INTELLIGENT TRANSPORTATION SYSTEM AS AN EFFECTIVE REMEDY TO IMPROVE THE PUBLIC TRANSPORTATION IN SOUTH AFRICA

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ABSTRACT

South African transportation is generally observed as uncoordinated with hitches and pitfalls. The ease of public transportation movement is highly dangerous with unguaranteed safety and comfort. Despite the funds budgeted for public transport restructuring and management in South Africa running into billions, the situation is still left exasperated. However, the solution to the transport system is rather a long-term infrastructure plan in which improvement can be achieved in a piece meal manner. This study provides a solution to the challenges faced in public transportation by improving the public transport system via application of Intelligent Transportation System (ITS) to improve safety and reduce congestion resulting to a sustainable and efficient transportation system. Quantitative analysis was carried out on public transportation vehicle owners, drivers, public transportation users and non-users within Free State to assess the current state of public transportation that could potentially be solved by ITS and the challenges likely to be faced. The use of questionnaires was used to assist in identifying elements needed for successful integration of ITS into South African Public Transportation.

1 INTRODUCTION

Advancement in technology initiates the need for improvement in transportation over time due to the trend in global urbanization and sustainable development. However, advanced technologies are utilized to improve the transportation systems under the aegis of Intelligent Transportation Systems (ITS). In such cases, performance measures, which consist of a set of productivity and service indicators, help decisions on transportation resources, their use and allocation (Xu et al, 2002). Intelligent Transportation System refers to the integration of various advanced communication, sensors and computing technologies to infrastructure and vehicles to improve efficiency, safety, convenience, and comfort of travel (ITS Joint Program Office, 2009). It is however imperative to relate Intelligent Vehicles with Intelligent Transportation System since both are dependable on each other.

The idea of automated driving dates back more than 50 years, when General Motors (GM) presented a vision of “driverless” vehicles moved under automated control at the 1939 World’s Fairs in New York (Lay et al, 1996). In the late 1950s, research by industrial organizations conceptualized automated vehicles controlled by mechanical systems and radio controls. After the first appearance of computers in the 1960s,

researchers began to consider potential uses of computers to provide lateral and longitudinal control and traffic management. The fully automated highway concept was initially examined by GM with sponsorship from U.S. Department of Transportation (DOT) during the late 1970s. In this period, the focus was placed on automated vehicles operating on a highway, because the computers were not powerful enough to consider a fully automated highway (Cheon, 2003). The Automated Highway System (AHS) concept defines a new relationship between vehicles and the highway infrastructure. AHS refer to a set of designated lanes on a limited access roadway where specially equipped vehicles are operated under completely automatic control. AHS use vehicle and highway control technologies that shift driving functions from the driver/operator to the vehicle (Cheon, 2003). Decades upon decades passed on and the need to further incorporate ITS into road vehicular communication system became paramount especially in developing countries (Guchan, 2016). Intelligent vehicles as important components of ITS makes use of system and programmed sensors to monitor, perform, control and take decisions via written algorithms. The use of these on the road way helps to improve communication between the driver and vehicle in operation. Inefficiencies in the public transportation system in the Free State province resulting in poor quality public transportation has led to the investigation of Intelligent Communication Systems to improve the public transportation system, through integration, and the challenges and opportunities that may result from this integration (Bashingi, 2016). South Africa is lacking in this regard as a result has led to the increased traffic congestion, increased travel time, delay as well as increased mortality rates due to road accidents and poor communication between the road users.

1.1 SOUTH AFRICAN PUBLIC TRANSPORTATION SYSTEM

South Africa's economy was originally based on agriculture and mining. This has changed over the years with services and manufacturing now contributing the greatest share of GDP. The South African white paper on transportation system (White Paper, 1996), is insufficient to meet the basic accessibility needs to work, health care, schools and shopping places in the developing rural and urban areas. Although, It's vision states that South African transport is a system which will: "Provide safe, reliable, effective, efficient, and fully integrated transport operations and infrastructure which will best meet the needs of freight and passenger customers at improving levels of service and cost in a fashion which supports government strategies for economic and social development whilst being environmentally and economically sustainable" (White Paper, 1996). Bus rapid transit (BRT, BRTS, busway, transitway) is a bus-based public transport system designed to improve capacity and reliability relative to a conventional bus system. Bus rapid transit (BRT) is a broad term given to a variety of transportation systems that, through improvements to infrastructure, vehicles and scheduling, attempt to use buses to provide a service that is of a higher quality than an ordinary bus line. The BRT is expected to play a leading role in transforming public transport within cities to a situation where it will become the preferred mode of travel for most residents and will make a major contribution towards the more efficient development of the city. Nelson Mandela Bay Metropolitan Municipality, Eastern Cape, South Africa, undertook a project to purchase 60 metro buses to be integrated into the public transport system. The project started in 2008 at a cost of R2 Billion (approximately $130m). The buses were purchased in 2009 as part of a program to refresh municipal bus service in Port Elizabeth, South Africa. Though the fleet was used during the 2010 Soccer World Cup, they were parked as soon as the tournament was over. Six years down the line,

