International Journal of Innovation and Applied Studies
ISSN 2028-9324 Vol. 15 No. 1 Mar. 2016, pp. 175-182

http://www.ijias.issr-journals.org/

Reference architecture for an intelligent transportation system

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ABSTRACT: Intelligent transportation systems are revolutionizing the way in which road safety is monitored worldwide. These systems have evolved from the 90's with the integration of new technologies and the design of more efficient detection systems for traffic violations. At present, through these systems, it is possible to predict the most dangerous places on the road and store a set of data to support decision-making regarding safety and road maintenance. In this paper, the current situation in the development of intelligent transportation systems worldwide and the traffic situation of Ecuador is examined. The main objective of the research is to suggest a reference architecture for the development of an intelligent transportation system that meets the needs of Ecuador.

KEYWORDS: intelligent transportation, transportation information, traffic violation, transportation architecture, road safety.

1 INTRODUCTION

Intelligent Transportation Systems ITS are strategic tools for improving the road network of a country [1]. An ITS is the implementation of advance technology for capturing and information processing, communications and control, in order to improve efficiency and safety in a transportation system [2]. These systems are composed of cutting-edge technologies along with communication systems [3]. These systems use advanced technologies and communication systems in the transportation sector, in order to improve the handling of the transportation network, consequently making improvements in areas such as security, simplicity, confidentiality and road efficiency. Among the most commonly used devices in different countries to improve these aspects are [4]:

1. video cameras to reveal accidents on the roads.
2. dynamic message boards to provide traffic information to the user.
3. vehicles detectors to calculate and provide the users with travel times.

Nowadays in Ecuador, road safety is one of the most discussed and debated issues. This is mainly due to high rates of accidents and road irresponsibility registered. Every year there is an average of 24,750 victims, due to traffic accidents with different causes. The causes of road accidents, of which 95 percent of cases are because of road indiscipline, are shown in Figure 1. The statistics of the different causes of accidents, from the Interagency Committee on Education, Prevention and Road Safety in 2013 [5], are:

1. 5 percent due to fortuitous events, bad weather and mechanical problems.
2. 62 percent due to negligence and irresponsibility.
3. 11 percent due to alcohol intoxication.
4. 10 percent due to over speed.
5. 9 percent due to invasion of the opposing lane.
6. 7 percent due to violation of traffic signals.

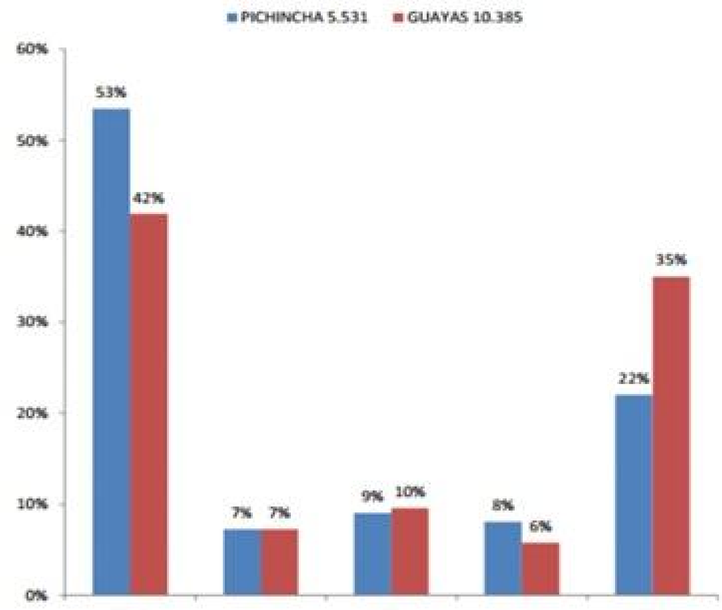

Fig. 1. Causes of traffic accidents in two states of Ecuador

Speeding is one of the main causes of car accidents, therefore, speed control is an effective and efficient measure to help reducing the number and severity of accidents. It is estimated that reducing speed in about 1.6 km / h, may reduce accidents in about 5 percent; while increasing it in about 1.6 km per hour, may increase accidents in about 19 percent. As evidenced in Scottsdale Arizona, with the implementation of a cameras system, the average speed decreased more than 9 km / h and was achieved a 50 percent reduction of accidents in general and 40 percent of accidents involving injuries [6].

