, integrated transport, and efficient

management of transport infrastructure and assets are supported by intelligent transportation systems (ITS) implementations [19, 20, and 21].
Specific examples of intelligent transportation systems (ITS) application are: -Traffic management, Real-Time Passenger Information, Ticketing, and Revenue Protection, Logistics and Fleet Management, Driver Information, Cooperative Highways, and Infrastructure systems, Road safety and security, Enforcement solutions, Emissions reduction, Road User Charging, Automotive and Telematics, Fare collection, Mobility and accessibility, Navigation services

1.5 What is Intelligent Transportation Systems (ITS)?

Intelligent transportation systems (ITS) represent major transportation on many dimensions. Intelligent Transportation Systems (ITS) is an international program intended to improve the transportation system's efficiency through advanced technologies in information systems, communication, and sensors. Intelligent transportation systems (ITS) are designed to promote advanced technology to ensure that the Electronic Toll Collection System (ETCS) is effective and supports safe driving. With this system, people, roads, and vehicles use the latest information communication technology [22, 23 and], see Fig. 3.

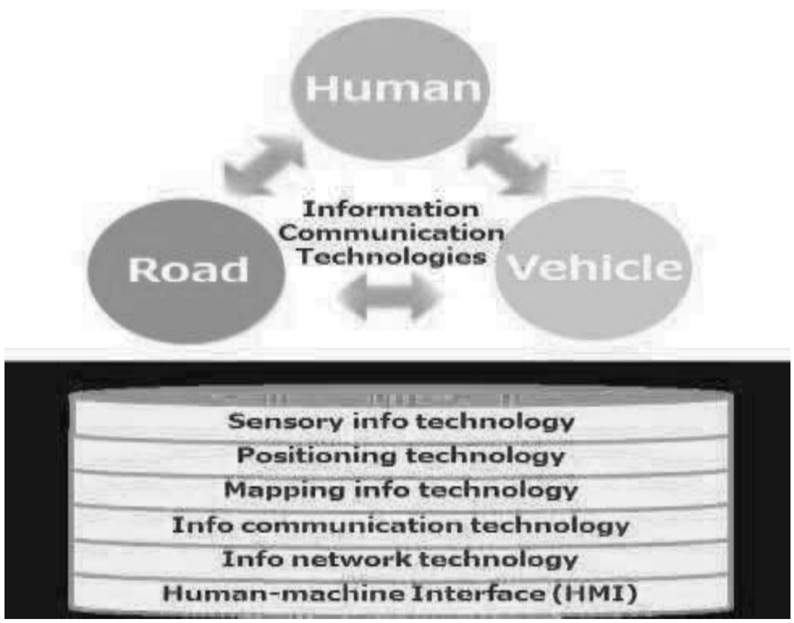

Fig. 3: ITS

An intelligent transportation system (ITS) is an advanced application that aims to provide innovative services relating to different modes of transport without embodying intelligence. Air, Land, Water, see Table 2, and traffic management and enable various users to be better informed and make safer, more coordinated, and 'smarter use of transport networks [25, 26, 27, 28 and 29]. Some of these technologies include calling for emergency services when an accident occurs, using cameras to enforce traffic laws or signs that mark speed limit changes depending on conditions. They are systems in which information and communication technologies are applied in all modes of transport, including infrastructure, vehicles and users, traffic management and mobility management, and interfaces with other modes of transport. Intelligent transportation systems (ITS) may improve the efficiency of transport in several situations, i.e., General Transport, Traffic Management, Data/Information Management, Mobility, R&M, Transport Budgeting, Transport Costing, Routes, and Scheduling, etc. (30, 31, 32, 33 and 34].

1.6 Characteristics of Intelligent Transportation Systems (ITS)

Some of the special characteristics of ITS include but not limited to the following: -

a. Information dispels and wears out ignorance:

The single biggest cause of driver impatience that leads to reckless driving, incidents, road rage, and accidents is ignorance. When a traveler encounters an obstacle and does not know what lies ahead, a rational or irrational fear may arise in that he or she might not succeed in reaching the destination on time, which, in turn, may have untold consequences [35, 36, 37, 38 and 39].

b. Automated computation:

Unlike in many transportation systems across the world, where the decision-making and the computation of the arrival times are still estimated manually, future system architectures must employ automated decision-making computer systems to yield accurate information and achieve precise control and coordination.

c. Accuracy of information is crucial:

The information must be accurate, timely, relevant, and consistent. Otherwise, drivers will begin to question the value of the ITS technology and may even abandon it prematurely. Any out-of-date piece of data can quickly assume the form of misinformation with severe unintended consequences.

d. Respect for drivers' freedom is of paramount importance:

Except under true emergency conditions, the intelligent transportation systems (ITS) architecture should neither attempt to control nor dictate a driver's behavior.

e. The individual traveler must constitute the focus:

The ITS architecture must be fundamentally centered around each driver or traveler, subject to safety and fair resource availability for all

f. The design of asynchronous, distributed algorithms for control, coordination, and resource management:

Since the constituent units and the resources of any transportation system are geographically dispersed, it is logical for future system architectures to exploit distributed algorithms.

g. Continual checking for operational errors:

By their very nature, complex. Systems may contain design errors that manifest irregularly during operations and elude detection but are severely damaging

1.7 Intelligent Transportation Systems (ITS) Challenges

Despite their technical feasibility and significant benefit-cost returns, many nations underinvest in ITS because there are a significant number of challenges involved in developing and deploying them, including system interdependency, network effect, scale, funding, political, and institutional challenges. Whereas some ITS, such as ramp meters or adaptive traffic signals, can be effectively deployed locally, the vast majority of ITS applications—and indeed the ones positioned to deliver the most extensive benefits to the transportation network—must operate at scale, often at a national level, and must involve adoption by the overall system and by individual users simultaneously, raising complex system coordination challenges [40].