they remain idle and gathering dust (Venter, 2017). “Challenges in the project have also resulted in significant turnover in key resources working on the project. Local news reporters note that from 2008 to 2013 the project has been through five different Engineering companies and four Project Managers. Such turnover compounds the problems in a project as decision-making gets reset each time a new person or organization joins the team”. Over the past eight years the South African government has spent more than 130 billion rand on public transport projects in the country’s main cities. The projects included the refurbishment of rail services and the establishment of a new rapid rail and Bus Rapid Transit (BRT) systems. This is a lot of money by any standards. As a percentage of gross geographic product, South African cities devote about twice as much money to transport as other developing countries, and as much as four times more than some regions of the world. The solution to improve the South African transportation system is with limited or no improvement. Furthermore, except policies makers, stakeholders, government and industries find a way to bring people together closer to where they live, work and play by developing residential houses, work place and access to health facilities along transportation routes. Then improvement will be positive. This can also be achieved through mixed land use (Venter, 2017).

According to the vision statement of The Department of Transport on Integrated and Sub-Sector Broad-Based Black Economic Empowerment (B-BBE) Charters of Transport in South Africa “Transportation is the heartbeat of South Africa’s economic growth and social development” (Delwyn Verasamy, M&G 2013). The South African National Taxi Council reported that “the South African taxis transport approximately 15-million commuters daily and this consists of 60% to 70% of the commuting public and workforce” (Delwyn Verasamy, M&G 2013). The transportation industry is plagued with health and safety issues and a track record of death and poor driving. Consequently, the South African Institute of Race Relations report, released in 2012, stated minibus taxi death rate was 27 deaths per 10 000 vehicles and three times higher than the nine deaths per 10 000 for motor cars. Yet they are still statistically safer than cars. This report indicates the need for drastic improvement in the public transport system.

In South Africa it is at a very critical stage where authorities are gaining momentum and allocating resources to implement new strategies and initiatives to potentially improve the public transportation (van Ryneveld, 2008). The deployment of Intelligent Transportation System can be used to provide positive results. Major factors affecting the quality and development of public transportation such as reliability, safety, convenience could be resolved gradually by integrating ITS into the public transportation system. ITS has improved safety, convenience, reliability and quality of the system in places such as London and New York; this is through applications such as NXTBUS and availability of on- street information display screens (Using NXTBUS-ACTION Buses, 2015).

2 INTELLIGENT TRANSPORT SYSTEMS: ROAD FURNITURE

The growth of South Africa’s economy is dependent on the successful delivery of a comprehensive and integrated transport system for the country (Mzansi Empowerment Network, 2011). Experimenting ITS on vehicles brings about multiple concerns. Interest in the intelligent system comes from problems caused by traffic congestion and a synergy of new information technology for simulating real-time and communication networks. Intelligent Transportation System is designed for the urban, state or private road transport organization (Mallik, 2014). This primarily consists of a hardware component to provide an integrated solution for the driver console unit,

electronic ticking machine, passenger information system amid vehicle tracking system. This further provides a single solution for monitoring vehicular schedules with the advent of modern technology such as; GPS, Wi-Fi, and GPRS. The impact of the application of ITS in-highway transportation is therefore vital in improving growth of public transportation system in South Africa.

2.1 Road User System

In recent times, there has being a saturation of the transportation infrastructure due to the induced growth of vehicles caused by increasing population growth rate. This situation affects the standard of living especially in developing cities where traffic congestion, transportation delays, large vehicle pollution emission, accidents cause a menace. Nevertheless, presently, building more roads to reduce traffic congestion is not the right solution to improving public transportation system (Figueiredo et al, 2001). Rather, the ability to exploit emerging intelligent transportation system technology and modern-day vehicle systems, results in an efficient and environmentally friendly road system, using Navigation Display screens in the vehicles to assist drivers, on Screen Display Board to inform drivers with information within the vehicle to assist performance and functionality of the vehicle. This relies largely on data log information on electronics, control, and communication system, sensing devices, robotics, signal processing and ICT within the vehicle and outside the vehicle.