At present, the country has a number of devices for traffic control, however, these devices are located in a decentralized manner. For this reason, each entity manages and proposes its own projects. In order to avoid technological isolation, the design of an architecture for an intelligent transportation system is proposed, in order to control, manage traffic and improve safety levels.

On the other hand, the Ecuadorian society has raised awareness that much of the transportation problems not only appear in a lot of spaces, but have also gained greater rigidity in both industrialized and developing countries. In recent years, the growth of the instance of transportation as well as traffic, have resulted in a considerable increase in congestion, delays, accidents and environmental problems much higher than those considered by citizens, particularly in big cities.

The purpose of this investigation is the development of a national architecture for the intelligent transportation system in Ecuador, as well as the identification of schemes intended to achieve interconnections among elements of the intelligent system, with the aim of promoting the exchange of information and interoperability among the system elements. This paper is organized as follows: section 2 provides an analysis of the background of the investigation, section 3 describes the reference architectures and in section 4, the architecture proposal derived from the research is presented.

2 RELATED WORK

The first term related to transportation technology, was proposed in Europe [7]. The ATT (Advanced Transport Telematics) was proposed with the objective of using technology to solve problems of management and control transportation. From various projects developed in the 70's in the US and in the 80's in Japan, arises the concept of ITS which is used to refer to innovation in traffic area at the time [8]. Several projects were carried out in these countries to define the architecture of the intelligent transportation systems. The objectives of these projects were:

1. Reduce travel times.
2. Reduce the price of the transportation infrastructure.
3. Enhance highway safety.
4. Advanced Traffic Inspection.
5. Perform hazard warnings.

As a premise, intelligent transportation systems must be designed according to the needs, mistakes and vulnerabilities of people [9]. Speed is the aspect of greater attention and is the most important cause of regulation, so the technical models of both the infrastructure and the vehicle, must pay special consideration. Mostly an ITS architecture must prevent accidents and reduce the rigidity of injuries in case of happening [10].

As part of this research background is the traffic and citizen safety plan for public and productive transportation "Safe Transport". This is an initiative of the Ecuadorian government, directed by the National Traffic Agency (ANT) and regulated by the Integrated Security System ECU 911. The "Safe Transport" project aims to reduce the accident rate on Ecuador's roads, with an adequate planning and control of public and commercial transportation service. It will include 55,000 transportation units (17,000 buses and 38,000 taxis) nationwide. Each will have a safety kit, consisting of help buttons, one satellite tracking device (GPS), 2 video cameras capable of infrared recording, sensors to open and close doors in the case of buses, and 1 UPS for power backup of components.

The signal emitted by transport units will be received by the ECU 911, that will monitor it in case of any emergency occurs. In addition, the National Traffic Agency will monitor via the traffic management department, routes and units across the Ecuadorian territory, in order to optimize and control the traffic and transport management. This information will also be available to carriers by means of the platform implemented by the ANT, as shows in figure 2.

