

Technical and Economic Evaluation of Sound Alarms and Their Effects on Road Safety

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Received: October 15 2013

Accepted: November 5 2013

ABSTRACT

Today, with ever-increasing number of vehicles and road trips, a lot of accidents on urban and suburban roads are seen. Human factor is one of the contributing factors in road accidents which usually involve driver's behavior and his failure while driving. In order to increase road safety, much research has been conducted among which making the transport system intelligent has had a significant role in reducing accidents. Sound alarm systems are one of the sub-branches of smart road systems which today play an effective role to alert the car drivers. In this paper, first, roadside and in-vehicle sound alarm systems are introduced. Then, advantages and disadvantages of sound alarm systems are studied and their effects on the increase of road safety are discussed. Finally, an economic evaluation to provide the necessary infrastructures for roadside alarm systems has been done.

KEYWORDS: intelligent transportation, audio warning, driver's behavior.

1- INTRODUCTION

Today, road in every country and region is considered as one of the most important indicators of development.

Ever-increasing population of people and vehicles on one hand and lack of proper development of the roads on the other hand have led to thousands of deaths, injuries, and disabilities each year. Many hidden costs such as costs of medical and psychiatry services, police services, road traffic accidents etc. are imposed on communities due to urban and suburban road accidents.

Limitations in the field of traffic management, directing the cars to suburban routes and costs resulting from these problems are the big challenges that seem to be dealt with by information and communication technology as an appropriate strategy through the means called vehicular intelligent communication technology. The use of ICT in transportation requires the provision of the communication context consisting of in-vehicle electronic and communication equipments and communication equipments on roadsides that need to be implemented by public telecom network.

On the other hand, in many road accidents, the driver is directly or indirectly influential. These effects are usually caused by driver's errors or delays in rapid decision-making. These delays and lack of rapid decision-making are mainly due to the lack of being informed and warned in time in emergency situations.

Normally, accidents distribution on roads network is not random and some spots have more frequencies which are called road black spots. Identifying and providing solutions to reduce crashes at accident black spots can be a great help in promoting the safety of road network [1].

2 – Research History

The first use of a system for controlling transportation dates back to the 1860s in London when a traffic light was installed at an intersection near the parliament for the safety of its members. The first modern traffic light was used in Detroit, Michigan in 1920. After that, over the time, intersections control systems, variable switchgears, speed control systems etc. were invented [2]. Gradually, primary traffic control lights with timing evolved into modern regular forms which are intersections control based on counting existing traffic. In 1920, some systems were installed at 5 points in the United States which were planned using the computers of that time (IBM 1800). Actually, this process was the starting point to use intelligent systems for traffic control.

In France, national network of 4,000-mile freeway is equipped with a 24-hour FM radio transmitter. Traffic information station has been established since 1988 and is still growing. Since 1988, about 60 percent of the freeways have been under the transmitter coverage [3]. The whole radio stations that have been established personally but work under the supervision of the government, is known as "Auto route FM" that are responsible for providing real-time information and traffic accidents to drivers. These stations broadcast their daily reports every 15 minutes for the entire network and announce traffic conditions, weather conditions, areas where

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construction, repair and maintenance operations are being performed, and other items. In these reports, they also broadcast safety recommendations, tourist information, music and commercials. Accident occurrence, traffic congestion, or weather condition in every part of the freeway after 5 minutes is broadcasted (as a breaking news) on FM frequency. French authorities believe that the use of this audio system is more cost-effective than variable message signs in the roads.

Angela W. L., et al. (2006), explored the different types of in-vehicle alarms and their effects on drivers' distraction in their paper [4]. They concluded that driver's recognition of an alert among other alarms that may be announced at the time of accident can lead to the reduction of his concentration in controlling vehicle. Sven Vlassenroot et al. (2008), in a study entitled "Speed management through vehicle measures, Intelligent Transport Systems and Intelligent Speed Assistance" investigated the strategies to control speed in an intelligent manner [5]. In addition to introducing the systems of intelligent vehicle speed control, they studied the impact of these systems on reducing accidents. These alarms alert the driver in case of emergency and force him to decelerate and even they automatically stop the driver from increasing the speed.

3 – Statement of the Problem

Driver weaknesses may show themselves in different forms. In general case, it can be interpreted as the reduction of control over the vehicle or weaknesses and delays in diagnosis and understanding of people, events and upcoming barriers. Generally, occurrence of an incident can be due to the closure of both eyelids (fatigue condition) and dazzling eyes (visual distraction).

Another dangerous state of distraction is when a driver consciously chooses to turn his attention to another issue in the vehicle and in fact the driver discards his complete attention to the problems he is faced with. In this case, commonly the vehicle control (such as moving between the lines or keeping pace) is not influenced, but another responsibility of the driver which is diagnosis and reaction to the likely events is severely defected.

