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Impact of ICT in Monitoring Vehicle over Speed on Highway In Tanzania: A Review

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***Abstract**: Many road accident results from the breach of traffic police rules. People are continuously losing lives and some get permanent body disabilities and property destruction due to road accidents. So, there is a importance to develop simply adaptable, cost-effective and reliable, over speed and alcoholic monitoring systems so as to provide a real time information on the road, Vast of Studies have been conducted concerning road safety and monitoring systems, these systems provide a real time safety and alarm the driver, pedestrian, passenger or traffic police whenever any information needed to know concerning roads. Since human factors including over-speed, driving while drunk, reckless driving, and overloading contribute a lot in causing crashes, Alcoholic detection and over speed monitoring has been selected for this study. This paper presents summarized review information of the developed systems for adaptive vehicle over speed and alcohol monitoring system. Several technologies have been implemented to existing systems, such as Global System for Mobile Communications, GPS, Mobile Phones and sensing equipment that allows remote access of information from any place of the country.*

Keywords— Intelligent Speed Assistance (ISA); ITS; GPS; GSM; BAC; Over speed; HMI

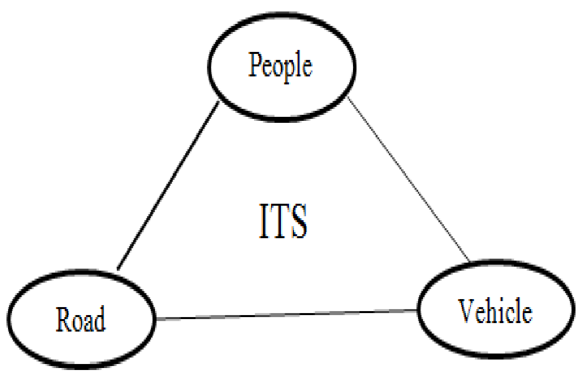
1. Introduction

Road transportation is one of the mostly used mean of transport used for daily life activities, it has been easier way for travelling of goods and passengers thus many citizens prefer to use it frequently. Even if it has simplified the transportation system but it suffer many problems that results from road crashes. Road crashes are a serious societal and public health issue. According to the World Health Organization (WHO), road crashes are the ninth factor worldwide for causing deaths. If the situation is not reversed, road crashes will rise to the third place in causing deaths by the year 2020[1]. Human factor is stated as a main cause of many road crashes, which include over speeding, improper overtaking, drinking and driving, overloading or poorly loaded and careless driving (N. A. O. Tanzania, 2012). Illegal and inappropriate speed is the single biggest contributory factor in fatal road crashes. It increases both the risk of a crash happening and the severity of injuries resulting from crashes. Managing speed is therefore the most important measure to reduce death and injury on our roads[2]. The concerned authority in transportation lacks real time information which can affect crash monitoring and death or injury avoidance. A more complex version of the mandatory system have been developed, including a capability to respond to current network and weather conditions, which would result in a reduction of 36% in injury accidents and 59% in fatal accidents[2]. Many studies have been conducted dealing with road safety and prevention and some modern technologies offers great improvement road infrastructure and speed management. Intelligent Transport Systems (ITS) provides the ability to gather, organize, analyze, use, and share information about transportation systems. In the modern world, this ability is crucial to the effective and economical construction and operation of transportation systems and to their efficient use[3, 4]. By developing intelligent transportation systems technologies, road vehicle systems can be safer, more efficient and more environment friendly. Most of these systems depend on sensors, communication, control, robotic and electronics. ITS technology is too large categorized and it used in most countries transportation infrastructure. Intelligent Speed Assistance (ISA) technology is one of the ITS systems used to provide real time information on the road, it provide a speed limit into the vehicle. Typically a use of Global Positioning System is applied which gives precise location and heading while the on board map database compares the vehicle speed with the location's known speed limit. Despite of the benefits and opportunities brought by ITS, the major problem is how to introduce them in developing countries with many challenges in network infrastructure and economic problems[5]. Speed Radar Detector and breath analyzer is mostly used in developing countries to monitor speed and alcoholic content, these are hand held Touch like devices which uses transmission of microwaves to detect the speed of the car and breathalyzer obtain amount of alcohol in the blood through inhaling .Therefore, these developed technologies were successfully designed and implemented to provide real time information on the road especially speed limit and alcoholic content. In this paper we will review ITS systems that already implemented and still in use, our objective will be aimed on speed limit and alcoholic detection, and at last we will come with recommendation on which system is suitable for developing countries.