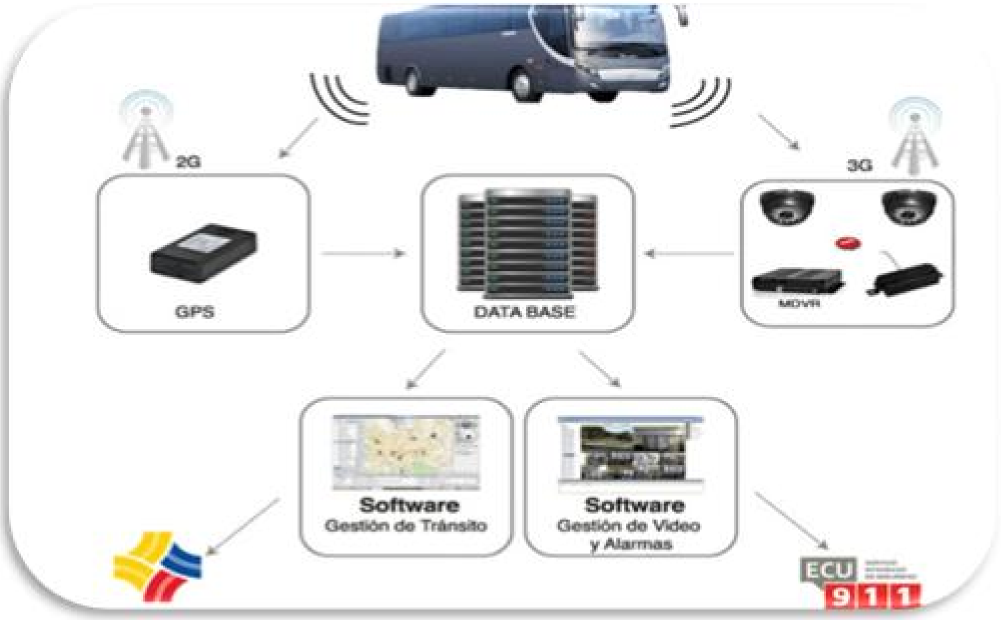

Fig. 2. Causes of traffic accidents in two states of Ecuador

An analysis of multiple systems worldwide is performed, in order to identify elements of the intelligent transportation systems architecture [3], [11], [12]. Among the analyzed intelligent transportation systems are:

1. ITS America
2. ITS Canada
3. ITS Japan
4. ITS China
5. ITS Chile

For each, the logical and physical distribution of its components was analyzed and the services provided to users. The logical architecture defines the processes (activities and functions) required to provide user services. Different processes must be synchronized and share information to provide a user service. Each of these processes can be implemented through software, hardware or firmware. The logical architecture is independent of the technologies and implementations. Figure 3 shows the logical layout of the components in the architecture of the intelligent traffic system of the United States of America.