ITS presents a set of challenges not found in most other types of transportation strategies. There is much that is unknown about intelligent transportation systems (ITS): -

- the market for in-vehicle devices,
- the level of benefits ultimately achievable, and
- the impact that institutional barriers may have on the rate of deployment of intelligent transportation systems (ITS).

This paper talks about the challenges that are somewhat unique to intelligent transportation systems (ITS) and how they might be overcome. Some of these challenges include: -

- Intelligent transportation systems (ITS) emphasize operations that many transportation departments are not used to dealing with. For example, information systems pay more attention to maintain credibility with the public and other users.
- ITS crosses modal, institutional, and geographic barriers. This presents significant coordination challenges. These are usually substantially more difficult than the technological ones.
- ITS works best as a cohesive system of individual elements that work together. The integration of these elements makes the total concept of ITS more complex.
- ITS is not well understood by the public or elected officials.
- Up to this point, ITS has received substantial special attention and priority as the globe undergoes defense industry downsizing and transfer of some of those technologies into the realm of transportation. This has made it more difficult to integrate ITS strategies with other planning and implementation programs by the world [41, 42, and 43].

1.8 History of Intelligent Transportation Systems (ITS)

The promise of a future with technologically advanced transportation options has occupied the collective American imagination for decades. The 1939-1940 New York World's Fair tagline promised to show visitors "the world of tomorrow." Arguably, the most popular feature was a ride called Futurama in the General Motors Pavilion. Futurama attracted huge audiences; many waited in line for hours to experience possible life in the then-distant future year 1960 [44, 45, 46, 47, 48, 49, and 50].

The Futurama ride carried visitors past miniature yet realistic landscapes that focused on what transportation might look like in 20 years. Simultaneously, a narrator described this futuristic utopia forged by sophisticated transportation planning. Highways ran through rural farmland before moving into well-ordered cities. Automated vehicles had radio controls to help them maintain a proper distance from one another. In 1939, there was no interstate freeway system, and many people did not own a personal vehicle. The audience left this exhibit with new ideas of what was possible and particularly new visions for the future of transportation, setting the stage for a period of incredible transportation advancement [51, 52, and 53].

The history of intelligent transportation systems (ITS) was greatly influenced by specific champions who pushed the branding of Intelligent transportation systems (ITS) and created a much-needed consciousness of what intelligent transportation systems (ITS) can do.

a. Air

The most important technological elements in the air transport mode are the maneuvers support system for aircraft landing and takeoffs (IL) International Landing System and MLS-Micro Landing System). Navigation and system (VOR-VHF Omnidirectional Range. GNSS), and radars.

b. Maritime / Water

In maritime or water transport, the most representative element is the Automatic Identification System-AIS and GNSS positioning and communication system (Global Navigation Satellite Systems). In this mode of transport, the radioelectric systems and navigation are widely used, Terrestrial or Satellite radio navigation systems such as LORAN-Ctype (Long Range Aid for Navigation), GPS- Global Positioning system and radar. (Radio Detection and Ranging) have been key technologies elements to avoid collisions and to allow the development of this mode of transport

c. Rail

In rail transport, the higher technologies development is seen in the railway traffic management systems, such as the European Rail Traffic Management System- ERTMS, composed of ETCS (European Train Control System) and GSM-R (Global System for Mobile Communication-Railways).

For railway traffic management in cities, a system such as Train Protection-APT or the Automatic Train Operation- ATO is used, enabling integrated rail network management, producing safe and high-quality service, and reducing the system's energy consumption.

d. Road

The most important technological element in road transport is related width positioning systems like GPS and traffic monitoring through cameras. These systems can be used for automatic incident detection (AIDS), toll management, urban transportation control, congestion detection, tunnel control, speed control, and calculation, dangerous goods transport control, and infraction detection. Other relevant technology elements for road transport are the advanced Driver Assistance System – AIDS - and the in-Vehicle Information System IVIS - which provide users with information about secondary tasks related to transport, such as navigation.

1.9 Aims / Objectives of the Study

An intelligent transportation system (ITS) aims to facilitate a national multi-modal surface transportation system that features a connected transportation environment around vehicles of all types, the infrastructure, and carry-in passenger devices to serve the public good by leveraging technology to maximize safety mobility and environmental performance. The study evaluates the immense contribution of intelligent transportation systems towards stimulating productivity and other economic activities. Others are to: -

- Provide innovative management and enable users to be better informed and make safer, more coordinated, and smarter transport.
- Provide innovative services relating to different transport and traffic management modes and reduce smart wars on the road.
- Enable users to be better informed and make safer, more coordinated, and 'smarter use of transport networks.
- Achieve traffic efficiency by minimizing traffic problems.
- Reduce the time of commuters, as well as enhances their safety and comfort. The use is limited to traffic congestion control and information and road safety, and efficient infrastructure usage.

1.10 Scope of Present Work

Intelligent transportation systems (ITS) transform the transportation sector with the generation of intelligent transportation systems (ITS) that helps optimize logistics and fleet management, goods and services, traffic management, driver assistance, etc. Intelligent transportation systems (ITS) helps in automating railways, roadways, airways, and marine vessels. It also helps in tracking and delivery of goods. Increasing the Intelligent Transportation System (ITS) adoption to improve and reduce road accidents is also expected to drive the intelligent transportation system market significantly. The growing population and rise in the number of vehicles have driven the need for effective traffic management. By generating an intelligent transportation system (ITS), it can automate an entire vehicle, congestion on urban roads, and rising accidents which need smart transport management solutions leveraging sensing, communications, and data processing technologies, smart parking solution, traffic management solution, passenger entertainment, fleet management, and telematics solutions, and security solution, moreover, prices of sensors are projected to come down shortly.