2. BACKGROUND OF THE ITS TECHNOLOGY

The Intelligent Transport System is a worldwide phenomenon; it applies information and communications technologies (ICT) to the real-time management and monitoring of vehicles, transportation and all road users as a whole involving the movement of people, goods and services. It's an integrated system involving people, roads and vehicles designed to significantly contribute to improving road transport safety, efficiency and comfort, as well as environmental conservation and enhance productivity [6] as presented in Fig. 1 below.

Fig. 1: Basic concept of ITS



ITS was introduced during the 1980s, when technological development matched the expectations of vehicle, road and traffic control experts. Intensive research and development programmers started simultaneously in Europe (Prometheus and Drive) and in Japan (AMTICS, RACS). While efforts in the United States started somewhat later, development is now very rapid. Many systems and functions are already commercially available on the market in all three mentioned areas, although Japan is ahead in this respect [7]. Since then, the technology has done extremely good in the transportation sector. ITS as a whole is very large and complex, so to install it at once is very difficult even not only in developing country but even in developed countries as well. In most countries, including both developed and developing countries, the right approach is to introduce ITS slowly and in stages, concentrating first on the parts of ITS that provide the extreme value in proportion to the cost. Therefore, the successful introduction of ITS must include staging, and planning for change, growth, and on-going integration as new functions are introduced and existing [6]. Normally, ITS systems include:

- Vehicle-based system

This system includes on-board sensors that collect data and on-board units (OBUs) that issue warnings or take partial control of the vehicle. The advantage of these systems is that they can warn the driver of potential dangers or override and, to some degree, the driver's control of the vehicle in an attempt to avoid collisions [8].

- Infrastructure-based safety system

This system includes roadside sensors that collect information and road side equipment that issues warning and advisories. The advantages of these systems are detection of phenomena that on-board sensors cannot detect, such as weather conditions, obstacles and traffic around curves or in the distance [8].

- Co-operative system

This system employs both infrastructure-based and vehicle-based systems with communication links between them. The advantage of these systems is that information is received from the infrastructure (*e.g.* speed limits, traffic and road conditions) and provided dynamically at the appropriate time to individual vehicles [8].

3. GENERAL OVERVIEW OF AN ADAPTIVE VEHICLE SPEED AND ALCOHOL DETECTION MONITORING

Most automated speed enforcement systems incorporate both radar technology to determine vehicle speed and supplementary photographic equipment to record the speed and document information on the vehicle and breathe analyzer for obtaining driver's alcoholic status through breath taking. In some countries, speed radar and alcohol testers (breath analyzers) are very useful, although manual check-up is mostly used. Since these devices are not automatic in the sense that they would need to be manually operated by the traffic police, they lack the continuous monitoring of speed and therefore their efficiency in speed detection is low as many drivers tend to reduce speeds when they approach the traffic police or any checkpoints. For example, Intelligent Speed Adaptation (ISA) is an automatic system and one of ITS systems used to control vehicle speed within a limit and it's been used in many European countries with the highest safety prospective to reduce injury crashes in the whole road transport system [7]. It is a GPS based navigation system combined with on board digital road map. ISA is a type of system that just limits and alerts the driver on his or her behavior on the road. Although it is helpful, but some studies have found some drawbacks and one of them is the higher implementation cost. Due to this factor, many developing countries will not consider implementing it. Unit costs would be higher because of smaller production runs. Different systems with different standards might be implemented in various European countries, leading to reduced interoperability across Europe [9]. Also, another possible negative effect of ISA as stated by [8] is that it reduces driver attention and shorter headways. ISA cannot tackle the issue of inappropriate speeding below the speed limit and there will always be an area outside the zone where ISA is not available, which will affect drivers [10].