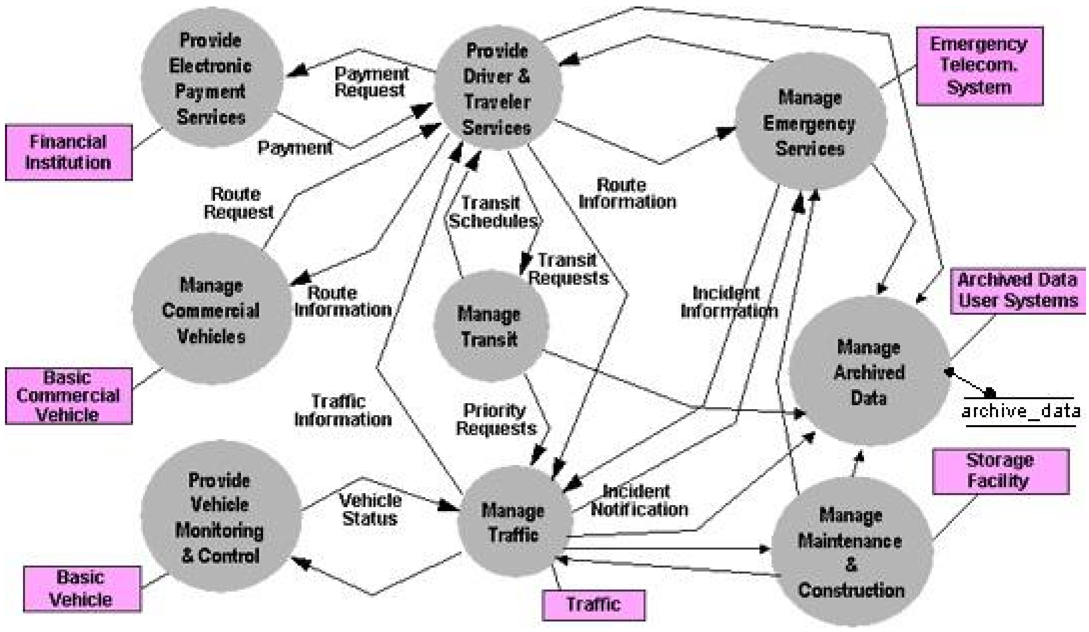

Fig. 3. Logical Scheme of the intelligent transportation system in the United States

The physical architecture forms a high-level structure around the processes and data flows in the logical architecture. The transport layer defines the physical entities (subsystems and terminators) that make up an intelligent transportation system. In this layer flows architecture are defined, which interconnect the different subsystems and terminators in an integrated system. Generally, the subsystems provide a rich set of capabilities, more than what could be implemented at any place or time (Iteris, nd). Figure 4 shows the structure of the physical architecture of the intelligent transportation system of the United States.

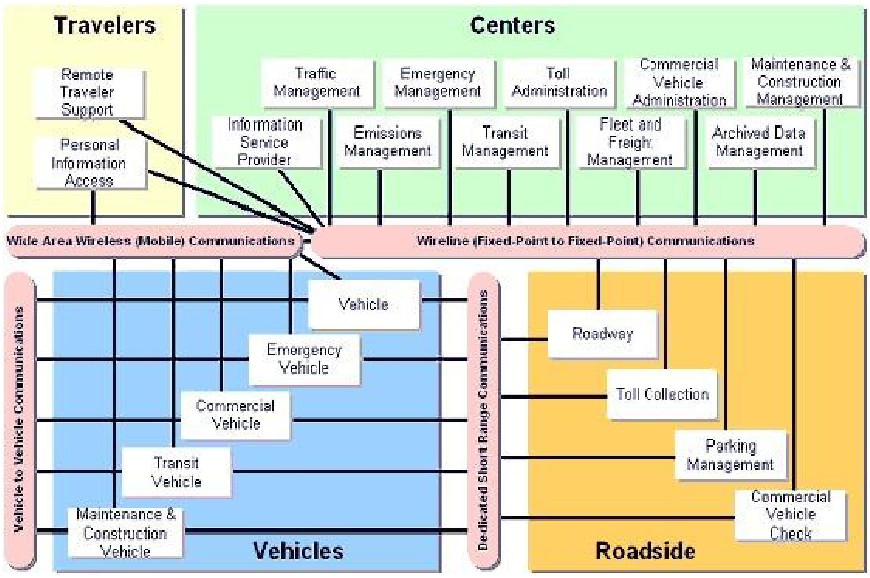

Fig. 4. Physical architecture of the intelligent transportation system in the United States

3 PROPOSED ARCHITECTURE FOR THE INTELLIGENT TRANSPORTATION SYSTEM

Any technique that uses information and control technologies can be decomposed into sub functions:

A. Data gathering.

B. Process and dissemination of the main information.

C. Arrangement and inspection support based on information.

On intelligent transportation systems, these sub-functions are applied to traffic, vehicles and people involved and use an extensive range of technologies. These functions can be summarized in:

1. Data acquisition

This category includes all functions that have to do with information gathering. The main requirement for this sub function is that the collected information must be accurate and to be available in the time it takes.

2. Data transmission

Data transmission is another key sub function in ITS services. There are two categories of technical means to transmit information: fixed terminals, such as telephone, radio and television; and mobile terminals such as cellphones and radio. Typically, they are also classified as wired and wireless transmission.

3. Centralized control room

Because of information of different nature is being collected simultaneously in different places, a control center that will consolidate and process all data is needed. In the control center is where operators receive the data and relying on different software and hardware tools, make decisions about the transportation system.