2.2 Automated Transport System

Automated Transportation System (ATS) is a global phenomenon, attracting worldwide interest from transportation professionals, automotive industry and political decision makers. ATS is a system of optimization of the overall transport efficiency performance with focus on connected collaborative self-driving vehicles by taking advantage of new possibilities for efficient communications and computing, accurate position estimation and smart decision systems (Wahlberg, 2016). This also involves application of advanced communication, information and electronic technology to solve transportation problems; traffic congestion, safety, efficiency and environmental conservation. The purpose of ITS in South Africa, aims at taking advantage of modern appropriate technology to create intelligent roads, smart vehicles and users. One major impact incorporating Automated Transport system into public road transportation allows communication with ground stations to acquire traffic conditions for route planning. However, ITS is expected to optimise transportation network performance and further improve the reliability of travel times which will lead to changes in travel behaviour that may reduce externalities such as unreliability and congestion (Pendyala and Bhat, 2012). The synergy between South African roads and vehicles considering ATS is essential for promoting vehicle to vehicle safety; i.e. communication between vehicles on transit with other vehicles to alert the driver or vehicle user on possible dangers, actions taken while driving on the road which may affect other vehicles to avert collision and to provide accident free journey on every transit taken. DSRC (Dedicated Short-Range Communications) is a short to medium range communications service that supports both public safety and private operations in roadside to vehicle and vehicle to vehicle communication environments can be implemented (Xu et al, 2004). It is meant to be a complement to cellular communications by providing very high data transfer rates in circumstances where minimizing latency in the communication link and isolating relatively small communication zones are important within the road way system (Xu et al, 2004).

2.3 Survey Data Report on Traffic Congestion

A survey was performed within the Free State Metropolis where questionnaire was distributed to taxi drivers, bus drivers as well as passenger car drivers. The survey also included participants from the department of Roads and Transportation to have precise information as well as reaction behaviour of the different individuals. According to the survey, one of the respondents from the department of Roads and Transportation indicated that improvement on the public transportation can be achieved using implementing Information Technology Devices in Synchrony with vehicle systems. Furthermore, schedule in vehicle delay on public buses should be provided as there is a 0% vehicle delay data log display screen along commuter bus transportation routes. Another respondent noted that one major problem associated with the Public Transportation system was due to the lack of integrated ticketing system and taxi fare payment. In conclusion, respondents from the participants noted that only the Interstate buses make use of the ticketing system which constitute 35% of public transportation and recommended that this system should be applicable to all modes of transportation.

2.4 Transport Infrastructure System

Infrastructure systems are integral to the proper functioning of all modern economics. Investments to provide reliable and resilient national infrastructure facilitate economic competitiveness and positively impact growth (Egert et al, 2009). Cities exist and thrive because they enable people to access each other. Thus, they depend on a good transportation system, as confirmed by the strong impacts of transportation infrastructure on both economic growth (Gramlich 1994) and urban structure (Giuliano 2004). Furthermore, there is little doubt that, at least in a city of any size, a healthy economy requires a transportation system that includes both private and public modes, since neither alone can possibly accommodate the enormous variety of trips that such an economy generates.

2.5 Data Collection and Analysis: Quantitative Survey on ITS in Free State South Africa

Data collection was acquired in a custom of interview questions and short questionnaires to procure evidence from every individual who makes use of transportation facilities seeing that this affects everyone in transit and movement from one place to another as discussed previously. The interview questions and questionnaires were emailed to the different participants from different sectors within Free State to familiarise themselves with the interview questions before the interview took place. The interview questionnaires were personally delivered to some of the participants and if the opportunity presented itself, some interviews took place upon delivering these questionnaires and interview questions. Before the formal interview, participants had to complete the short questionnaire. The interviews were conducted in an international language understood by everybody (English Language). A letter of confidentially accompanied the interview questions and questionnaires. Participants were made aware of the reasons for this interview. The instrument consisted of three sections. The sampling population was made up of One hundred and sixty-two (162) participants whom 97.5% participants responded. The respondents included all classes of workers in Free State from Professors, managing directors, stake holders, students, lecturers and to labourers. 2.5% did not respond. From the interview conducted, it was observed that 54% of the respondents were

males while 44% were females. From the survey conducted, 69.8% of the respondents make use of public transportation while 29.6% make use of private transportation system. Although, 27.5% of the respondents agreed that it was a cheaper means of transportation compared to having a vehicle following other factors inclusive of environmental concerns. However, affordable the public transportation is, 8.3% responded it was not easily accessible, while 11.9% responded that is was not convenient. Hence the need for improvement.

From the survey conducted, 16.5% are satisfied with the current state of the Public Transportation System. However, 50% of the people who were interviewed and who completed the survey are aware of Information Technology System and computing literacy, while 43.8% of the respondents do not understand Information Technology System, internet computing and its application in day to day living. From the survey conducted, 63.6% indicated the relevance of ICT in public transportation while 20.4% agreed that introduction of ICT will be relevant in providing accessibility information on public transportation routes. However, 65% of the public transport users opt for the taxis, which is more flexible and more accessible than the buses.

ITS, is a sustainable concept to the South African developing system, and acceptance of this concept is not automatic. This is supported by, (Hu, Chiu and Shelton, 2016), by stating that Advanced Traveller Information Systems (ATIS) provide generic information to travellers and leave it to them to react to it in their own ways. Thus, accurate and useful information to transportation decision-makers, providers and users throughout the state must be explicitly communicated. The value of ITS in enhancing the safety, efficiency and convenience of transportation must be actively promoted. Although, many different strategies and techniques exist for marketing ITS which can be incorporated into South Africa transportation guideline to generate a framework of a sustainable reliable and safe public transport system.

