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Development of a Techno-economic Model of Intelligent Transportation System (ITS) for Deployment in Ghana

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DEVELOPMENT OF A TECHNO-ECONOMIC MODEL OF INTELLIGENT TRANSPORTATION SYSTEM (ITS) FOR DEPLOYMENT IN GHANA

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Abstract— The concept of Intelligent Transportation System (ITS) is about the development and deployment of advanced Traffic Management Systems, Traveler Information Systems, Commercial Vehicle Operations, Public and Private Transportation Systems, and Rural Transportation Systems. Several key technologies stand to serve the synthesis of each and every one of these objectives. These technologies include: Wireless Communications technology (GSM), Computers, Digital Maps, Path Planning, Sensors, Vehicle and Traffic Control Systems. This paper is not intended to discuss each of these technologies, rather, the paper looks at how these modern technologies can be deployed in developing countries, with emphasis on wireless communications applications which will enable developing countries to take off smoothly and progress into their emerging economies successfully. In this paper we have looked at the key technical features to be considered for developing and deploying ITS in Developing Countries. The empirical data are taken from a detailed case study of ITS deployment in Ghana. The methodology used for data collection included interviews and surveys - face-to-face discussions and questionnaires. The results show that deployment of Intelligent Vehicle Tracking Technology (IVTT) will address the problems of inefficiencies experienced in the Ghanaian road transport haulage tracking industry. Research for ITS development and deployment in these countries should be cost effective.

Key Words — Intelligent Transportation Systems, Intelligent Vehicle Tracking Technology, Digital Maps, Wireless Communications.

1   INTRODUCTION

Currently, there is the need for developing countries to identify wireless communications requirements which will enable them to take off smoothly and progress into their emerging economies successfully. These requirements will include modern wireless networks or infrastructural designs [1], software applications and services. The emerging market economies are looked upon as the next engines for growth in the wireless infrastructure sector. With developed regions of North America, Western Europe and Eastern Asia maturing as 3G networks move towards 4G, the emerging market economies are playing "catch-up role", improving existing 2G coverage and in some cases beginning to deploy 3G networks [8]. 4G technologies such as LTE and Wireless

Access in Vehicular Environment (WAVE) technologies [9] have bigger roles to play in these emerging markets, as wired broadband infrastructure finds it difficult to compete with wireless technologies. Wireless vendors see emerging markets as a top priority, jostling for contract wins in the development and deployment of ITS tracking systems for road haulage tracking in developing markets.

Key Motivation: The motivation for this paper is derived from the need and importance of Effective Communication and Efficient Road Transportation Systems to enhance National Economies. Mobility of people and goods is extremely important to the overall societal way of life and the national economy of every nation. Similarly, communicating while moving is a necessity. It is a basic right, and the transportation of people and various consignments is an essential element supporting people's lives. Since regional and international trade creates interdependency between nations, it is essential to make sure that the communication and transportation needs for people and goods are effectively and adequately met.

Potential Problems: Automobile transportation is widely accepted by most countries around the globe, particularly, by developing countries, due to its convenience and comfort-ability. On one hand, this sector stimulates the flow of people, freight and information, and helps to improve national economies and facilitates changes to social life style of numerous people in many nations today. On the other hand, the increasing demand and use of automobiles also come with their attendant problems. These problems include traffic congestion, fatal road accidents, air pollution, environmental hazards, etc [3]. It is imperative to emphasize here that, these unfortunate societal-calamities have been taken away a lot of valuable human lives and souls and have been destroying numerous treasured properties in many countries (if not all), of course, not excluding Ghana.

Ghana's ITS Problems is directly linked with the traditional haulage tracking methods. These methods need to be changed radically and rapidly, due to the huge booming of national and international trade and investment opportunities in this country. Customers now demand that, their road transport haulage service providers are up to date with state-of-the-art tracking technologies and applications of modern ICT facilities, e.g., the use of GSM wireless [8], WAVE, GPRS, GPS, Satellite Communications and efficient Transportation Management Systems (TMS), which do not exist currently in Ghana. The move by these customers is to

drive home their demands for improvement in operational efficiency and profitability in the road transport haulage tracking industry.

Factually, there are significant inefficiencies in the Road Transport Haulage Tracking Industry in Ghana. The factors that contribute to these inefficiencies include, but not limited to: Lack of application of Intelligent Vehicle Tracking Technology systems; In-effective communication between freight owners and drivers due to lack of modern ICT; Diversion of routes and commodities due to misconducts of drivers and mates (human behaviour); Undue delays of destination and transiting consignments; Inappropriate use of haulage resources by drivers and other personnel; Most importantly, lost of vital man-hour production times and ultimate revenues (e.g., Taxes, Duties, Levies, Etc) much needed to sustain the national economy.

The research questions for this paper are: "Why do inefficiencies exist in the road transport haulage tracking industry in Ghana" and "How can Intelligent Vehicle Tracking Technology (IVTT) of the ITS technologies be deployed to meet road transport haulage tracking needs, and to enhance socio-economic development in this country?"

The methodology for this paper was based on empirical studies in which analytical case study - investigatory method (face-face interviews) was used to find answers to the above questions. The investigation exercise identified and collected data on existing user requirements and limitations. Collected data was then analyzed by local case study categorization method to determine which IVTT of ITS tracking system applications and devices can be deployed in Ghana.