4. Vehicle

There are three basic types of sensors in vehicles: to record the absolute position, to record the relative position and to record the vehicle functioning. On the other hand, there are interfaces between the system and driver, which are also located in the vehicle, going from radios to complex navigation systems. Finally, in the vehicle also exist control devices that allow to operate the vehicle from the control center or operate itself based on the information it can gather from the system.

As part of the proposed architecture in this research, will be described the types of interfaces that must coexist among the devices of the intelligent transportation system, as well as the way they exchange information. Among the elements that the architecture specifies are:

1. Guidelines for choosing tactics of transportation information processing.
2. System elements, its main functions and organizations that implement them.
3. The information to be shared.
4. It must have an established framework for the Intelligent Transportation systems scheme.

An important feature is components interoperability. This means that all system components must accept, send and apply information and services from other components. Interoperability may occur at different levels, such as technical, institutional and operational. To do so standards are used, in order to regulate the behavior and data transfer in all aspects of intelligent transportation systems.

For the design of the proposed architecture the architecture of an intelligent transportation system in the United States is taken as reference, because it was the first architecture designed in which all other countries based on. The main purpose of an ITS architecture, is to protect the execution of external interconnection of the elements matching the architecture (e.g. Interconnections between specific centers, ITS equipment, vehicles, passengers and tourists.). The ITS architecture proposed in this investigation will match the actors, the available technological elements and those that appear in the future. Figure 5 shows the logical view of the proposed architecture.

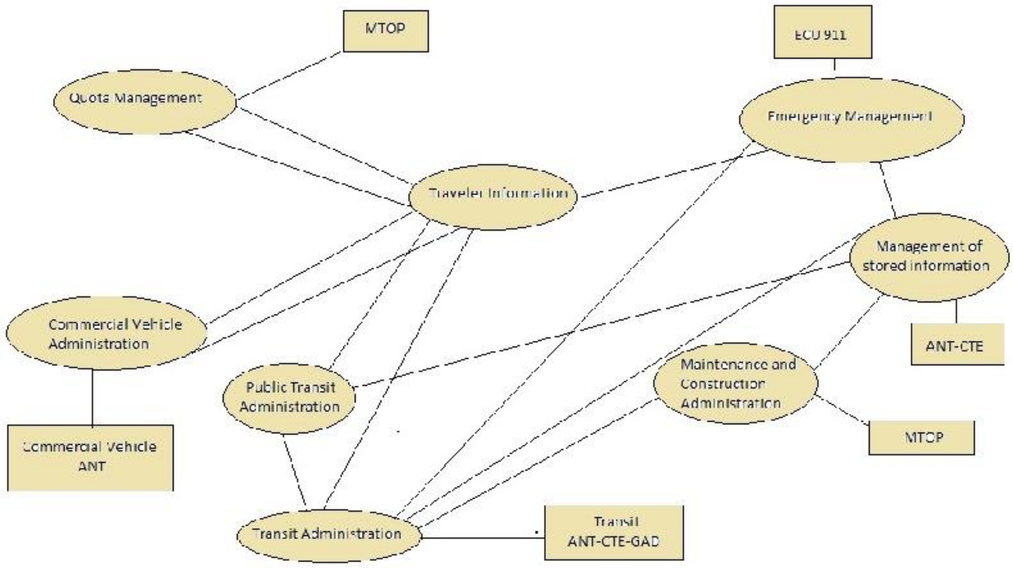

Fig. 5. Diagram of the proposed logical architecture

In the logical view of the architecture, the processes of user services and the flow among them are defined. For its preparation, each of the elements of user services are listed. Figure 6 shows the logical view along with the physical view of the architecture.