Alcohol detection and interlock system is another ITS system that uses alcohol testers (breath analyzers) into a vehicle and lock the ignition to start if any alcohol is there when the driver exhales. A review done by [11] expressed some drawbacks of alcohol detection and interlocks that it reduces over time,

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especially when the device has been removed from the user's vehicle. It must be reliable in order to be acceptable to users. The system can be vulnerable to circumvention and tampering, and on top that it is expensive to install and maintain. Hence, there is a need to implement an integrated system in which violation management provides efficient monitoring, registering and reporting system of speed of the vehicle when it exceeds the limit. The driving behavior of the driver is monitored based on penalty points are calculated. A message is sent to the remote station so that the police must be able to detect when a driver has exceeded that legal limit and once this is detected, the driver must be punished [12, 13].

4. REVIEW OF RELATED WORKS

Many studies on the deployment of ITS on road transportation have been conducted, especially in the aspects of speed limit and driving while drunk areas. Intelligent Speed Adaptation (ISA) is the generic name for advanced systems in which the vehicle "knows" the speed limit and is capable of using that information to give feedback to the driver or limit maximum speed [9]. As illustrated in Fig. 2, the ISA system is a GPS-based navigation system that is installed in a vehicle, and the vehicle itself would know its location and speed limit for that location from an on-board digital road map in which the speed limit for each link in the network has been encoded. This system can be implemented as an advisory device which simply reminds drivers of the prevailing speed limit and exerts no control over the vehicle. Next level is voluntary ISA, which limits the vehicle to the speed limit, but allows the driver to override the system. The highest level of control is termed mandatory; it exerts full speed control, usually with an emergency system failure function [9, 14]. It commonly has three elements to deliver the ISA technology, which are position, information and control elements, as illustrated in Fig. 4 below. For the ISA architecture, the vehicle should know on which road it is being driven, were on that road is it currently located and which direction along that road it is travelling, and for this functionality Global Positioning System (GPS) technology combined with map matching and dead reckoning techniques is used. A digital road map should contain all the road information and its limits which can be stored on devices like CD-ROM and should be updated. There is a Human Machine Interface (HMI), which is used to display the speed limit and thus a processing unit linked with control so as whenever the vehicle reaches a road limit it could control the speed limit according to that road limit. It can provide a recording mechanism also so as to identify when and where there was override and what the maximum speed was after the override [14].

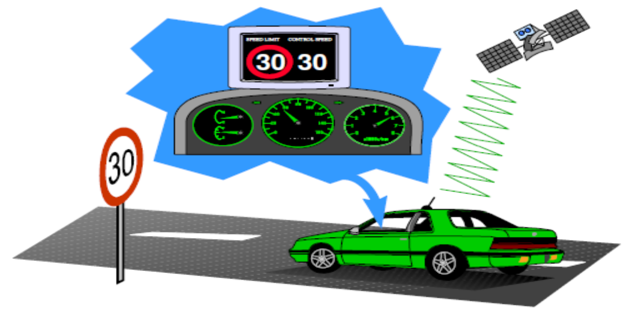

Fig. 2: Concept of ISA System

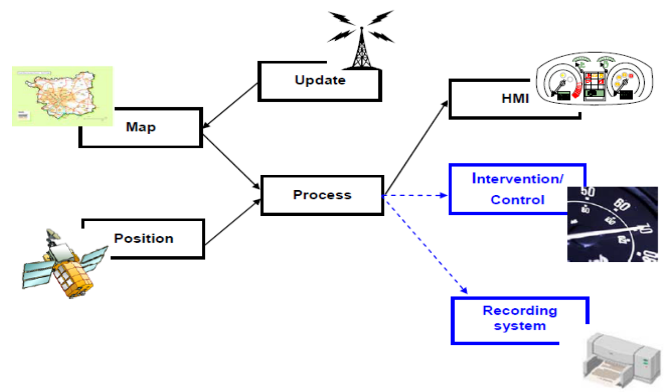

Fig. 3: Architecture of ISA System

Although the device is perfect in speed limit, it has some drawbacks. Carsten [14] stated that ISA will not be able to tackle the issue of inappropriate speeding below the speed limit. There will always be an area outside the zone where ISA is not available; this may have an effect on the drivers, and thus they may use the opportunity to make up perceived lost time or simply engage in thrill seeking behaviour.