Questionnaires were designed and administered to collect data on operator performance evaluations to examine the route causes of the inefficiencies from Customs Exercise & Preventive Services, Internal Revenue Services, Haulage Freight Owners and other operators and stake holders to be able to suggest possible solutions to these limitations and inefficiencies.

The structured of this paper is as follows: The introduction section emphasizes on the need for developing countries to identify their wireless communications requirements which will enable them to take off smoothly and progress into their emerging economies successfully. This section also discusses the motivation for writing the paper, the problems addressed, the research questions and the methods used to collect data. Section two covers the concept of ITS, its role in emerging economies and the function of Intelligent Vehicle Tracking Technology (IVTT) in ITS and its importance in the road transport haulage tracking industry in Ghana. The next section identifies the key technical ITS features, applications and services that can be considered for development and deployment in developing countries. Issues of standardization and interoperability, institutional

capabilities and approaches are also touched on. Section four throws light on the current implementation of road transport haulage tracking in Ghana (as a case study). The last but one section is devoted to the discussions of the results of the empirical studies, barriers and potentials. Section six, the last section, outlines the conclusions and recommendations originated from the studies.

2. ITS TECHNOLOGIES

2.1 What is ITS?

ITS refers to, scientific endeavour to add Information and Communications Technology (ICT) to Transport Infrastructures and Vehicles, in a bid to administer features that originally are at odds or at disparity with each other, such as vehicles, goods & passengers, and routes to improve safety on our roads and reduce vehicle wear, transportation times, fuel consumption and environmental pollutions (CO2). Technically, ITS is a family of services and technologies that apply ICT in the road and transportation industries. It is the application of IT (computers, sensors, wireless communications and databases) to solve the problems of road transportation. It encompasses a broad range of wireless and wire-line communications-based information, control and electronic technologies [5].

The underlying intents of ITS technologies are the development and deployment of advanced Traffic Management Systems, Traveller Information Systems, Vehicle & Traffic Control Systems, Commercial Vehicle Operations, Public, Private and Rural Transportation Systems. Several key technologies stand to serve the synthesis of each and every one of these objectives. These technologies include: Wireless & Satellite Communications, GSM & Optical Fibre Communications Systems; Computers (ICT), Digital Maps; Path Planning; Sensors & GPS Tracking Systems; Vehicle & Traffic Controls and Human Factors [11].

2.2 The Role of ITS in Emerging Economies

ITS technologies enhance productivity in emerging economies through the application of advanced information and communications technologies. It encompasses a broad range of wireless and wire line communications-based information and electronics technologies which when integrated into the transportation systems' infrastructure, and in vehicles themselves, these technologies relieve traffic congestion [3], reduce travelling times and costs. The technologies are also deployed in monitoring and tracking vehicles to check driving behaviours, vehicle utilization and to prevent loses of transportation revenue and tax collections for emerging economies; enhance productivity and efficient utilization of limited road haulage resources; and save lives, time and money.

2.3 Intelligent Vehicle Tracking Technology

Intelligent Vehicle Tracking Technology (IVTT) – a major constituent of ITS technologies is a technique of monitoring the location, movements and real-time status of a vehicle and the behaviour of the occupants of a vehicle. This is achieved through a combination of Global Positioning System (GPS);

Satellite & Wireless Communications Systems, GSM, Dedicated-Short Range Communications (DSRC); Wireless Communications Technologies (e.g., Radio Modem, UHF; VHF; IEEE 802.11 Protocols; WAVE; Roadside Communication Devices; Mobile Ad-hoc Networks or Mesh Networks, Wireless Networks); Mobile Telephony; Optical Fibre cable (backhaul) and modern ICT infrastructure [9]. The data are processed into information by management reporting tools in conjunction with a visual display on computerized mapping software installed locally and remotely.

Invariably, vehicle tracking is a must for every road transport haulage and logistic companies. Vehicle tracking system - a great gift of technology, has become a blessing in disguise for the various transportation and logistic companies in Ghana, providing them with easy means to gather valuable information relating to their haulage trucks, and operations and management. National economic commodities such as agricultural products (cocoa, timber, fertilizers, etc.,); petroleum products from the Ghana's oil fields; minerals (gold, diamond, bauxite, etc.), are hauled across the country. These are done through haulage companies that run their fleet of cargo trucks to transport these products. Managing such a large number of haulage trucks is a more difficult task. However, the availability of vehicle tracking system ensures easy management and control of large fleet of haulage trucks and operations.

There are multitudes of benefits of vehicle tracking that force many road transport haulage operators in Ghana to install this system into their haulage trucks. In this context, the most vital benefits are: effective and efficient collection of revenues (duties, taxes, levies), reduction in haulage cost by monitoring valuable information like speed, irregular use of trucks, hard braking - wear and tear of the vehicle, and safety on the Ghanaian roads. Haulage companies and operators in Ghana are also able to reduce their overhead cost by eliminating underutilized trucks and by replacing nonperforming employees with more efficient and result-oriented ones.

3. KEY TECHNICAL FEATURES FOR DEVELOPING AND DEPLOYING ITS IN DEVELOPING COUNTRIES

This section analyzes the key features and major requirements of ITS development and deployment in Developing Countries. The section also discusses the technical features of ITS that should be considered for development and deployment by developing countries, and for that matter by Ghana, as a case study. The introduction of a system with minimal disturbance of the heterogeneous environment with minimum cost and time in R&D and deployment will be an important criteria in the selection of such a system for developing countries [23].