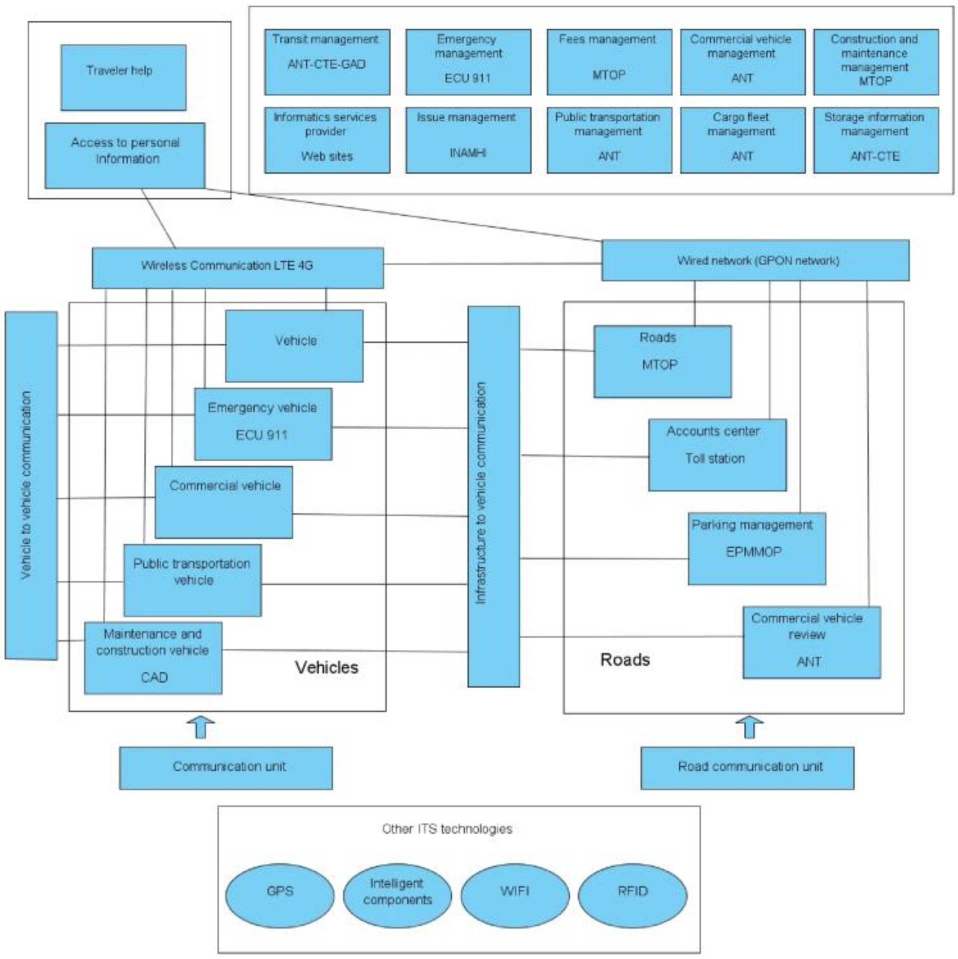

Fig. 6. Diagram of the proposed physical architecture

This architecture is made once the logical architecture and its graphical representation of the services provided to users are defined, properly sorted according to their functions. The architecture proposed in this research is based on the United States intelligent transportation system architecture.

3.1 Benefits of implementing an ITS in Ecuador

The implementation of an ITS will help drivers, either cars, trucks or buses, to prevent accidents and to safeguard the driver along the road. At the same time, it will also improve driver's visibility, especially at night and in bad weather. Due to the current status regarding to road safety in Ecuador, it is sensed that the benefits provided by the implementation of an intelligent transportation system would be:

1. Road safety

It will help to save lives, prevent injuries, reduce time, save money and thus promote the safe transportation. It will provide information about the work on routes, traffic collisions and other potential hazards. At the same time, it will help to prevent accidents, determine the severity of the crash and potential injuries and it will favor the emergency management system.

2. Accidents prevention.

It will help to warn and manifest disastrous situations, either natural cause events, human failure or attacks. Continuously monitoring the process of the transportation systems to ensure safety of people using the public transport system.