1.11 Statement of the Problems

Managing urban traffic requires finding a balance between throughput, livability, safety, and sustainability. As cities are expected to grow in the coming decades (leading to increased traffic demand), the challenge of managing traffic will increase, as space to develop road networks is often limited or non-existing. That urban traffic is characterized by a mix of different modes of transport (pedestrians, bicycles, public transport, and motorized vehicles) makes the challenge even more complex [56 and 57].

The following are some main socio-eco issues identified and assessed as possible current bottlenecks or inhibitors bedeviling institutional arrangements regarding effective intelligent transportation systems: -- An under developed road network, - Severe budget restrictions, - Explosive urbanization and growth, - Lack of resources for maintenance and operation, - Less demand for automation, - Lack of interest among government decision makers, - Lack of user awareness, - Lack of proper justification, - Strong political and legal barriers if the monitoring is done through cameras and number plate recognition, - Residents and shopkeepers tend to have a negative attitude towards such measures, - Relocating the problem, i.e. traffic will redistribute to other parts of the network disagreements on how to set tolls, what to do with any excess revenues, whether and how certain drivers (e.g. people living/working in an area where pricing is implemented) should be compensated or exempted, - Risk to transfer the congestion problem to another area of the city, - Relatively difficult to implement, both technically and politically, - Relatively small acceptance; users do not want to pay, even if this may decrease urban congestion, - Mixed traffic conditions, - Encroachment resulting in reduction of capacity of roads, - Lack of enforcement measures, - Lack of engineering measures ,- Inefficient and inadequate mass transport system.

1.12 Justification / Significance of the Study

Little research has been undertaken on intelligent transportation systems as a viable tool for socio-economic development. Therefore, a study like the current one is timely as it examined the viability, profitability, or otherwise and economic development in the study area. The role of intelligent transportation systems in trade, manufacture, commerce, and agriculture cannot be swept under the carpet because the movement of people and goods from one place to another is very important. Control purposes, Safety concerns, Monitoring and Evaluation (M & M&E) purposes, Data Collection to Improve mobility, assisting in improving future transportation requirements. Assisting in planning for the supply of transportation facilities and services for rewards and punishments; for reacting to Emergence or Unforeseen situations, preventing accidents and Collisions, etc. [7].

1.13 Research Methodology and Organization of the Study

The study adopts the experimental method of research that examined and discussed relevant issues of interest in the history of intelligent transportation systems as a viable tool for socio-economic development. Thus, the paper reviews existing literature on intelligent transportation systems. Because of the nature of the study (macro), the writer relies on published documents in intelligent transportation systems using commissioned studies, non-commissioned studies, and published works from various sources. Some of these secondary sources are narrow in perspective and scope. Still, they serve as useful materials for researchers wanting to embark on a macro-study.

The study is organized in nine (9) sections apart from the introduction. These are overview of intelligent transportation systems, review of literature relating to intelligent transportation systems, components of intelligent transportation systems, intelligent transportation systems stage of work, benefits of intelligent transportation systems, best practices of intelligent transportation systems in selected megacities, future developments in intelligent transportation systems, conclusion and references.

1.13.1 Research Hypotheses

To aid the completion of the study, the following research hypotheses were formulated by the researchers.

H0: there is no positive effect of intelligent transportation systems on the effective functioning of the transport system.

H1: there is a positive effect of intelligent transportation systems on the effective functioning of the transport system.

2. Review of Literature Relating to Intelligent Transportation Systems (ITS)

A heterogeneous network of technologies comprises intelligent transportation systems (ITS) for highways and roads: video cameras, embedded or mounted traffic sensors, smart cards, smart card readers, GPS devices, license-plate readers, geographic information systems (GIS), computers, software, communications equipment, fiber optic networks, wireless networks, electrical supplies, traffic signals, emergency vehicle detection devices, and so on. The most visible public interfaces for intelligent transportation systems (ITS) are traffic signals, which regulate the flow of motorized vehicles, bicycles, and pedestrians on streets; "dynamic message signs," which can alert drivers to upcoming road conditions; and ramp meters, which regulate the flow of vehicles onto highways. Perhaps the most important intelligent transportation systems (ITS) interfaces, however, are hidden from public view: traffic control centers, which monitor and respond to traffic conditions through remote manipulation of the system (and its data) as a whole. The hallmarks of these control centers are their impressive and frequently massive "video walls," which display road conditions in real-time, whether through a graphic representation of roads and signals, CCTV video feeds, or some combination of both. The intelligent transportation systems (ITS) take the first step towards meeting this challenge by providing practical, reliable, and meaningful knowledge to motorists in time problems like high traffic congestion and low transportation efficiency. Low safety and endangered environment can be solved through innovative and sophisticated ways of handling the latest techniques that have emerged in recent years in integrating information technology, electronics, and telecommunication with roads and traffic management. Intelligent transportation systems (ITS) encompass a broad range of wireless and wirelinec communications–based information control and electronic technologies.

When integrated into the transportation system infrastructure and in vehicles themselves, these technologies help monitor and manage traffic flow, reducing congestion, provide alternate routes to travelers, enhance productivity. And save lives, time, and money. Intelligent transportation systems provide the tools for skilled transportation professionals to collect. Analyze and archive data about the performance of the system during the hours of pack use. Having this data enhances the traffic operator's ability to respond to incidents, adverse weather, or other capacity constricting events.