Developing countries are often at disadvantage, relative to developed countries regarding the development of ITS infrastructure, mainly due to limited financial and technical resources. However, developing countries have some advantages to developed countries, particularly when the infrastructure has high IT content [21]:

- Developing countries, more often than developed countries, are able to install electronic infrastructures at the same time that physical infrastructure is implemented
- Developing countries are often not bound to an outdated legacy in place of IT infrastructure
- Developing countries benefit from continuing decrease in the cost of IT development
- Building a new IT infrastructure from scratch is often less expensive than updating an existing one
- Developing countries can make immediate use of other systems like cellular telephones and internet that are spreading rapidly in parallel
- Developing countries can take advantage of products and applications which have already been tested and deployed in the developed countries.

ITS in Developing Countries are to be developed by considering the mixed environment and traffic conditions [23]. Research for ITS development and deployment in these countries should be cost effective. The system should be adaptive to fast changing technological aspects of Computer Science and ICT. The system should be developed by viewing the political atmosphere of democratic countries where minimal disturbance of the existing environment is to be envisaged during deployment. For these countries, standardisation of the economic and political state of affairs according to the prevailing rules is the maximum possible change that can be imposed in the environment. Obviously, outrageous changes in the environments is not prudent in developing countries [23].

3.1 Standardization and Interoperability

Standardization and interoperability have been another major issue in development of ITS. Systems in use in different parts of the world remain incompatible and fragmented particularly for 5 GHz systems for which North America, Europe and Japan have different implementations using different frequencies [20]. Here, one may say that developing countries have an advantage of being late, as they, for the most part, have not yet invested heavily in ITS, there is a good chance that they will avoid the standard battles that currently reign in this area. The standardized vehicle licence plate is the raw data of ITS, which will have to be standardised in developing countries [23].

3.2 Required ITS Applications for Developing Countries

Basically, ITS provides two kinds of traffic benefits. One kind is the resolution of traffic problems, including, enabling more efficient mobility and reducing traffic congestion, air pollution and traffic accidents. The other kind is provisioning of improved services for the users and increased efficiency of transportation systems and its operations [21]. The road safety is a major issue and ITS is an important technology that improves road safety. In particular, in developing countries, road safety is a major problem due to the level of development, and here bringing safety considerations and combining ITS in the design

process should be a major element in the development of new road infrastructures.

Some types of ITS applications like reduced traffic congestion has wide societal implications and is only possible as a result of a political consensus at the social level. These applications, however, have less immediate appeal to consumers and in the market place, justifying expenditure of public funds because their benefits are long term, gradual and less immediately obvious to users, vehicle operators and the private sector [21]. On the other hand, there are other ITS applications that may not provide significant effects to solve conventional traffic issues but help to increase quality of services which individual users or individual transportation operators can see, understand and appreciate. e.g., applications reducing traffic uncertainty or increasing security for flight movement. In some cases, these types of ITS application have commercial appeal and can be provided by the private sector [22].

3.3 Necessary Characteristics

As minimum, required characteristics of ITS for developing countries include but not limited to: Parking Lot Management, Access Control Systems, Traffic Management Applications, Highway Planning, Vehicle Theft Detection, Automatic Toll Collection (ETC) System, Real time Traffic Management Systems, Security Management Systems, Etc., [23].

Invariably, some of these characteristic components can easily be governed with Digital Image Processing (DIP) as a basic concept. Due to the technological advancements in Communications Networks and Computer Systems, real time image processing solutions can also be made available so that real time application components of ITS which requires real time processing can be made. In this way, the entire system can be developed from a single platform. Current application programmes and databases being implemented in the Open-Source Technology Stream deployed in Open Source Operating Systems form the application layer of ITS which will further reduce the development and deployment costs to average or affordable levels for developing countries.

3.4 Institutional Capabilities and Approaches

Existence of institutional capacities and technological competencies are vital for development of ITS. Introducing ITS is a complex undertaken and decision makers in developing countries, particularly in Ghana, have to understand the prerequisites for deploying ITS, which are both institutional and technological [21]. The development and deployment of ITS can be broadly classified into two categories for developing countries: a) the Public ITS - to be maintained under the control of Governments or the states; b) Private ITS - to be operated and managed by Private Institutions. Public ITS can be developed as a highly integrated distributed systems having all the basic ITS applications integrated. Private ITS on the ether hand, can be developed and deployed as a small ITS managed by specific organisations to meet their own needs and

requirements. In this perspective, the Private ITS can be considered as a miniature version of Public ITS for developing countries [23]. Technically, this institutional approach is the recommended practise for Ghana and many other developing countries.

Many ITS projects are being carried out by public-private partnership (PPP) in developed countries. There are many good reasons for forming such partnerships [21]:
1. Each sector does parts of the work it is best at doing
2. The risk is shared between the parties.
3. Collaborative approach that involves private and public resources, including the research institutions.

The PPP approach is very much relevant in the developing countries and even though it may not be feasible for many developing countries to develop their own ITS infrastructures, there is a scope for them to break into the market for ITS, which tends to be dominated by small and medium sized enterprises and by service rather than devices [20]. In Ghana, road transport haulage tracking is undertaken by the Government in collaboration with other private partnerships (PPP).

Excitingly, there are differences in the ways that developed countries (EU, USA, Japan, Singapore, South Korea, Etc.) have developed and deployed ITS successfully. The reasons are that, there were some differences among these countries and regions in terms of different economic problems and differences in their political, social and cultural backgrounds. Similarly, as each developing country (e.g., Ghana, Brazil, Philippine, Bulgaria, South Africa, etc.) starts planning to develop and to deploy ITS, it is important for them to consider their unique economic problems and their tailored ITS features and requirements, so that they can adapt ITS approaches from the developed countries to suit their specific needs.