3. Efficiency and Economy

It will avoid impacts, saving time and money. The goal is to reduce the number of accidents, deaths or injuries caused by road accidents, in order to renew and accelerate the response of medical and technical services. It will be linked to immediate assistance units to provide initial care to the injured persons.

4. Mobility and Access

It'll help travellers by providing requested information without age restrictions. The ITS will make it easier to pay for transport services as it will contain a single payment electronic element; customer service and efficient work are the new needs.

5. Environment

Trips will be faster and less complicated, discarding congestion times. The objective is to reduce pollution every year. It'll keep a flowing traffic on highways, with or without tolls. It will provide information about weather, traffic on highways or streets.

6. Transport for all

Current transportation services are intended to provide the users the destination safely and efficiently, making it environmentally friendly.

4 Conclusion and future work

This research proposes an architecture for the implementation of an intelligent transportation system in Ecuador, to help improve accident rates and reduce human and economic losses. The applying of surveys and interviews to various entities of the country, allowed to define the services as well as the logical and physical architecture of the proposal. The user needs were identified through qualitative estimation of various criteria, which contributed essential elements to the construction of the proposed architecture. As future work, the goal is the implementation of the architecture in different cities, to improve the proposal through the spiral development and the detection of new problems and insufficiencies.

REFERENCES

[1] W. Barfield and T. A. Dingus, *Human factors in intelligent transportation systems*. Psychology Press, 2014.

[2] J. A. Acha Daza and J. C. Espinosa Rescala, "Hacia una arquitectura nacional para los sistemas inteligentes de transporte," *Publicaci{ó}n T{é}cnica*, no. 251, 2004.

[3] V. Katiyar, P. Kumar, and N. Chand, "An intelligent transportation systems architecture using wireless sensor networks," *Int. J. Comput. Appl.*, vol. 14, no. 2, pp. 22–26, 2011.

[4] L. Figueiredo, I. Jesus, J. A. T. Machado, J. Ferreira, and J. L. M. De Carvalho, "Towards the development of intelligent transportation systems," in *Intelligent transportation systems*, 2001, vol. 88, pp. 1206–1211.

[5] "Comisión Interinstitucional de Educación, Seguridad y Prevención Vial." 2013.

[6] CONASET, "Comisión Nacional de Seguridad de Tránsito." 2010.

[7] P. S. Porell and M. O'Connor, "Loop 101 Freeway Photo Enforcement Demonstration Program, City of Scottsdale, AZ," in *ITE 2007 Annual Meeting and Exhibit*, 2007.

[8] Y. GARCÍA ORTIZ and F. Mieles Pinto, "ITS: Una oportunidad para el sector transporte en Colombia," *Rev. Colomb. telecomunicaciones, 17*, vol. 8, 2010.

[9] J. Zhang, F.-Y. Wang, K. Wang, W.-H. Lin, X. Xu, and C. Chen, "Data-driven intelligent transportation systems: A survey," *Intell. Transp. Syst. IEEE Trans.*, vol. 12, no. 4, pp. 1624–1639, 2011.

[10] X. Chang, B. Y. Chen, Q. Li, X. Cui, L. Tang, and C. Liu, "Estimating real-time traffic carbon dioxide emissions based on intelligent transportation system technologies," *Intell. Transp. Syst. IEEE Trans.*, vol. 14, no. 1, pp. 469–479, 2013.

[11] J. Miller, "Vehicle-to-vehicle-to-infrastructure (V2V2I) intelligent transportation system architecture," in *Intelligent Vehicles Symposium, 2008 IEEE*, 2008, pp. 715–720.

[12] L. Wang, R. Wakikawa, R. Kuntz, R. Vuyyuru, and L. Zhang, "Data naming in vehicle-to-vehicle communications," in *Computer Communications Workshops (INFOCOM WKSHPS), 2012 IEEE Conference on*, 2012, pp. 328–333.