3 ITS IMPLEMENTATION PLAN IN PUBLIC TRANSPORTATION

A theoretical framework is presented to lay out expectations for the integration process as well as deployment of technologies and adaptations to the new integrated public transportation system based on technology acceptance within the Free State. The application of Intelligent Transportation technology system to traffic signals and control to enhance safety and mobility while reducing hazardous environmental impact aims to facilitate a multi-modal surface transportation featuring a synchronized transportation system of all vehicles types, configuration and probable driver response behaviour to maximize safety and environmental performance. From the survey carried out, the respondents agreed that installing digital map and route display screen will assist in improving ITS on the road ways. 32.1% of the respondents agree that the condition of the public vehicles are in a poor state, not convenient and hence have no reason to make use of it. ITS in this study thus offers a scope for integration. However, arguments have proven that it is only through integration of ITS components that full impact can be achieved (Mallik, 2014). Although, ITS relies on a wide range of technologies and communication functions such as: Infrared, internet Wi-Fi (Wide Area network, Local Area Network), Bluetooth; Geographical location and information System; Data Acquisition and Exchange System; Camera and Artificial Vision System; Moving Object Detection and Classification System; In-vehicle and Digital Mapping Systems; to provide sustainable transportation potentials and safety modes.

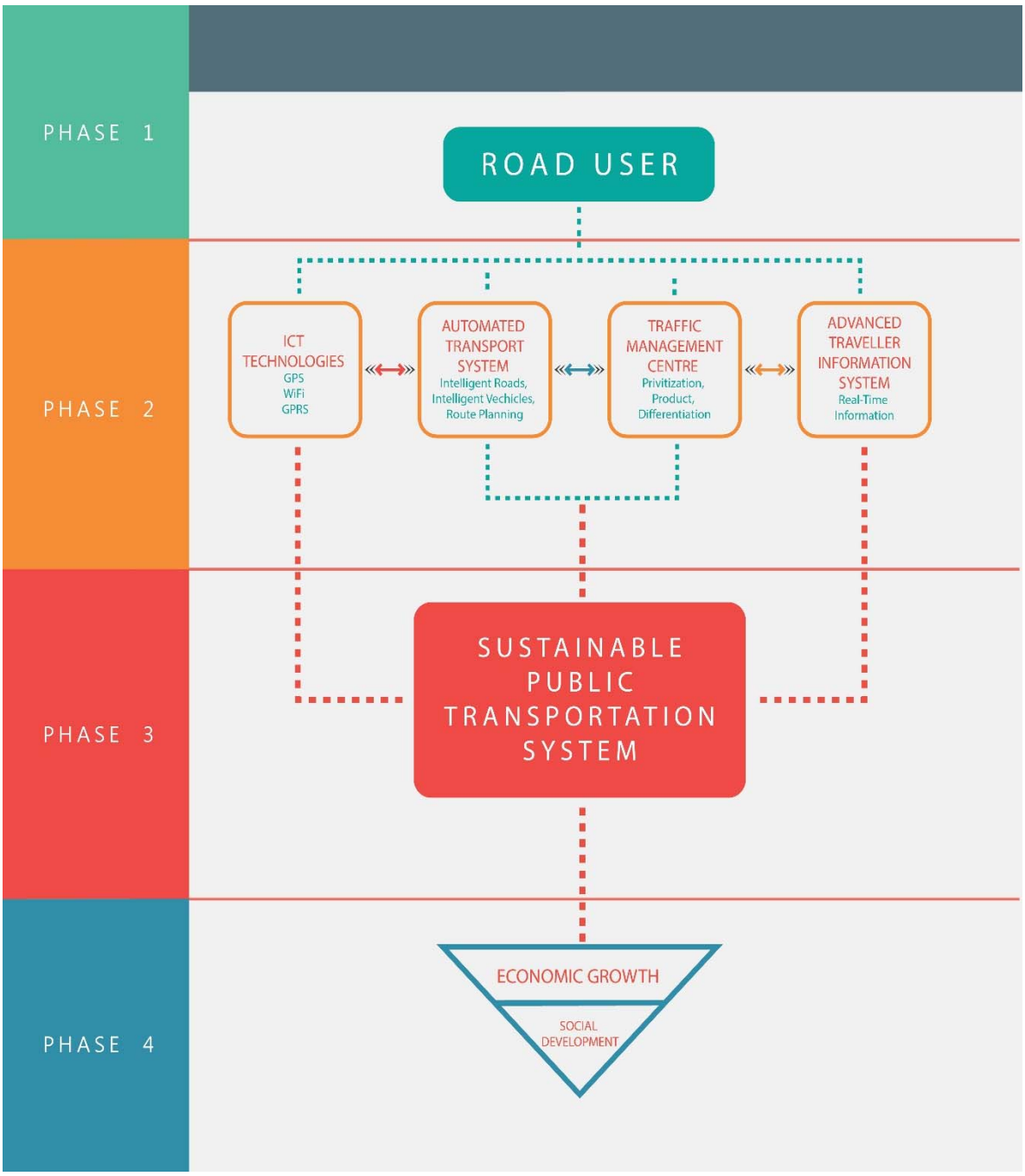

Figure 1: ITS Framework Implementation to Public Transportation System.