3.5 Key Technical Features for Consideration

Empirical studies conducted in Ghana through face-to-face interviews and discussions show that, the key technical features of ITS that can be considered for development and deployment by developing countries are:

a) Basic Road Traffic Management Systems:- Traffic Signal Systems, Traffic Surveillance Systems (CCTV Cameras), and Traveler Information Systems (Dynamic Message Signs – DMS).
b) Automatic Data Collection Systems:- Roadside Sensors
c) Systems that provide a high return on investment:- Electronic Toll Collection (ETC), Commercial Vehicle Tracking Systems, Bus Management Systems and Electronic Fare Payment Systems.
d) Traffic Information Services:- Multiple Broadcasting and Communication Media.
e) Road Management Systems:- To identify road surface conditions and the trading of "empty cargo space" to improve transportation efficiency.
f) Border-crossing Systems:- To promotion Cross-border Trade to enhance the strength of regional economic zones.

4. CURRENT IMPLEMENTATION OF ROAD TRANSPORT HAULAGE TRACKING IN GHANA

4.1 What Is Road Transport Haulage Tracking?

Road transport haulage tracking is an essential part of ITS. It is the technique of installing or attaching electronic devices (trackers) to haulage vehicles that communicate valuable operational information by transmitting signals, which are gathered by orbiting satellites, through GPS, that returns the signals back to the screen of remotely computer monitoring systems via Vehicular Communications Networks (VCN), Wireless Access in Vehicular Environments (WAVE) [4]. It is the process of capturing and monitoring the precise and continuous locations and activities of cargo trucks and their occupants at a particular time or at all times, to ensure effective and efficient operations and management in the haulage tracking industry. This GPS vehicle tracking system enables road truck haulage managers to monitor the activities of their drivers and vehicles in real time using state-of-the-art satellite mapping, via the Internet.

4.2 The Need to Implement Road Transport Haulage Tracking In Ghana

Road transport haulage tracking in Ghana is inevitable as a result of the challenges facing government, investors and the general public at large, in the areas of national revenue collection activities and road transport safety. The Major Challenges include:

- Revenue leakage through diversion of destination transit goods into the Ghanaian local markets

- Cargo Tracking based on manual or physical escort system which is unreliable, costly and out-dated

- Criticism from logistics companies and neighbouring countries (e.g., Togo, Benin, Nigeria, etc.) on being an obstacle for regional and international trade in the Sub Saharan Africa.

- Security problems e.g. smuggling of fire-arms into Ghana and the neighbouring countries, e.g., Togo.

- Lack of co-ordination, effective scientific monitoring and evaluation of road safety planning, strategies and programmes

- Non-availability of standards for road safety equipment

- Non-existence of R&D of road safety in Ghana

4.3 Empirical Studies at Ghana Customs, Excise & Preventive Services (CEPS)

Empirical studies conducted at the Ghana Customs, Excise & Preventive Services (CEPS) gave an insight into the design of the road transport haulage architecture of CEPS. At CEPS, most of the tracking operations are manually done. With the exception of the headquarters, CEPS has very little IT setups for minimal road transport haulage tracking and monitoring activities at very few check points and revenue collection outlets. For this reason, modern electronic tracking of state haulage trucks is a very huge challenge facing the government of Ghana [17].

### 4.4 Road Transport Haulage Tracking By Public Private Partnership (PPP)

To address the above challenges, government established The Ghana Community Network (GCNet) in 2000 as PPP and mandated it to deploy and support the Information Technology (IT) systems of Ghana TradeNet (GTradeNet) and the Ghana Customs Management System (GCMS) [17]. The GCNet PPP is made up of: Ghana Customs Excise & Preventive Services, Magnate Technologies Services, Hi-Tek Inc., National Road Safety Commission, Ship-owners and Agents Association of Ghana, Ghana Free Zones Board, Ghana Institute of Freight Forwarders, Association of Ghana Industries, Ghana Standards Board, Ghana Export Promotion Council, Ghana Minerals Promotion Commission and the Ghana Investment Promotion Centre [17].

The GTradeNet is an Electronic Data Interchange (EDI) for the exchange of electronic documentation between trade and haulage operators. GCMS on the other hand, is a modern Information Management System (IMS) for Ghana CEPS, which is the government's sole agency responsible for collecting all revenues due government from road transport haulage operations at all the customs check points. The Government found it expedient to use PPP to modernize its customs operations without having to foot, on its own, the total cost of US $12 million for physical infrastructure work, the establishment of haulage tracking communication networks, the upgrading of customs facilities, and electric generators placed in remote border stations [2].

4.4.1 The Magnate Technologies Tracking Systems

In the Magnate Technologies GC e-Trak Tracking System, tracking is achieved by attaching a tracker (an intelligent electronic device) to a haulage cargo truck to capture and record the precise and continuous (real time) position of a cargo truck at a particular time or at all times. The Main components in designing these tracking systems are as shown below.