For example, if the driver is moving with a fixed longitudinal distance and turns his attention to another issue, he cannot show a proper reaction if the front vehicle hits the brake suddenly; therefore, an accident would be inevitable. So, appropriate measures should be taken to identify the driver's distraction when using intelligent devices in the vehicle and strategies should be considered to reduce it as well.

Basically, safety level cannot be determined directly. However, indirect methods used to determine the effects of distraction-related safety are divided into several categories [6]. Driver's eye movement due to the extraordinary significance of vision while driving along with the interval between blinking and direction of vision are seen as the main criteria. Driver's performance and interaction with vehicle control equipments are other well-known criteria that keeping the car in between the lines, adjusting and stabilizing speed, keeping longitudinal and cross distance with other vehicles and reaction time on the upcoming events can be pointed out too. Control movements like how to control steering motion, accelerate, shift gear, and hit the brake and gas pedal are other measures that can be used for further control over driver's distraction. Finally, the time that the driver spends on every peripheral activity while deriving can be useful in some cases.

Standardization and improvement of the quality of the road network in order to increase road safety is important. In this regard, intelligent transport systems play an important role. Sound signals are part of intelligent road safety systems which are studied in this paper.

Intelligent vehicle communication system includes a set of capabilities, facilities and informative and electronic technologies that is used for sharing information between vehicles and the traffic control devices and works as an appropriate context. Intelligent vehicle communication system is designed and implemented based on the use of this technology and offers a variety of services and facilities in the field of safety, traffic management, and commercial services.

4 – Sound Alarms and Their Advantages and Disadvantages

In general, various information tools in this regard are divided into three categories: information tools on the road, in-vehicle tools and outside the road tools that are used to inform before traveling. In this paper, first, the sound alarm equipments inside the vehicle and after that, roadside equipments are studied. Then, economic evaluation of installing these equipments is carried out.

4.1 – In-Vehicles Alarm Equipments

These equipments are installed inside the vehicle. They are typically used for information during the journey, and are of two types of audio and visual. The audio type consists of a radio to advise the driver, especial wireless telephone lines, and private radio networks [7]. In figure 1, components of a road information system are displayed.



Figure1. Components of a road information system

4-2 - Forward Collision Alarm

This system warns the driver when the vehicle is about to have an accident with the front vehicle and makes the driver aware of the potential risk. This system includes a sound alarm along with reflecting lights that an example of which is shown in Figure 2. Also, whenever the distance with the front car is less than 2 seconds to reach, distance adjusting alarm is applied [8]. An example of a distance adjusting alarm with the front car is shown in Figure 3.



Figure.3. Following Distance Warning



Figure.2. Forward Collision Warning

4.3 - Lane Departure Warning

This system identifies the lining of the road by cameras attached to video processing equipment or other available methods, as shown in figure 4, and alerts the driver to any kind of vehicle deviations through sound alarms.

4.4 - Fatigue Alarm

The system controls the driver's entire moves such as the driver's hands, mouth and eyes movements from the beginning of the journey to the end by sensors, and warns fatigue-induced changes and distractions. An example of this system is shown in figure 5.



Figure.5. Fatigue Warning

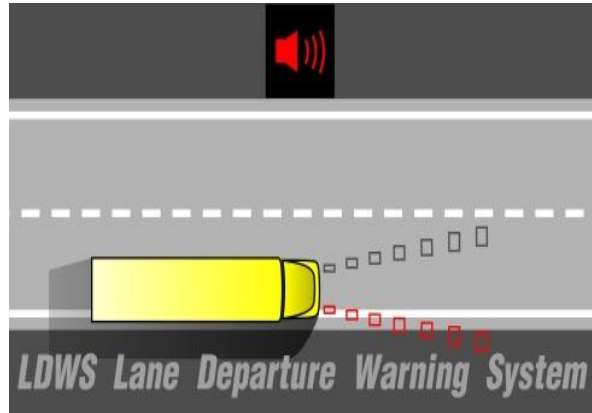


Figure.4. Lane Departure Warning

5- Economic Evaluation of Roadside Sound Alarm System Implementation

Technical evaluation of sound alarm system was described in the previous section and economic evaluation is discussed here. According to the surveys conducted, 4 square meters land possession will be required for the station installation. The cost of land possession and its leveling and preparation are shown in table 1 and also in table 2, specifications of the materials required and the estimated cost for the construction of a station are shown:

Table 1 - Estimated cost of land and preparation of the building (Figures in thousand Rials)

Total Value	Unit Price	Number	Title	Raw
800	200	4 m ²	Land	1
600	150	4 m ²	Leveling and Landscaping	2
700	700	1 m ²	Building	3
2100	Sum			