Further interrelated systems have been developed to avoid over speeding related crashes as shown in Fig. 4, Rubini and Makeswari (2013) proposed a system that has alerting, recording and reporting features for over speeding violation management through the use of ZigBee. The Zigbee transmitter and transceiver is used, in which the transmitter sends the speed limit and a receiver unit placed in vehicle receives the messages and sends to the microcontroller. When the speed of the vehicle nears the speed limit, it displays the warning and if exceeds the limit, the microcontroller records the violated speed and time. The LCD displays the lane speed limit and shows the number of times speed was violated. A GSM module sends a message to the nearest traffic personnel immediately after a violation occurs [13].

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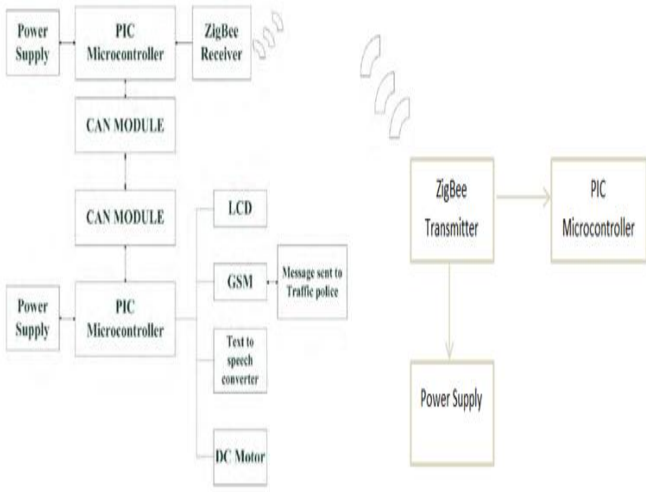

Fig. 4: Block diagram of Transmitter and Receiver section

The use of ITS expanded broadly and many systems were developed and implemented. Another system proposed by [15] is a model for tracking vehicles over-speeding in Tanzania, upcountry buses in particular. The proposed system constantly tracks buses in real time and updates the central database as illustrated in Fig. 5. It promptly pops up warning messages in case of over speeding for appropriate action. They make use of Global Positioning System (GPS), Global Positioning Satellites and Global System for Mobile communications (GSM) technology in delivering its services.

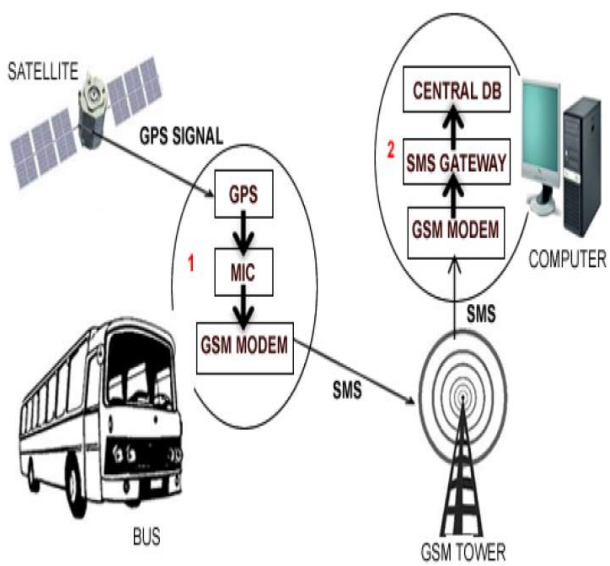

Fig. 5: GPS-GSM based over speed vehicle tracking system

In the alcohol detection part, ITS is also involved. A device used to detect alcohol content through breath is Alcohol Detection Advisory and Interlock System was introduced in order to reduce the crashes caused by drinking and driving. This system is installed in the vehicle to prevent a driver impaired by alcohol from operating the vehicle. They consist of a detection device, designed to detect and measure the driver's BAC, which is connected to the starting system of a motor vehicle. Once the detection device registers a BAC that exceeds a predetermined limit, it will prevent the vehicle from starting. This limit value is typically lower than the BAC limit set by justice authorities for drinking and driving offences [12].