These are: The Freight or cargo truck to be tracked, tracking devices (GPS Satellite Transponders), Tracking Channels (GSM/GPRS, GPS, WiMAX, HAPS, Etc.) and Monitors / Workstations (Computers with special software) are embedded in the system as shown below.
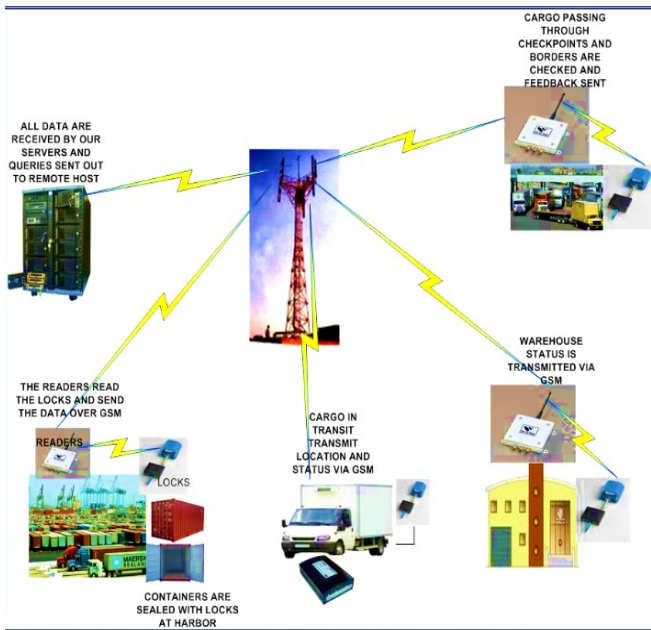
Source: Magnate Technologies
Fig. 1 Magnate Technologies GC e-Trak Tracking System
Source: Ghana CEPS ITS/ICT Implementation Document

Figure 1 above shows the setup of the Magnate GC e-Trak Tracking System. The setup demonstrates a cargo truck transiting through Customs Check Points and Ghana's Border Points between Togo, Cote D' Voire or Burkina Faso). At any point in time, the location and status of the cargo truck is captured and transmitted by an Onboard GPS device via GSM Network, and received by servers at CEPS Control Room at the CEPS Headquarters in Accra and at other dedicated remote monitoring centres at the Accra International Airport and at the Tema Harbourh.

4.4.2 Magnate GC-eTRACK Communication Platform

Communication channels deployed in this system include:: RF, RFID, GSM/GPRS & GPS. All of the above are deployed and interconnected into a network so effective and efficient that the users at the CEPS offices do not notice breaks in the network. Every communication highway on this system has a backup should the main channel go down. The strength of the communication environment is based on the design and setup of the communication infrastructure. The diagram below shows the GC-eTRACK set up for CEPS in Ghana.

The set up of the Communication Platform of the Magnate Tracking system consists of Base Stations, linking Data Centre, Checkpoints and Optional-warehouses. For the purpose of simplicity, only few devices are shown. The 18 GHz Microwave Backhaul links interconnect the Base Stations and the Data Centre. The 4.5 - 4.9 GHz Dedicated Short Range Communication (DSRC) links interconnect the Base Stations to the Checkpoints and Optional-Ware-houses. The Checkpoints are equipped with 450 MHz RF devices such as Readers, Tags, Seals and Locks to ensure security and effective monitoring activities.
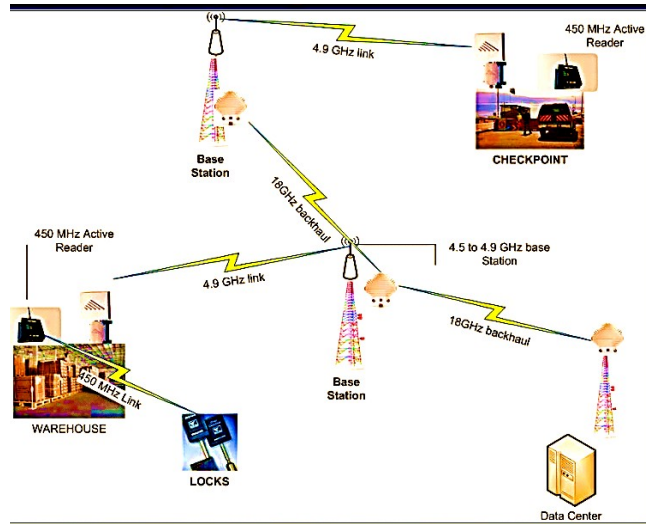
Source: CEPS GCNet Systems
Fig. 2 Set up of the Communication Platform of the GC e-Trak Tracking System

4.4.3 Data Communications Network for the GC e-Trak Tracking System for CEPS

The design of the Data Communications Network deployed in the GC e-Trak tracking system to interconnect the various CEPS revenue collection and monitoring points in Ghana is as shown in figure 3 below. The network is IT based [18]. The central pivot of the network is the internet. The network devices include the following: LAN, MAN, WAN and VSAT elements; CISCO Routers, Switches & Servers; Adaptive Security Appliance (ASA), Transparent Firewalls and Microwave Links. The network interconnects sea ports and border towns like Takoradi, Tema, Elubo, Paga, etc., to the CEPS's "Strong Room" at the Headquarters in Accra.
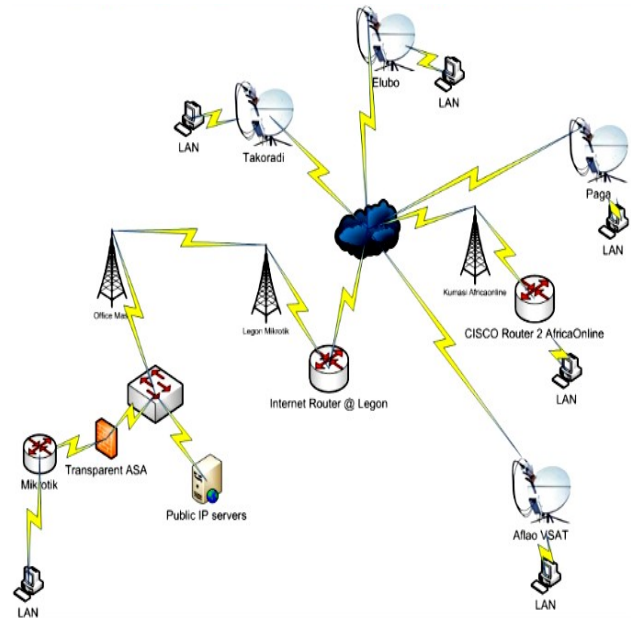