Table 2 - Estimated cost of the materials needed (Figures in thousand Rials)

Total Value	Unit Price	Number	Title	Raw
20000	20000	1	Galvanized Mast	1
15000	15000	1	Transmitter	2
5000	5000	1	Transmitter Antenna	3
1500	300	5 m	Cable	4
20000	20000	1	Power Supply	5
200	200	1	Receiver Antenna	6
2000	2000	1	Receiver	7
63700	Sum			

Other expenses including costs related to electric utilities and staffing costs are estimated in tables 3 and 4:

Table 3 - Estimated cost for electrical utilities (Figures in thousand Rials)

Final Cost	Explanation	Raw
2540	Membership Fee for Electricity	1
15000	Transformer	2
17540	Sum	

Table 4 - Estimated labor cost (Figures in thousand Rials)

Total Cost	Wage/Hour	Person/Hour	Title	Raw
12000	100	120	Project Manager	1
2240	70	32	Construction Force	2
7000	70	100	Mechanical Technician	3
4480	70	64	Technicians of Electrical Utilities	4
25720	Sum			

According to the above tables, fixed capital required for the establishment of alarm systems are in table 5. The depreciation cost and power consumption of this plan is obtained equal to 13,324 thousand Rials.

Table 5 - Estimated cost for electrical utilities (Figures in Thousand Rials)

Final Cost	Explanation	Raw
2100	Land And Building	1
63700	Equipment	2
17540	Electrical Utilities	3
25720	Human Resources	4
109060	Sum	
13324	Depreciation And Electricity Consumption	5
122384	Sum	

In general, implementation of each station requires 109,060 thousand Rials fixed capital and 13,324 thousand Rials working capital that the total capital required for setting up and operation of the plan is equivalent to 122,384 thousand Rials.

Generally, use of transport sound alarms can have many applications and can be used in different domains. Below are some of the advantages of sound alarm system:

- Fast road condition information to users
- Low cost of construction and implementation
- Ease of construction and installation
- Increase of road safety
- Reduce of losses

The positive effects of using these modern systems are so palpable that all countries are seeking to expand in various fields, but there are still some concerns that the use of these new systems individually or in combination may cause driver's distraction. A typical combination of these systems in the vehicle is shown in figure 6 that their synchronization during an accident can be effective in driver's distraction.

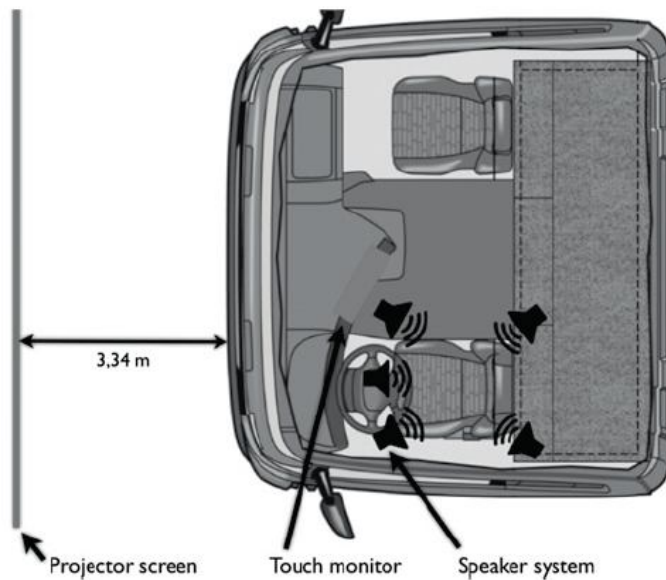


Figure 6 - Layout of alarms in the car

6 - Summary and Conclusion

In this paper, evaluation and study of sound alarm systems was introduced. One of the main applications of this system is using it in the suburban roads. In this way, these systems can be installed at one point or a road black spot and the user can be informed of the risk; therefore, he can make the necessary decision to deal with it. Transmitter installed on roadside sends sound alarm to the receiver installed inside the vehicle by radio waves from the time of entering the vehicle into the range of transmitter until leaving the area and then the pronouncer announces sound alarm every one-second as long as the ranges of the transmitter and receiver are located in the same area. Obviously, timely receiving information about the road by the driver can be crucial in right time decision making. Considering the fact that so many accidents on the road take place due to the lack of familiarity with the road, so use of these signs can be effective. The economic analysis conducted in this paper showed that availability of the required equipment is easy, cheap, and available that can be implemented with the cost of 122,384 thousand Rials. This cost compared to the cost of road accidents is very low.

Acknowledgment

The authors declare that they have no conflicts of interest in this research.

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