3.1 PHASE I: Road User

Passengers sometimes do not make the right travel decisions due to lack of information and sometimes they find themselves in situations that could have been avoided had the public transportation owners communicated with them in time (Nunes et al., 2014; Minhans et al., 2015). Road user eligibility via driver license requirement and experience must be on point to ensure that drivers of the vehicles; either smart or analogue are fully experienced and certified to use the road facility and are well learned to understand traffic signs, traffic signals and digital display information board tools on the road way.

3.2 PHASE II: ITS Technologies

Cohen et al., (2002) defined Information Communication Tool (ICT) as “a collection of electronic technologies, applications and services which facilitate the processing, storage, transferring and sharing of information, improving the performance of information related human activities provided by and benefiting the private and public sectors as well as the general public”. South Africa as a developing country has experienced the emergence of a competitive ITS sector over the years, producing one dominant fixed-line operator, Telkom and five mobile owners (MTN, Virgin Mobile, Telkom (8ta), Vodacom and Cell C) (Gillwald et al., 2012). Survey carried out in 2012 by Research ICT Africa, South Africa shows that the use of fixed – line internet is decreasing while mobile internet use is increasing as 86% of respondents said that they used mobile internet (Gillwald et al., 2012). ITS and Transportation as far different disciplines are becoming closer as a result of improved infrastructures and advancements in technology, and their relationship is expected to grow rapidly in future (Thomopoulos et al., 2015). ITS can be seen as an enabling factor to the public transportation system as it offers tools to the sector which can help reduce costs, increase responsiveness and improved decision making by stakeholders (Nair and Devi, 2011). Improved ITS infrastructure, ITS components such as smartphones, travel applications and social networking have over the years improved the way transportation systems operate.

3.2.1 Traffic Management Centre

Traffic Management Centre (TMC) is a system where data is collected, analysed and combined with other operational and control concepts to manage the data obtained in complex transportation problems. This will be accomplished through sharing of transport infrastructure responses amongst various state administration transportation agencies through a network of traffic operation web server centres. And data cloud storage systems, where loads of information is gathered and linked with data users and analyst to resolve, simulate and provide real time response to drivers within the road infrastructure as they drive.

3.2.2 Advanced Traveller Information System

Advanced traveller Information systems’ main focus is the provision of real-time information to travellers, mainly drivers. They provide information on traffic situations, congestion levels, accidents and delays on a specific route the driver is travelling on (Ezell, 2010). ATIS have also been proven to be a factor affecting travel choice behaviour of commuters (Sun et al., 2014). The incorporation of travel information can also be provided in South Africa through mobile applications available on Google play, Appstore and Blackberry World, social networks such as twitter and direct telephone services from owners as it’s already in use within the Netherlands. Information offered by 9292 includes maps, public transportation fares of all the available modes of public transportation (9292.nl, 2015).

3.3 PHASE III: Sustainable Public Transportation System

Sustainable mobility "Satisfying the needs of the current generation without compromising the ability to satisfy the needs of future generations", WCED (1987) is therefore the mobility model that enables movement with minimal environmental and territorial impact. The result of the cumulative impact of PHASE I and PHASE II,

incorporating ITS technologies and implemented, should be effective enough to improve the South African public transportation system and result in efficiency and visible improvement in Public Transportation. The indicators should reflect in; reduced waiting times, availability of Real-Time information, and lastly a significant increase in several people using public transportation and less private vehicles on the roads. Following the developed guidelines and considering factors therein, should help decision makers and other public transportation stakeholders to start planning for ITS integration and eventually implementation.

3.4 PHASE IV: Economic Growth and Social Development

Sustainable development is an approach to economic planning that attempts to foster economic growth while preserving the quality of the environment for future generations (Basiago, 1999). The implementation of ITS resulting to Sustainable Public Transportation system will result to maintaining a standard growth rate of wealth creation through evolving innovative job creation to empower human development in productivity, equity and reduction of bio degradation of the environment. Social development will result to a system which alleviates poverty through optimum resource usage, prioritized resource allocation equitable resource distribution.