Fig. 3 GC e-Trak Data Communication Network
Source: CEPS ICT Plan

Operational Procedure:

1. Every process concerning bonds starts from CEPS Compliance Workstation

2. The next step is cash payment at the Cash Collection Workstation

3. The Ghana Client creates a new Manifest for the new Bonded Cargo

4. The CEPS Examination Workstation writes the Manifest created by the Ghana Client to the e-Seal or e-Lock

5. The Gate Workstation registers the departure of the new Bonded Cargo

4.4.4 Road Transport Haulage Tracking By Hi-Tek, Inc. In Partnership with Magnate Technologies

6. Governments and Customs' authorities in many parts of the world are challenged by the needs to enhance the competitiveness of their respective ports of entry, while grappling with the tactical problems of revenue collection, cargo theft, and regulatory compliance. Globally, partnership underscores country's efforts to create more competitive trade lanes while addressing these problems [14]. In this regard, the government has mandated Hi-G-Tek, Inc. (UK based), a leading global provider of wireless monitoring and tracking solutions that deliver real time location, security, and status information about haulage trucks and cargo, in partnership with Magnate Technology & Services, Ltd (in Tema), a private company providing road haulage tracking security solutions, to implement (already implementing) Ghana's Customs Trade Lane System (GCeTrak) to enhance the operations and performance of Ghana Customs Exercise and Preventive Services in the area of road transport haulage tracking.

Hi-G-Tek has good Cargo Tracking and Monitoring System (CTMS) and unique insights into the challenges facing customs authorities worldwide and it is very instrumental in enhancing Ghana's trade lanes competitiveness. It is for these reasons that Hi-G-Tek Inc. is working with in-country partner - Magnate Technology and Services Ltd., to provide the most optimal road haulage tax and revenue collection solutions for the Ghana Customs, Excise and Preventive Service.

4.4.5 CEPS Transit Tracking System

Ghana CEPS is operating a new satellite transit tracking system to monitor transit operations in the country in line with the World Customs Organization's Framework of Standards. The system is known as the Satellite Tracking Units, with a number of added features to facilitate the processing of transit consignments, and in concert with the ECOWAS Convention on Inter-State Transit of goods, makes Ghana the first ECOWAS member state to install such a system. The system is attached to all transit vehicles to electronically monitor their movements, actions and in-

actions by means of Global Positioning System (GPS) in order to plug all possible areas of revenue leakages. With this system now in place, the traditional CEPS's transit manual or physical escort operations are disengaged from accompanying vehicles on their journeys.

By means of electronic tracking it is now possible to determine, from the CEPS transit management centre (the long-hall at CEPS offices in Tema and the control room at the headquarters in Accra) whether a cargo truck had remained at any particular point over a period longer than scheduled and expected, or veered completely from its approved route. The information generated by the system is also accessed on the CEPS/GCNet websites.
This monitoring process enables transporters ascertain where their trucks and drivers are at any given time, and transistors also monitor their consignments via the system. Customs authorities from neighbouring countries who enter into appropriate collaborative arrangements with the Ghana CEPS also transmit information to confirm the exit of their cargoes into Ghana to ensure that such cargoes are not diverted onto the local markets.

However, this system has communication backhaul, backbone and customer access networks bandwidth limitations as well as transmitting power limitations. For these reasons, the networks for the transportation information management systems (i.e., the ICT networks) at the main monitoring and remote offices of CEPS are broken down more often than not, also registered very often are: microwave link outages, non-availability of internet links, computer hardware and software malfunctions, human attitudes, etc.). Very rampantly, these systems break down very often due to mains power failures, thereby registering very low system availability, efficiency, effectiveness, reliability quality of service and customer satisfaction. Consequently, very low revenue generation and collection are recorded, and these are disincentive to stakeholders, local and foreign investors.

4.4.6 Challenges with the "i-Transit" Tracking & Possible Solutions

The following challenges are associated with the "i-Transit" Tracking Model deployed by GCNet [15]:

a) Widespread perception that Transit Regime is an 'open door'. The end result is: Transit goods are diverted into local markets, Government and Investors Revenues are lost and these create distortions in the national economic. Possible solution is to review and re-engineer the tracking systems and processes.

b) Reliance on Escort System: This model is ineffective and costly in tackling diversion. Possible solution is to replace the method with a range of modern tracking tools.

c) Inherent problems due to Poor Controls; e.g., More control points on a given route; More paper works, Check points and Agencies; Unnecessary delays

and Costs. Possible solutions include; Effective Electronic Controls, Online Check Points (Logical Tracking), Remote Monitoring, IP Cameras, Satellite Tracking and Data Exchange.