According to Niksh [39] the objectives: This paper aims to build a structured literature review to the field of intelligent transportation systems (ITS). In this literature review, an effort was made to evaluate the earlier researcher work and methodologies related to intelligent transportation systems to study. Analyze and evaluate its relevance in today's changing environment. The recently published research articles related to ITS are undertaken for the study.

Results: the literature review focuses on ITS applicability in developing countries like India with major traffic congestion, infrastructure constraints, and high traffic loads. Non – lane traffic system etc., there are few research gaps identified in the field, specifically in the areas of ITS and its practical implementation. To fill these gaps and extend previous studies, there is a need for researching to investigate the relationship between ITS and its implementing issues.

Adeleke et al. [1] reviewed intelligent transportation systems (ITS) and the facilities that make up its operation, analyzing its implementation in the Nigerian system, arguing that with the current financial and technological strength of the Nigerian Economy, little may be achieved in implementing intelligent transportation systems (ITS).

Sagar et al. [43] Objective: Vehicular traffic is a significant problem in a country, especially in major cities. The effects are worst in emergency vehicles such as ambulance, fire engines, etc., when they are stuck in congestion. It may even lead to the loss of lives of a few too many. Congestion occurs mainly due to two reasons: traffic lights and other is due to incidents such as accidents, vehicle breakdown, etc. Congestion results in various problems such as increased average waiting time, decreased average distance traveled, increased pollution, increased fuel consumption, etc. This, in turn, results in intolerance of drivers, which may even lead to an accident. However, there are many solutions to overcome the traffic problem. One is to build new roads and widen existing roads. Another is to make effective and efficient utilization of the available ones. The first one is very costly and needs more time. It also creates a lot of disturbance in public.

In some cases, it can be said that the first solution is impossible. In contrast, the second solution is comparably easier to implement without disturbing the available infrastructures. Building new roads may be the permanent solution to some extent. But, without effectively utilizing the available ones, if we build new ones, it is mere waste of resources and time. So by going for a second solution, i.e., by building an intelligent traffic management system, we can make effective and efficient utilization of the available resources. The ways of achieving it are being discussed in this article.

Results: So, from the literature, the following conclusions are made. Firstly, in vehicular traffic control, RFID solution is hardly possible. Each vehicle must be embedded with an RFID tag that can't be removed, which is almost impossible in real-time. Secondly, remote traffic signal control is not as efficient as a fully connected one. Simple because it is making decisions independently without considering traffic in other intersections. Fully connected traffic lights are achieved in two ways, centralized and distributed. Both have advantages as well as disadvantages. Thirdly, an EV may not travel in an emergency always, i.e., traveling to a fuel station in its free time, etc. In such a case, there is a chance of misuse by the driver by unnecessarily requesting priority. So future work is to build an intelligent traffic management system that is feasible to implement, efficient, scalable, flexible, and fully connected with very high interoperability. The system also should aim at overcoming the misuse of the priority assigned to emergency vehicles.

3. Components of Intelligent Transportation Systems (ITS)

Intelligent transportation systems (ITS) are advanced applications that, without embodying intelligence as such, aim to provide innovative services relating to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated, and 'smarter use of transport networks. Although ITS may refer to all modes of transport, EU Directive 2010/40/EU (7th July 2010) defines ITS as systems in which information and communication technologies are applied in the field of road transport, including infrastructure, vehicles and users, and in traffic management and mobility management, as well as for interfaces with other modes of transport [58], see Fig. 4.

The commonly adopted functional taxonomy of intelligent transportation systems (ITS) services is as follows [21, 28]: -

Fig. 4: Intelligent Transportation Systems (ITS) Taxonomy or Classification [58]

3.1 Advanced Traffic Management System (ATMS)

ATMs integrate various sub-systems (Such as CCTV, vehicle detection, communications, variable message systems, etc.) into a cohesive single interface that provides real-time data on traffic status and predicts traffic conditions for more efficient planning and operations (see Fig. 5.

✓ Monitors the flow of traffic appropriate decisions promptly.

✓ Employs inexpensive detectors, cameras, and communication systems to control the flow of traffic.

✓ Optimize signals timing on major arterials.

✓ Manages congestion dynamically.

Fig. 5: Example of ATMs

3.2 Advanced Traveler Information System (ATIS)

ATIS provides users of transportation systems, travel-related information to assist decision-making on route choices, estimate travel times, and avoid congestion (see Fig. 6.

Advanced traveler information system (ATIS) is one of the most common ITS services, aiding the transportation of travelers from their origin to their destination. Information about traffic congestion, delays, accidents, and weather are disseminated through the media, Internet, visual messaging, and public announcement systems (https://en.wikipedia.org/wiki/Advanced_traveller_information_system).

- GPS enabled in-vehicle navigation systems
- Dynamic road message signs for real-time communication of information on traffic congestions, bottlenecks, accidents, and alternate route information during road closures and maintenance
- Website to provide a colour-coded network map showing congestion levels on highways (a.k.a. congestion index).