Dai, J., et al (2010) developed mobile phone based drunk driving detection. They used a mobile phone, especially smartphone to detect the drunk and driving cases as they designed an algorithm that analyse the drunk driving related behaviour and extract its fundamental cues based on lateral and longitudinal accelerations of the vehicle, which are determined by the accelerometer and orientation sensor readings in mobile phones [16].

The work done by Mohamad., et al (2013) proposed a Vehicle Accident Prevention System as shown in the block diagram of the system in Fig. 6. They embedded with Alcohol Detector, MQ-3 alcohol sensor integrated with microcontroller as well as ignition system circuit so as whenever alcohol is detected the microcontroller will command the ignition not to start [17].

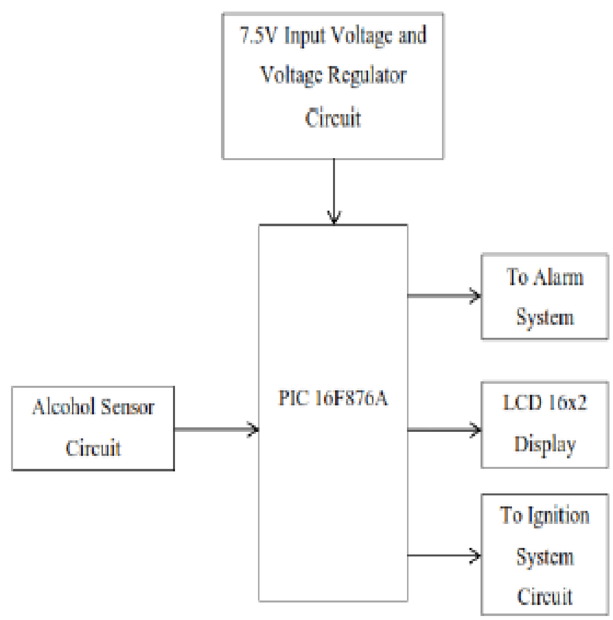

Fig. 6: Vehicle Accident Prevention System Embedded with Alcohol Detector

5. Deployment of ITS in Adaptive Vehicle Speed and Alcohol Detection Monitoring Systems

Road transport telematics and intelligent transport applications (ITS) contribute much to decrease in unacceptably high human and economic toll from road crashes. This system not only deals with component monitoring, it does even more than that including passenger activity monitoring, behavior analysis, system behavior, notification and co-ordinate. In the remote monitoring environment, it is crucial to provide fast, reliable and on-time responses when dealing with unexpected road events. It is essential to develop systems actively monitoring driver's operating situations and alerting of any insecure conditions to prevent accidents. It is preferable that the monitoring system satisfies the following requirements: a real-time monitoring system with quick response; a reliable system performing accurately; a non-intrusive system and a low cost system [16]. Intelligent systems are in use with every aspect of systems. Vehicles are the critical systems which are real time and lives are involved. These are the most significant high-level and general requirements to be fulfilled by the system.

5.1 Characteristics of Good ITS System

It has been reported in [5] that the successful introduction of ITS must include staging and planning for change, growth and on-going integration as new functions are introduced and existing functions evolve. Good ITS systems that are capable of developing and growing effectively have a number of necessary characteristics in common, as listed below [18]:

- *Compatibility* - Compatibility means that when software or hardware components in a system are replaced or upgraded, the system will still work; on other hand, it is the capacity for two systems to work together without having to be altered to do so. Consistent specifications of functionality and of the interfaces between components provide great aid compatibility [5, 19].
- *Expandability* - Expandability means that a system can be successfully upgraded to handle greater volumes of work, operate in additional locations, or incorporate new tasks. The issues of expandability and compatibility have many points in common. Expandability depends on many factors, including good system design and component compatibility [5].
- *Interoperability* - Interoperability means that two separate systems can be linked to work cooperatively and without interfering with one another. Interoperability can be an issue for multiple systems used by a single operator, but it is a much larger challenge when connecting two systems from different operators, regions, or countries. If both systems were developed under the same overall system architecture and were developed conforming to the same standards, the likelihood of success in making the systems interoperable is greatly increased [5].
- *Integration* - One approach to providing interoperability is to integrate applications into a single system. Integration is the mutual connection and harmonization of multiple systems. Integration can be an effective approach, especially when planned in advance. When a single integrated system is built to provide multiple applications, there can be significant savings in development time, effort, and cost as compared to building each application separately [4, 5].
- *Standards* - All of the necessary characteristics of successful ITS systems listed above are easier to achieve if the developers and deployers make use of good standards. It is through standards that data models, interfaces, and functionality are made consistent [4].
- *Cost Effective* - Any developed ITS system with all the characteristics stated above can perform very well, but it also needs to consider that an end user of the system can afford to implement and make use of it. The system must optimize the ratio of costs in relation to output with regard to meeting objectives; costs must include operations and maintenance costs [18].

5.2 Adaptive Vehicle Speed Monitoring System Integrated with Alcohol Detector for Public Buses

As road crashes are increasing and causing many deaths and fatalities, the reason behind these crashes is driving while drunk and is a problem that is widely acknowledged. In developing countries, the proportion of serious injured and killed casualties is higher than in the developed countries [20]. In most countries, public condemnation of drunk driving is increasing and is one of the major factors causing road accidents. Speed, however, is still a sacred cow for many people and consequently for policymakers. Speed influences both active and passive safety in an exponential or accelerated way which is one of the reasons why it is such an important variable in road safety work. In many studies regarding speed monitoring and alcoholic detection, several systems have been developed to overcome these problems, but some have shown a weakness on solving the problem. There is a need of a system that can overcome the limitations of the other speed adaptation systems, reduce the memory requirement of conventional GPS speed adaptation techniques, reduce the system cost, enhance the system performance to a provide dynamic update of information, and provide a remote monitoring system. An adaptive vehicle speed monitoring system integrated with alcoholic detectors is capable of monitoring vehicle speed and provides alcohol content from the breath of the driver along the journey. It can also provide location and other information stored in a central control unit for record purpose. Remote monitoring is also possible with this system as it makes use of either a smartphone or website on internet. There is even the possibility of alerting a respective authority or traffic police for any breach of traffic rules done throughout the journey, and furthermore the driver could get punished according to the country's law.

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5.3 Components and Methods Used

Most of the systems use commercial hardware to allow the attainment of data from several sensors (alcohol, seat belt sensors, etc.) and remote devices placed in the vehicle as on-board equipment so as to acquire the data regarding the vehicle and driver behavior on the road. These devices can communicate with the control room through communication media that will also allow remote monitoring capability.

5.3.1 Components Used

These systems, mostly divided into three parts, which are on-board part, control part (database), and communication part. Each part has its duty to perform accordingly when in use. On-board parts are elements that are implemented in the vehicle so as to issue warnings or take partial control of the vehicle and intended driver on the road. They consist of remote devices such as GPS so as to track the location of remote vehicles. An on-board part typically consists of GPS receptor and communication equipment, such as a mobile telephone or a radio device. A communication device allows the system to communicate with remote GPS devices using wireless media. Example of these components is GSM Network, ZigBee etc. *Geographic Information System* (GIS) visualization component shows locations and routes on digital maps. It also offers the typical map-management functions and consists of information, control and on board sensor units. These units are integrated with on board unit (OBU) used to monitor car and driver behavior while driving; thus it is the information unit used to receive road map through GSM network from control centre that can guide the vehicle accordingly about road limits. Control unit comprise elements that are interlinked with some or all of the elements of the vehicle's power train: throttle, ignition, fuelling system, gearbox and brakes [8]. The route storage component stores the locations from a particular remote vehicle in the database using the persistent component, thus building a route, which can then be visualized or analyzed [18]. Communication system is used for communication between the vehicle and the outside world. It links the on board unit with the control centre and also to the respective authority (traffic police) if in case any breach is reported. The communication means mostly used is the GSM network through SMS feature which is reliable and has widely covered network, beacon based short range communication (infrared, microwave), broadcasting (Radio Data System and, Digital Audio Broadcasting), and the satellite communication is also used [7]. The persistence component is also vital in the system. All the components and applications of the system need some persistence for their data, as they need to store the locations they receive or generate for further analysis. Usually, this persistence is provided by a database manager. The components can be combined in order to build different systems. They should be able to solve different kinds of problems and act as distributed GPS data collectors, local area control centres or headquarters control, or provide distributed management of the same GPS data [18].