4.4.7 Faster transit with GCNet Satellite Tracking System

In order to combat these problems, GCNet introduced a new Satellite Tracking System (shown in Fig.4 below) into its infrastructural setup. With the introduction of satellite tracking of transit goods, transit consignments are exiting the country faster than when physical escort methods were being used.
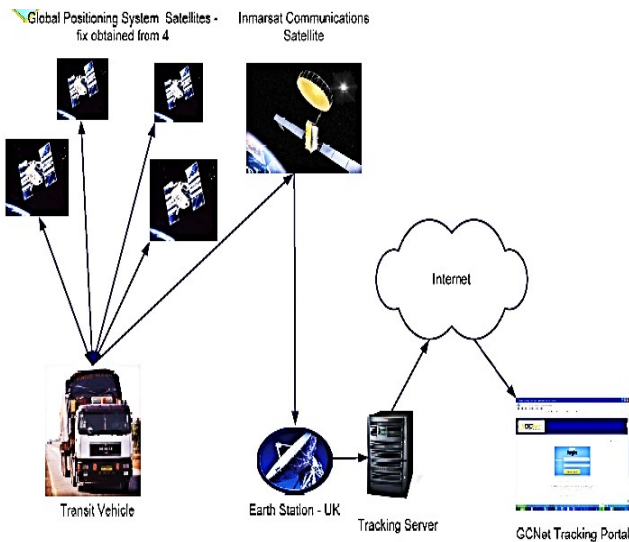

Fig. 4 GCNet Satellite Tracking System
Source: CEPS ICT Development Center

The operation of the system is such that, the positions and coordinates of cargo trucks are captured by four GPS and relayed to an IMARSAT Communication Satellite. The latter then relays the tracked information to a Satellite Earth Station in the UK. The tracked information is stored in a Tracking Server at the Earth Station. This information is received online via the Internet at the GCNet Tracking Portal terminals installed at the various CEPS entry and departure check points in Ghana. The tracked information can always be monitored or retrieved by browsing the internet anytime and anywhere. The system requires administrative authentication and authorization [17].

## 5. DISCUSSIONS OF RESULTS, BARRIERS AND POTENTIALS

5.1 Results

Analysis of collected data indicate that with the combination of Wireless and Satellite Communications Technologies (e.g., Radio Modems, UHF; VHF; IEEE 802.11 Series Protocols; WAVE; Roadside Communication Devices; Mobile Ad-hoc Networks or Mesh Networks, WWAN); GPS, GSM; Dedicated-Short Range Communications (DSRC); Optical Fibre backhaul and backbone networks, Intelligent Vehicle tracking Technology (Traffic Sensing Devices; Motion Detectors, Electronic Toll Collection,

Number Plate Recognition, Remote monitoring & control systems) and Advanced Traffic Information Management Systems (modern ICT networks) deployed into both existing and new road transportation infrastructures will go a very long way to address the inefficiencies in the road transport haulage tracking industry in Ghana.

There was a commendable surge in revenue collection by Customs when the GCNet Tracking system was established and implemented by CEPS and the PPP [15]. When the project started in 2003, an average annual revenue growth of 33 percent was recorded from the Tema Harbour and 32 percent from the Kotoka Airport haulage revenue collection points. Between the year 2003 and 2008, the Total Revenue collected by Customs increased by nearly 170 percent. These increases were recorded for each month, except for the month of July in 2007 when the economy of Ghana faced downward trends as a result of global astronomical increases in prices of petroleum products. The average revenue per month was over 90 million Ghana Cedis. This amount realized was woefully inadequate for any meaningful national socio-economic and infrastructural developments.

Table 1 Total Revenue Growth for Kotoka Int. Airport
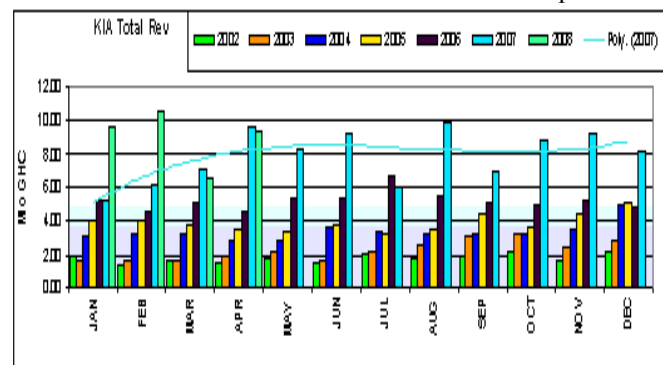
Source: Ghana CEPS "i-Transit"

5.2 Barriers

Active promotion of Ghanaian Transit Corridor in fulfillment of the Governments objective of becoming the "Gateway to West Africa" had caused a huge increase in transit goods between 1999 (108, 000 tones) and 2006 (705, 000 tones). This has posed significant monitoring and control challenges to CEPS. In connection with this, in 2006 GCNet and CEPS launched the "i-Transit Project", with the objective to replace traditional and manual means of control that have proven cumbersome and woefully inefficient in relation to modern IT-based solutions [3]. As part of the "i-Transit Project", government decided to deploy a state-of-the-art satellite haulage tracking solution. This project was required to track all destination and transit haulage trucks during their journey along the designated transit corridors, giving CEPS the ability to intervene in cases where high risk behaviour was detected. An average of 2, 500 haulage trucks is being tracked per month [4].