4 PROPOSED GUIDELINES FOR EFFECTIVE IMPLEMENTATION OF ITS IN SOUTH AFRICA PUBLIC TRANSPORTATION SYSTEM

Intelligent Transportation Systems (ITS) as an established route to resolve, or at least minimize traffic problems should be developed on strategies based on the geographic, cultural, socio-economic and environmental background to integrate the various components of ITS into an interrelated system; using location-based broadcast protocol based on repetition coding as first proposed by Xu et al, 2004). The growth of ITS will be facilitated by the ever-improving electronic technology, improved and more accessible internet connectivity. The development of the internet and wireless communication, especially mobile phones revolutionised communication (Maritz and Maponya, 2010). Internet connectivity has become the spine to implement ITS and it is very important in the transportation sector as a communication mode. As indicated by Michael Clausecker during the proceedings of the 2012 International Transport Forum, connectivity is the key to increased demand for public transport (OECD 2012). From the ITS Strategic Plan Framework as shown in Figure 1, the efficient improvement of the South African public transportation system can be achieved in the FOUR (4) PHASES as indicated. The gradual implementation of this process in a step by step process will result to economic growth and social development of the nation.

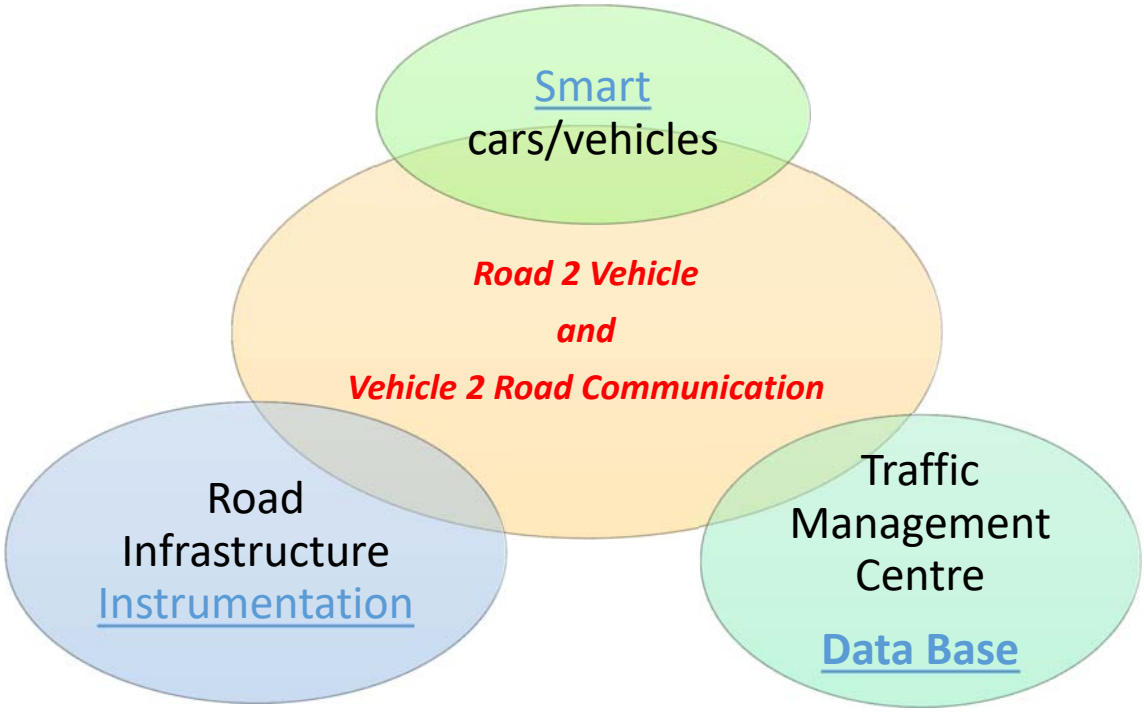

Figure 2: ITS Strategic loop plan for Public Transportation System.

However, many challenges could be encountered just to mention a few; insufficient funds to promote development, acceptance of new/modern technological change, familiarization and adapting to global technological changes. These challenges can be overcome through government budget on strategic infrastructure funding to improve the road transportation system by building new roads where necessary, rehabilitation as well as incorporation of Modern Technology i.e. ITS into the design, construction and maintenance of road infrastructure by employing other fields of study and expertise in job creation. The adoption of location and information-based technologies into vehicles (Navigation and GPS Tracker System), infrastructure design and construction, traffic data management and traveller information service will foster dramatically great improvements in the safe and efficient mobility of people and freight in the South African Public Transportation Sector. The Figure 2 above shows a strategic plan for incubating ITS technology system in South Africa. The Diagram shows the inter relationship between the Road Infrastructure, road user, vehicle and the traffic management centre. In Shanghai, buses have real time communication devices, which allow communication between vehicles, owners and the infrastructure (roads and bus stops) which allows for monitoring of the vehicle driver behaviour, passenger numbers and location of the vehicle. This system is called the 'bus smart information system; also available are information screens on buses and at bus-stop signs, predicting how much time is left for the next bus to be at a certain bus stop (Karlenzig, 2011). In Oslo, Norway there are more than seven hundred electronic display screens showing real-time information on expected arrival times of different modes of public transport (Weber et al., 2014). In conclusion, each transportation mode involves important policy decisions about the extent of capital investment, the level of service provided, and the financing and pricing of that service (William and Kenneth, 2007). The implementation of ITS Strategic Plan into South African Public transportation system will significantly improve passenger and freight transportation.