5.3.2 Method Used

5.3.2.1 System Operation

To operate and implement systems, interfacing and hardware configurations should be properly set to reach the desired goals. Most of the automation systems operate by means of taking input and processing to deliver output and as soon as the output is delivered, it will start performing the operation according to that output. Fig. 6 above shows a block diagram of the estimated systems which is divided into two portions, vehicle part and user part.

Vehicle Part: To acquire data, the following hardware are used in the vehicle: a programmable microcontroller that acts as an interface between the sensors, GPS, control unit, information unit and a GSM modem. The use of programmable microcontroller is to control all the devices integrated with it and perform any action commanded by it. The communication between the vehicle part and the central system is through two types of GSM modem: the transmitter and receiver modem for sending information regarding driver and vehicle behavior to the central server.

User Part: Information regarding speed, location, and alcoholic status gathered by the prototype will be presented to the users through the web and mobile application that requires an internet connection. Users could also get real time information on monitoring the vehicle without an internet connection, through SMS service.

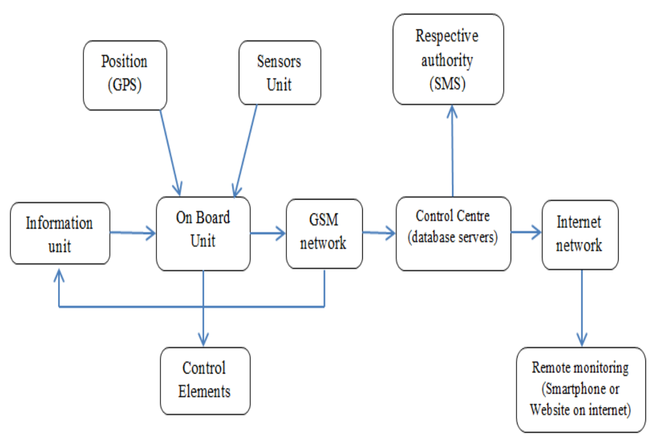

Fig. 7: Block Diagram for vehicle speed monitoring and alcohol detection system

Fig.7 above represents blocks of the different implemented vehicle speed monitoring and alcoholic detection systems. Most of the systems use a remote device like GPS to be used to locate and find out speed status of the vehicle; thus for an adaptive system, there is need for road information that will know the speed limits. On-board unit is used to control all functions as well as a command control unit to control the vehicle speed according to the limit. Some sensor unit is available, especially alcoholic sensor for obtaining alcoholic content in breath at the start-up of vehicle; the sensed signal is received, processed and interpreted into useful information by on-board unit. This information is then sent to the control centre through the use of GSM shield. According to information captured, it can just be saved into a database or can trigger database to send Short Message Service (SMS) to a respective authority or nearby traffic police to alert them the event of upcoming vehicles. Remote monitoring is also possible through a smart phone or website on the internet.

6 CONCLUSION AND FUTURE DIRECTIONS

This chapter has reviewed the implementation of ITS in an adaptive vehicle over speed and alcoholic monitoring systems. It can be noted that reducing road accidents is necessary. For effective reduction and control of road accidents, the current measures should be enhanced by more sophisticated ways. One among other parameters to ensure road safety is through limiting vehicle speeding and drunken driving and provide real time information that could track a vehicle all through the journey. It is strongly recommended to have a system that actively monitors driver's operating situations and alerts any insecure conditions to prevent accident. A system which provides a real-time monitoring with quick response, a reliable system performing precisely, a non-intrusive system and a low cost system should be implemented so as to avoid road accidents. But also the functionality of the systems must be improved so as to enhance reliability and efficiency.

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