Currently, the major challenges facing CEPS are:
- Revenue leakages through diversion of transit goods into the local markets
- Human attitude and behavioural change

These have called for the development of a secured and robust virtual private wireless communication network which includes acquisition of a mobile radio frequency with broadband fibre optic links powered by satellite systems. This design is making a significant improvement in revenue collection at all tax and revenue collection points connected to the system, thereby plugging most sources of tax and revenue leakages and augmenting transparency of CEPS operations to some degree, but not to the utmost solution. The behavioural and attitudinal problems necessarily call for special human resource regular training and education for all operators, managers and other stake holders (not only drivers and their mates) in the road transport haulage tracking industry in Ghana.

5.3 Economic Potentials of Road Transport Haulage Tracking to Stakeholders

The following are few, but not the least benefits that can be derived by stakeholders, should they decide to deploy intelligent vehicle tracking technology into the existing and new road transport haulage infrastructures of the haulage industry of the national economy:

- Enabling accurate "real-time" statistics on revenue & foreign trade

- Building a Transaction Price Database

- Providing systematic monitoring of the movement of consignments from the country's entry points

- Encouraging Compliance and Professionalism

- Facilitating trade and promoting Ghana as the preferred Gateway to the West African Sub-region.

Additionally, this paper has the potential to educate players and stakeholders in the road transport haulage industry and revenue generation and collection agencies, on how IVTT can combat road transport haulage tracking inefficiencies. It has the prospective to inform players and stakeholders on how much revenue is being lost, how much can be saved and how much can be gained in their operations by the application of IVTT in their infrastructures and operations. Improvements in their haulage management systems, processes and procedures will be added advantages.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

In this paper, we have discussed how ITS technologies can be developed and deployed in developing countries with emphasis on how can Intelligent Vehicle Tracking Technology (IVTT) of the ITS technologies be developed and deployed in Ghana (as a case) to meet her road transport haulage tracking needs, and to enhance her socio-economic developments. These countries can address their transportation problems by considering the development and deployment of the basic ITS technical features or

applications and services. To start with, they can consider developing and deploying: Basic Road Traffic Management Systems, Traffic Signal Systems, Automatic Data Collection Systems, Electronic Toll Collection (ETC), Traffic Information Services, Road Management Systems, Border-crossing Systems, Etc.

Developing Countries will generally not have all the much needed technical expertise and economic strength in developing and deploying these basic ITS features or applications and services. This could result in a lower performance of ITS than expected, as pertains in the developed world. In some cases, (e.g., in Ghana where road toll is still being collected manually) the development and deployment of some of these modest ITS features are long overdue as a result of economic constraints, economic mismanagement, lack of political will, etc.

However, developing countries have some advantages to developed countries, particularly when the infrastructure has high IT content. Developing countries can take advantage of products and applications which have already been tested and deployed in the developed countries and deploy them straight forward in their respective countries.

In selecting communications solutions for developing markets, wireless infrastructure is a clear choice for both operators and users. With greatly reduced needs for cable installation and maintenance, wireless infrastructure is typically cheaper and faster to deploy. It is estimated that the capital cost of providing mobile coverage to an individual is about 1/10th the cost of installing a fixed-line connection [6]. Wireless infrastructure is also less susceptible to theft or vandalism as is often the case with copper lines in developing countries. Wireless also has the added benefit of being usable for portable and mobile applications as well as fixed ones. Although, wireless systems have network security vulnerability, this issue is addressed by the application of efficient network security management systems (e.g., Authentication, Authorization, Firewall, etc.).

Consequently, more people in the developing world need great access to the Internet, as the Internet will be All-Wireless (i.e., All IP), and most of the growth will come from emerging economies. Expectantly, the evolution of the wireless sector in emerging markets will continue to constitute a key building block to economic growth in developing economies. The in-vehicle ITS [2, 10] market is emerging as a major force in wireless communications. Thus, in-vehicle traffic information, safety & security, and wireless communications has become part of bundled ITS offerings in the road haulage tracking industry within the transportation sectors of many emerging economies [7].

With the deployment of the GC e-Trak tracking system in Ghana, the problems of compromised revenue collection due to ineffective control of destination and transit consignments, which led to their diversion onto the domestic market without payment of relevant duties and taxes, are effectively addressed. With the deployment of GCNet Satellite Tracking system, goods and transit consignments

are exiting the country quicker than when physical escorts were being practiced.

The considerable growth in revenue, under the given circumstances (not the ultimate) is not a coincidence, but it is attributed to the control features within the tracking system which ensured that whilst haulage was facilitated, revenue mobilization is not compromised.

6.2 Recommendations

In view of the foregoing, this paper highly recommends the following:

a) Governments of emerging economies should endeavour to prefer rapid installation of wireless communication systems in their national communications networks. This can both quickly improve existing infrastructures and smartly introduce competition with wire-line incumbents to drive down service prices.

b) Stakeholders in the haulage tracking industries of developing countries and emerging economies, and for that matter stake holders in Ghana, must begin to consider (if not yet) deploying wireless communications systems and the technical & economic potentials of intelligent vehicle tracking technology (a critical component of ITS Technologies) into their existing and new road transport haulage tracking infrastructures. By this way, the operational and management inefficiencies experienced in their road transport haulage industries will be addressed to very commendable degrees. This will create and ensure total customer satisfaction, customer loyalty and retention. Finally, this will register the ultimate revenue maximization – the bottom-line for every business venture, and will eventually culminate into appreciable escalation of the socio-economic developments of emerging economies in developing countries.

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