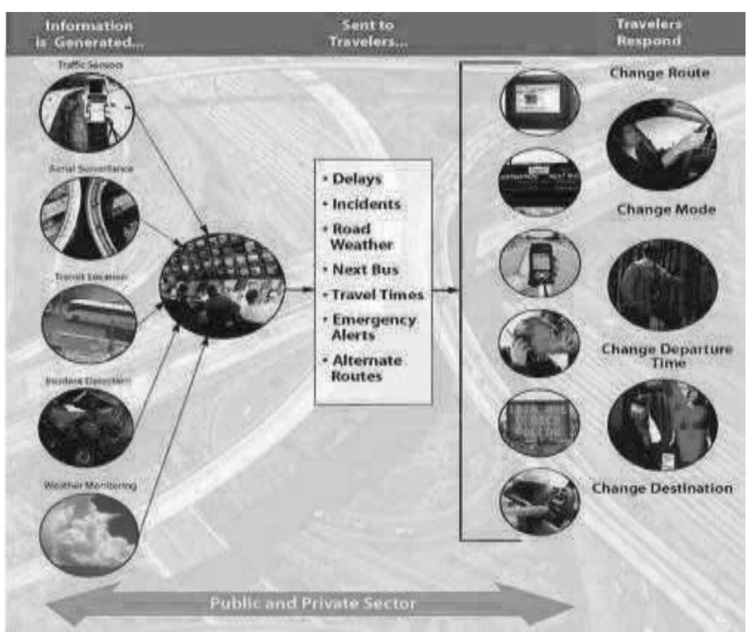

Fig. 6: Example of ATIS

3.3 Advanced Public Transportation System (APTS)

APTS apply state-of-art transportation management and information technologies to public transit systems to enhance the efficiency of operation and improve safety.

✓ Advanced public transportation systems are those services and technologies that help improve transport services, using satellite navigation systems, wireless communication systems, and other devices so that passengers can get more information on timing, for example, buses and carpooling services.

✓ APTS aims to provide more information to the public to make effective decisions and increase traveler convenience, see Fig. 7.

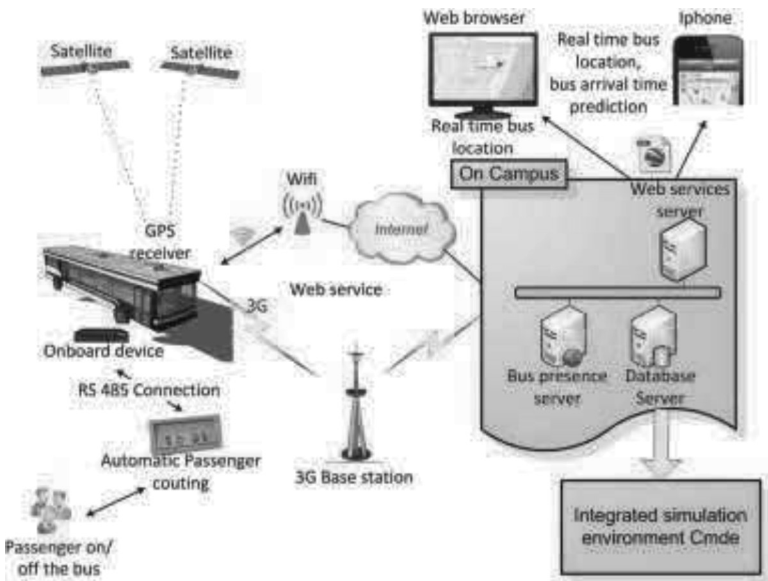

Fig. 7: Digital announcement of transit arrival

3.4 Emergency Management System (EMS)

✓ It offers real-time information about traffic conditions through variable message signs to warn accidents or other delays.

✓ A variable message sign is a board, which provides information to the motorist of an upcoming hazard.

✓ Enable authorities to identify and respond to vehicle crashes or breakdowns with the most appropriate and timely emergency services, thereby minimizing recovery time (see Fig. 8.

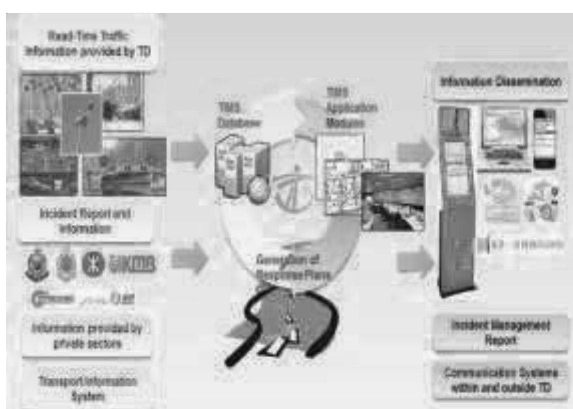

Fig. 8: Example of EMS

3.5 Electronic Payment System (EPS)

- ✓ An electronic payment system (EPS) is a system by which drivers can pay tolls without stopping at a toll booth.
- ✓ The fees are collected electronically through equipment installed in the vehicles and sensors at the toll location.
- ✓ EPS is based on a vehicle roadside communication system; see Fig. 9.

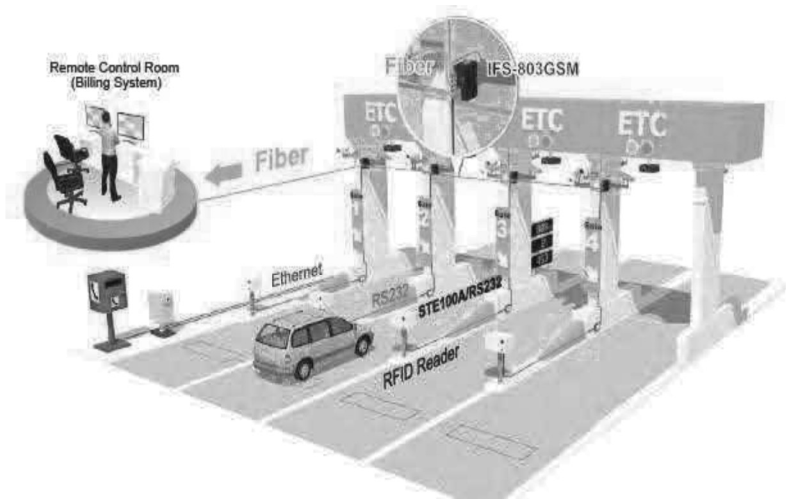

Fig. 9: Example of EPS

3.6 Advanced Vehicle Control and Safety System (AVCSS)

- ✓ This system includes updating all road users about traffic conditions and other information congestion, jams, roadblocks, pollution levels, etc.