5 CONCLUSION AND RECOMMENDATIONS

The major objective of ITS is to evaluate, develop, analyse and integrate new sensor, information and communication technologies and concepts to achieve traffic efficiency; improve environmental quality, save energy, conserve time and enhance safety and comfort for drivers, pedestrians, and other traffic groups. However, from the strategic plan conceptual framework, the public transportation system can be improved should PHASE II of the framework be implemented; considering a back to back initialization where each dependent function (travel time, traffic density, road condition, vehicle-2-vehicle communication, Information Communication Tools: (ICT) for sustainable transportation is properly taken into consideration. Innovative sustainable technology advancement should be deployed and tested progressively, taking note of pitfalls and short comings as it evolves, and necessary solutions provided to enhance a smooth running of ITS within the environment its being implemented.

However, the study on stakeholders of both the public transportation system and the IIT industry shows that ITS solution is needed in the Free State public transportation system. The quantitative data discussed above abridges the ITS need of the public transportation system from the stakeholder's perspectives. It is evident that Information Communication Technologies are needed by the Free Sate public transportation system but for successful implementation some possible challenges must be addressed beforehand; these challenges would be firstly: the willingness of private companies and transport providers to adopt changes in modern technology systems into their program in how they manage and take decisions. The implementation of ITS prototype projects as discussed in Phase II; ITS Technologies, ATS, TMC and ATIS etc.; should be introduced in a monitored algorithmic system environment and test run to see the feasibility and mode of adaptation by the public over a structured period within which the challenges and problems encountered will be noted and tackled systematically. With time while in service, there will be a tremendous improvement in the public transportation sector of South Africa once implemented. Successful implementation of ITS technologies will require significant emphasis on public relations and marketing; in a manner to reduce increased traffic time, congestion by several factors such as: Privatisation of road network systems, product differentiation on type of road system i.e. purpose, intended Equivalent Standard Axle Load (ESAL) traffic loading and accessibility linkage, qualities and benefits derived, toll gate fees while using the road; will be necessary. Provision of enough accessible internet in vehicles, bus terminals and bus stops to passengers while waiting or travelling is also a way of promoting interstate connectivity and providing navigation route plans within the buses or vehicles. Furthermore, alternative transit medium will attract more customers to public transport mediums.

REFERENCES

9292.nl, 2015. 9292 Your travel partner. [Online] Available at: http://9292.nl/ [Accessed 16 January 2018].

Bashingi, N. 2016. Investigating ICT Solutions for the public transportation system improvement in the Free State: Opportunities and Challenges. Magister Technologiae: Civil Engineering Central University of Technology.

Basiago, A. D. 1999. Economic, social and environmental sustainability in developing theory and urban planning practice. The environmentalist 19, 145-161 (1999). Copy right Kluwer Academic Publishers, Boston. Manufactured in the Netherlands.

Cheon, S. 2003. An Overview of Automated Highway systems (AHS) and the social and the institutional challenges that they face." Link: http://www.uctc.net/papers/624.pdf.

Clavero J. 2017. Fatigue in Construction: How to prevent it. eSub Construction Software. https://esub.com/fatigue-in-construction/.

Cohen G, Salomon I, Nijkamp, P. 2002. Information Communication Technologies (ICT) and Transport: Does Knowledge Underpin Policy? Telecommunications policy, 26(2002) pp 31- 52.

Egert, B., Kozluk, T. and Sutherland, D. 2009. Infrastructure and growth; empirical evidence. OECD Economics Department Working Paper No. 685

Ezell S. 2012. Explaining International IT Application Leadership: Intelligent Transport Systems. The Information Technology and Innovation Forum. pp 1- 45

Figuiredo, L., Jesus, I., Machado, J.T, Ferriera, J. and De Carvalho, J. M. 2001. Towards the development of Intelligent Transportation Systems. Intelligent Transportation Systems 88, 1206-1211 (2001).

Gillwald, A., Moyo, M. and Stork, C. 2012. Understanding what is happening in ICT in South Africa" A supply - and- demand side analysis of the ICT sector. Evidence for ICT policy action. Policy Paper 7, 2012. Research ICT Africa.

Giuliano, G. 2004. Land Use and Travel Patterns among the elderly. Chapter 7 in Transportation Research Board (ed). Transportation in an Aging Society; A Decade of Experience. Washington. DC: Transportation Research Board, 192-210.