- ✓ The information, via FM Band or through road maps, quickly showing traffic conditions in surrounding areas. The drivers can use this information to select the best routes using in-vehicle monitors (see Fig. 10.

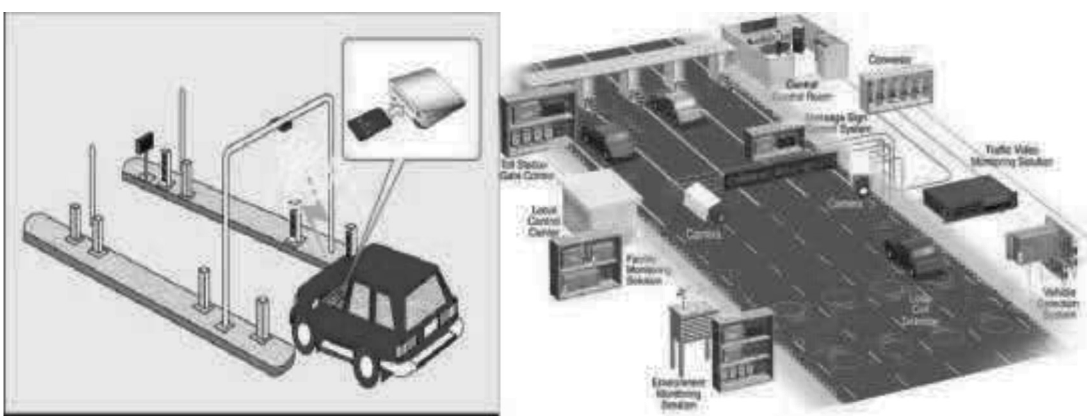

Fig. 10: Example of AVCSS

3.7 Vulnerable Individual Protection System (VIPS)

While everyone is equally entitled to human rights, international human rights law provides for specific protection and special measures for some groups of individuals to enjoy their human rights on an equal footing. Such groups are deemed to need enhanced protection due to their particular vulnerability or due to structural inequality.

When a hazard event (such as a drought, flood, cyclone, earthquake, or tsunami – among others) occurs, triggering a loss of life and damage to infrastructure, it highlights the reality that society and its assets are vulnerable to such events sees Fig. 11.

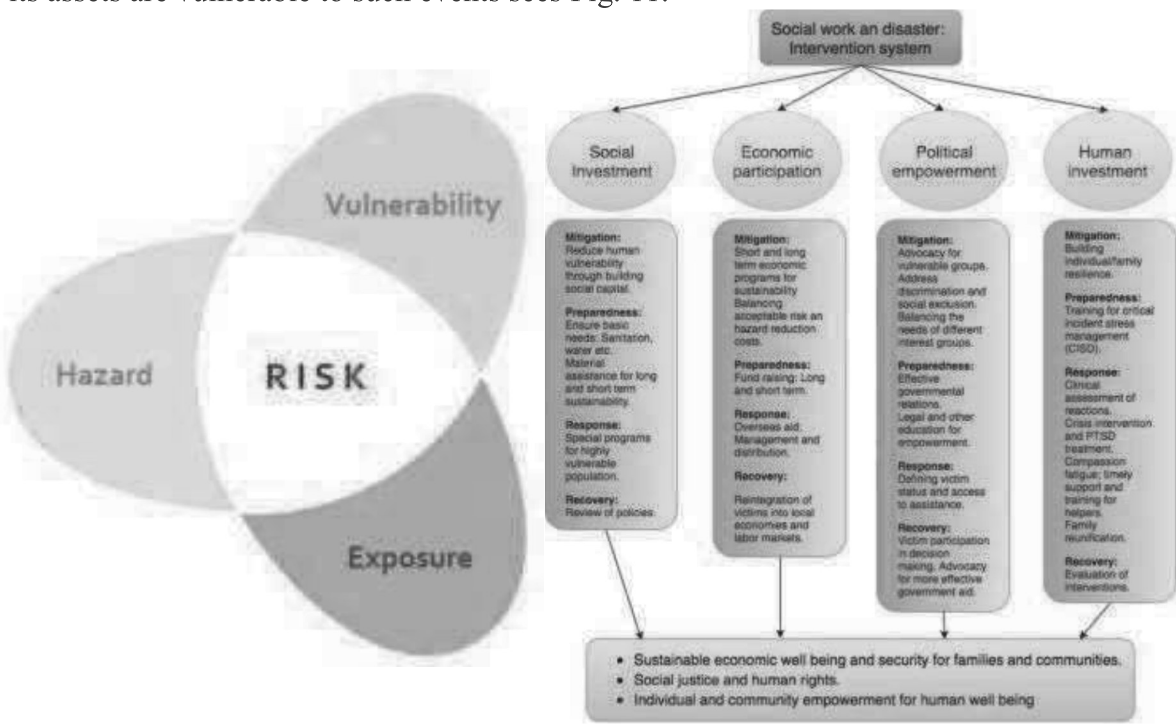

Fig. 11: Example of VIPS

3.8 Commercial Vehicle Operations System (CVOS)

A commercial vehicle operations system *(*CVOS) is an ITS solution for commercial vehicles that aids in efficient commercial vehicle operations. It leverages GPS locations along with digital radios and intelligent algorithms to manage commercial vehicles. It comprises an ensemble of satellite navigation systems, a small computer and digital radio, which can be used in commercial vehicles such as trucks, vans, and taxis (see Fig. 12.

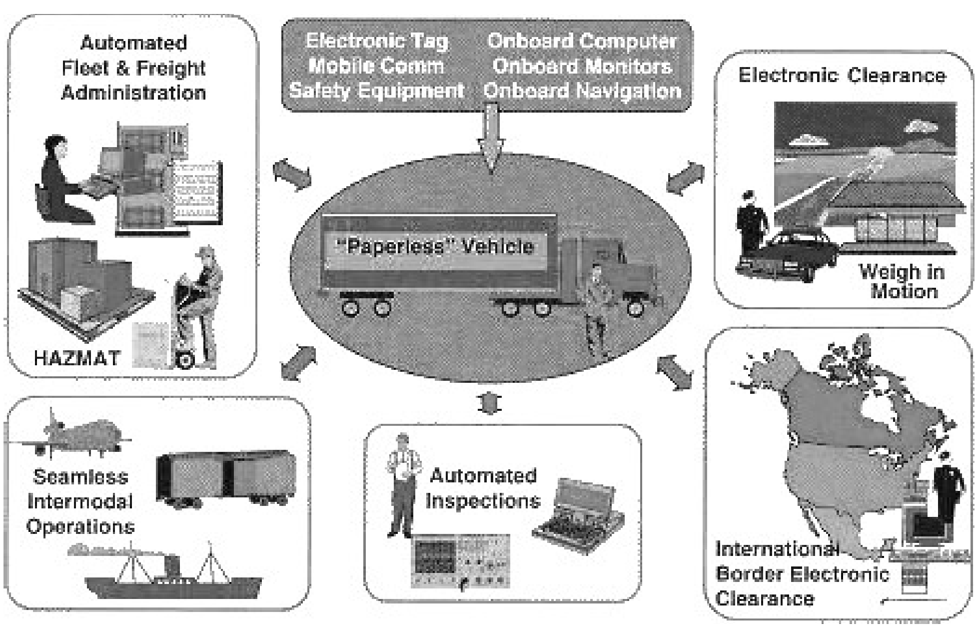

Fig. 12: Example of CVOS

4. Intelligent Transportation Systems (ITS) Stages of Work

4.1 Intelligent Transportation Systems (ITS) Data

Intelligent transportation systems (ITS) data refer to data that is typically collected by and generated for intelligent transportation systems (ITS) applications, such as ATMS (advanced traffic management systems). ATIS (advanced traveler information system), CVO (commercial vehicle operation), EMS (emergency management systems), and the emerging CV (connected vehicle) systems.

Archived ITS-generated data are distinct from traditional data sources in three aspects: -

(1) Intelligent transportation systems (ITS)-generated data are temporally intensive—that is, collected in very short intervals;

(2) Intelligent transportation systems (ITS)-generated data meet some major data gaps that could not be met in the past due to resource limitations;

(3) All Intelligent transportation systems (ITS)-generated data are on electronic media, thereby expediting data analysis and information dissemination. Common ITS data collection methods include: vehicle detection; video imaging; AVL (automatic vehicle location); in-vehicle transponders; license plate readers; cellular probes; GPS (global positioning system) probes; Bluetooth-based measuring systems; transit ITS; commercial vehicle operations and management; connected and automated vehicle technologies; telematics.

4.2 Data collection (Figures 13 a and b)

Many data collection methods have been used by public agencies charged with managing traffic flow, safety, carrying out planning activities, and maintaining roadway networks. Some, such as sensing and telematics that will allow for wireless V2V (vehicle-to-vehicle) and V2I (vehicle-to-infrastructure) communications for purposes related to safety, security, convenience, and maintenance, are relatively new and innovative, see Fig(s). 13a and 13b. Tools for ITS data collection include, but not limited to, the following: - Drones, Cameras, Satellites, Radars, Intel Processors, Computers (IT Systems), Sensors, Transmitters, Robots, GPS Systems, etc.

- ❖ There were, on average, 1,578 fatalities each year resulting from two vehicles' traffic crashes at intersections controlled by traffic signals.
- ❖ Approximately 51% of those fatal crashes were caused by drivers who ran a red light.
- ❖ Potholes accounted for 6,424 Roads Accidents & 2,324 fatalities. 9,483 accidents & 3,396 accident deaths were attributed to speed breakers.
- ❖ The state highway traffic police have identified more than 45 spots on the National highway, major accidental prone zones.
- ❖ According to data, the total number of accidents due to traffic signals involves 15,125 accidents, 4,233 killed, and 12,995 injured.

13a 13b

Fig. 13 a and b: Intelligent Transportation Systems (ITS) Data Collection with Drone and Laptop

4.3 Analysis of Collected Data

- ❖ Most of the accidents occur due to disobeying traffic signals, speeding, blind turns, and potholes.
- ❖ Road accidents have decreased by around 4.1% during 2016, with the year seeing 4,80,642 road accidents as against 5,01,423 in 2019. However, fatalities resulting from these accidents have risen by about 3.2% during the same period. Nearly 1,50,785 persons were killed in 216 as against 1,46,133 in 2019.
- ❖ One serious road accident occurs every minute, and 16 dies on Indian roads every hour.
- ❖ About 1214 road crashes occur every day in a city.