Gramlich, E. M. 1994. Infrastructure Investment: A Review Essay. Journal of Economic Literature, 32, pp. 1176-1196.

Guchan O. 2016. Relationship of Simulator and Emulator and Real Experiments on Intelligent Transportation Systems. Master of Science, Ohio State University, Electrical and Computer Engineering.

Hu, X., Chiu, Y. and Shelton, J. 2016. Development of a behaviorally induced system optimal travel demand management system. Journal of Intelligent Transportation Systems, 21(1), pp.12-25.

Karlenzig, W. 2011. Using Information and Communication Technologies for smart and connected cities. In: Chao, C and Perk, M (eds).Shanghai manual: A guide to sustainable urban development of the 21st century. 1st edition. Ghezi Press. Shanghai People Publishing House, China

Lay, Rodney K., Gene M. McHale, and William B. Stevens. The U.S. DOT Status Report on the Automated Highway Systems Program. Working Note 95W0000093. Mtretek Systems, Center for Telecommunications and Advanced Technology. McLean, Virginia. July 1996. pg. 2-10.

Maritz, J and Maponya, G. 2010 Development, use and potential contribution of appropriate ICT –based service systems to address rural transport related accessibility constraints – Emerging lessons from case studies in South Africa : 29th Annual Southern African Transport Conference, “walk Together”, CSIR International Convention Centre, Pretoria, South Africa, 16 -19 August 2010, pp 13

Mzansi Empowerment Network, 2011. Public Transport Challenges and Potential in South Africa. WordPress.com.

Nair R.M and Devi L.S 2011 Sanskrit Informatics: Informatics for Sanskrit studies and research. Centre for informatics research and development, Kerala. Pp 113-114

Nunes, A., Galvão, T. and Cunha, J. 2014. Urban Public Transport Service Co-creation: Leveraging Passenger's Knowledge to Enhance Travel 121 Experience. Procedia - Social and Behavioural Sciences, 111, pp.577-585.OECD (2010) Cities and Green Growth: Issues Paper for the 3rd Annual Meeting of the OECD Urban Roundtable of Mayors and Ministers,” 25 May, 2010, OECD Conference Center, Paris. P.15

OECD, (2012) Highlights of the International Transport Forum 2012 Seamless Transport: Making Connections. OECD Publishing. Pp 47-47 (seamless transport: making connections 2-4 may 2012, Leipzig, Germany

Pendyala, R. M. and Bhat, C. R. 2012. Travel behaviour research in an evolving world. 12th International Conference on Travel Behaviour Research. 13th – 18th December 2009, Jaipur, India, Lulu.com.

Sun, H., Wu, J., Wang, W. and Gao, Z. 2014. Reliability-based traffic network design with advanced traveller information systems. Information Sciences, 287, pp.121-130. Thomopoulos, N., Givoni, M. and Rietveld, P. 2015. ICT for transport. Cheltenham: Edward Elgar.

Using NXTBUS ACTION buses. Available on: http://www.action.act.gov.au/timetables_and_maps/real-time-passenger-information-system-tpis [Accessed: 16/03/2015]

Van Ryneveld P. 2008. 15 Year Review of Public Transport in South Africa with emphasis on metropolitan areas. Hunter van Ryneveld (Pty) Ltd

Venter, C., Hayes, G. 2017. South Africa needs to revamp its New Public transport System. The Conversation, Academic Rigour, Journalistc Flair. October 12. 2017. 4.34pm SAST.

Wahlberg, B. 2000. Automated Transport Systems (ATS). KTH Royal Institute of Technology, Sweden, 5, 3.

Weber K.M, Heller-Schuh B, Godoe H and Roeste R. 2014 ICT enabled system innovation in public services: Experiences from intelligent transport systems. Telecommunications Policy. 38, Issues 5-6, June-July 2014, pp 539 – 557

White Paper on National Transport Policy, 1996. South African Government Information, August 1996.

William and Kenneth. 2007. The role of road funds in improving maintenance. In Transport Infrastructure Charges and Capacity Choice: Self-Financing Road Maintenance and Construction. European Conference of ministries of transport, Transportation Research Centre Report 135, April 20. Paris; Organisation for Economic Co-operation and Development.

World Commission on Environment and Development 1987.Our Common Future. The Brundtland Report. Oxford University Press, Oxford.

Xu, Q., Hedrick, K., Sengupta, R. and VanderWerf, J. 2002. “Effects of Vehiclevehicle/roadside-vehicle communication on Adaptive Cruise Controlled Highway Systems”, IEEE Vehicular Technology Conference Fall 2002, Vancouver, Canada, September 2002.

Xu Q., Sengupta R., Jiang D., Chrysler, D. 2004. Design and Analysis of Highway Safety Communication Protocol in 5.9GHz Dedicated Short Range Communication Spectrum. Proceedings of the IEEE 57th Vehicular Technology Conference (VTC-Spring), Jeju, Korea, pp. 2451-2455.