5. Benefits of Intelligent Transportation System (ITS)

The investment in ITS will help increase the benefits and efficiencies of the transportation system. It was there, reducing the need for much costlier physical expansion of the system. This optimism is not to be confused as any kind of illusion that new infrastructure expansion in Indian can be avoided altogether by resorting to intelligent transportation systems (ITS) [59].
The following is a list of identified benefits of intelligent transportation systems (ITS) projects: -

- Reduced rush-hour congestion and delay, Increased safety and personal security, Time savings and operational efficiencies, Reduced fuel consumption and emissions, Improved customer services and reduces frustration, Reduced road accidents and fatalities, enhanced economic productivity, applying information technology to a country's transportation, network delivers five key classes of benefits by: -
- a. Increasing driver and pedestrian safety,
- b. Improving the operational performance of the transportation
- network, particularly by reducing congestion,
- c. Enhancing personal mobility and convenience,
- d. Delivering environmental benefits, and
- e. Boosting productivity and expanding economic and
- employment growth [60].

6. Best Approach of Intelligent Transportation Systems (ITS)

Numerous ITS applications are already applied since mid of 90's around the globe's most significant megacities by various organizations/institutions and tailored to offer transportation solutions to meet their specific needs. Intelligent transportation systems (ITS) have been used to tackle cities' challenges and ease the inhabitants' daily lives. In developed countries, road operators have become dependent on intelligent transportation systems (ITS) for congestion and demand management, road safety, and improved infrastructure. The scope of this assessment is generally limited to intelligent transportation systems (ITS) technologies and applications previously enumerated, focusing more on the application of intelligent transportation systems (ITS) in the road transportation network and for the benefit of motorists. Most advanced countries are in some way, shape, or form deploying intelligent transportation systems [60]. Approximately ten countries are taking moderate to significant steps to deploy intelligent transportation systems (ITS) applications, including - Australia, France, Germany, Japan, The Netherlands, New Zealand, Sweden, Singapore, South Korea, the United Kingdom, and the United States. Several developing countries, notably Brazil, Taiwan, and Thailand, are also deploying increasingly sophisticated intelligent transportation systems. China has also committed to making rapid leaps in intelligent transportation systems (ITS) and endeavors to become a world leader in the not-too-distant future. Many of these countries have particular strengths in intelligent transportation systems (ITS), notably: real-time traffic information provision in Japan and South Korea; congestion pricing in Sweden, the United Kingdom, and Singapore; vehicle-miles traveled systems in The Netherlands and Germany; electronic toll collection in Japan, Australia, and South Korea; APTS in South Korea, Singapore, and France. But, while there is a coterie of leading countries in intelligent transportation systems (ITS), several in particular stand out as world leaders: Japan, South Korea, and Singapore. As market research firm ABI Research concurs, Japan and South Korea lead the world in intelligent transportation systems. Singapore appears to be in the upper echelon of intelligent transportation systems (ITS) leadership as well. The power of intelligent transportation systems (ITS) to revolutionize transportation makes them an important factor contributing to countries' economic competitiveness [61].

7. The Way Forward

This section briefly describes some future developments that are foreseen in intelligent transportation systems (ITS) and traffic management. In the coming years, many changes in traffic and transport are expected, on a technical level and a societal, demographic, and economic level. All changes will impact the development and application of traffic management and intelligent transportation systems (ITS) solutions in cities.

New traffic management systems are possible due to increasing penetration rates of probe vehicles with more accurate positioning data. A lot of benefits are expected from automation. Some parties promise self-driving cars by around 2020. However, it is not expected to have fully self-driving cars (where you can sit behind the steering wheel and do something else) in the next few years. However, vehicles that are 'connected' and that have systems onboard that automate part of the driving task are already on the market. Connected and automated vehicles will influence traffic management. Cooperative systems may also influence the number of roadside systems that are needed. However, the transition from the roadside to in-vehicle systems will take time. Also, automated vehicles are likely first to be introduced on motorways; automated driving in cities is more difficult because of the mix of traffic. In addition to technology for motorized vehicles, ITS solutions are being developed for vulnerable road users (e.g., cyclists, pedestrians).

8. Conclusion

With nearly 1.25 million deaths a year on roads worldwide, a need exists for counter-measures to reduce the number and severity of crashes. A wide range of technologies and techniques are now available to vastly improve the performance of transportation systems to eliminate road crashes. Still, we have been slow to implement them. The continuous growth of population all over the world creates a significant challenge to the transportation management systems. The conventional methods are no longer effective enough for solving complex and challenging transportation management problems.

More economical, more efficient, and thus more intelligent methods have to be developed to deal with these challenging problems. Knowledge from different research areas is needed for developing these systems. Very often, complex transportation systems require the integration of different methods from different branches of science. Due to the increased number of vehicles, it is necessary to take effective steps to control the traffic and avoid all types of road crashes and losses that are caused due to traffic. Once we have predicted a high traffic density for a network segment, we can initiate strategies to avoid this problem. In the case of a road network, navigation systems can try to bypass the critical zone.

Furthermore, any traffic control systems can inform the drivers about the traffic jam risk to guide them around the critical zone. In order to detect the traffic, different sensors are being used, and different techniques are used to determine the traffic and thus solve the problem related to traffic. The broad recommendations emerging out of the study included: -

i. Planning should focus on reducing the traffic load on the existing road network through various travel demand management measures.
ii. Emphasis should be placed on the mass transport system.
iii. Concerted efforts are needed in removing encroachments, bottlenecks, improving traffic signal, road condition, and geometrics at intersections.
iv. Video image processing is recommended over other fixed sensors due to its high efficiency, easy installation, and large experience base.

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