

Road Traffic RFID Pedestrians Detecting System for Vehicles

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Abstract

Safe road traffic, clean environment, environmentally friendly vehicles and eco-buildings are components of the world's vision of immediate future supported by scientists and statesmen. Aspiration for healthy environment and sustainable development of technologies give life for idea of smart cities which consist of all these visions towards modern world. The aim of research was connection pedestrians and alarm system of the vehicle to prevent road incidents with the help of RFID technology. There were proposed vehicle RFID system and tags for pedestrians. System was designed on the basis of scientists' research in this area. The main factors influencing the construction of proposed system were working range of the system and coverage width of the reading devices. Further were compared existent subsidiary systems for drivers versus designed system. The study represents the expected effectiveness of the proposed RFID system as well as the ability to implement it even in old vehicle control systems.

Keywords: RFID, smart city, vehicles, detecting systems, accidents, pedestrians, road traffic.

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1. Urban traffic in SMART cities

1.1. Visions of the urban traffic safety

New or innovative visions need to brand new solutions, like a conception of information and communication technologies, IoT and other smart technologies. The concept of a smart city dates back to the year 2006, but the most widely used has become in the last years. The idea of such cities is on track thanks to the modern state of environment and due to development of new technologies. The smart city strategy combines several basic aims are to move information technologies, to provide efficient traffic, to supply sustainable energy consumption and clean environment. Modern view on the smart city concept is based on connection of the objects

with the IoT technologies, design and construction the smart buildings, modernization of the urban network and global collection data for establishment new real-time city logistic system. This concept has gained international support from a variety of international organizations, such as World Health Organization (WHO), United Nations (UN), The European Innovation Partnership on Smart Cities and Communities (EIP-SCC), government, city and regional organizations, also by another projects and entities. In 2015 the United Nations Economic Commission for Europe began development of road safety model "Safe Future Inland Transport Systems (SafeFITS)" to support knowledge based on transport policy decisions related to road casualty reduction. The primary objective is to assist governments and policy makers in tailoring road safety policies in order to achieve more tangible results, in both developed and developing countries. SafeFITS comprises a database with global data

on indicators from all layers of the road safety management system and a set of statistical models fitted onto that database, with resulting outputs [20]. All these projects are aimed on solutions in government and information systems, on another hand they also support design smart buildings, vehicles, autonomous and self-governing object, which will not have a harmful effect on the environment. But on the other side, not every developing country is able to invest enough resources to ensure fully implementation of such projects. In this regard, the aim of research was design technical solution of the accidents and will help to disseminate idea of a smart city. According to Navigant Research, global smart city revenue is expected to grow from \$36.8 billion in 2016 to \$88.7 billion by 2025 [1]. Such information reflects the prospects of the study.

1.2. The real state of the European urban traffic

A new report by the WHO indicates road traffic deaths continue to rise, with an annual 1.35 million fatalities [20]. The main part of the victims of the road incidents are 5-29 year aged people (according to WHO “Global status report on road safety 2018” report). This segment of the people is strategically important for every country. It is a reason why experts create effective legislation, safer vehicles, safer roads, qualitative emergency care. It is expected that all proposals will be implemented and discussed at the Global Ministerial Conference on Road Safety in Sweden in February 2020 [20]. The main traffic solutions, which are being implemented in many countries are self-driving cars, hybrid and electric vehicles, modern city logistic system and associated laws. All these solutions did not wholly fulfil expectations yet; it can be seen in WHO’s report of the traffic accidents (Figure. 1).

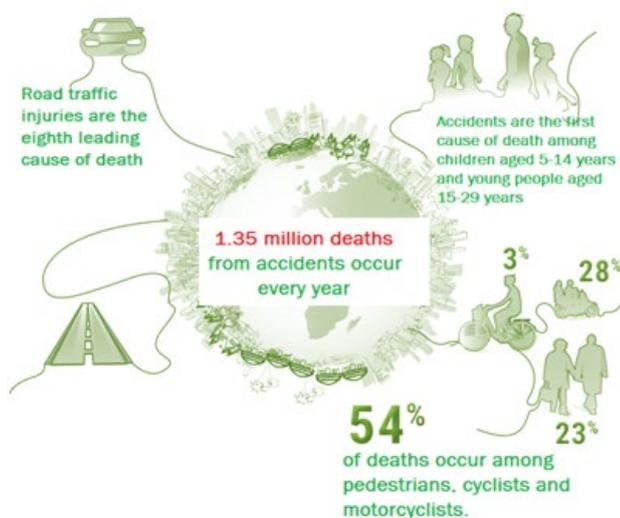


Figure 1. Road traffic injuries 2018 [20]

The car accidents happen most frequently on:

- Parking lots
- Stop signs

- Rural highways
- Two-lane roads [2].

This fact should be taken as ability to research existing preventive systems of the road accidents at the automotive industry.

1.3. Road traffic injuries prevention technologies

Modern and the most popular solutions proposed by automotive industry are self-driving cars and smart technologies that detects pedestrians and another participants of the road traffic, but the first one did not become widely used until nowadays [3].

Manufacturers of unmanned vehicle claim that the artificial intelligence, installed in it, allows making its own decisions effectively. The imperfect of self-driving cars are approved by volume of internet recourses [4]. The scientists, who studied these accidents with such kind of vehicles, made the schemes of the crashes. All scenes of the accidents displayed the imperfection of intelligent vehicle system [5]. That is why automotive enterprises do not cease to produce ordinary cars, however their production was modernized by technology of detection pedestrians on the road. The first announcement of such a system was in 2011 by Volvo in model S60 and was called the Pedestrian Detection System [6].

Principles of pedestrian recognition systems:

- Holistic pedestrian detection (moving object detection)
- Analysis of histogram of shades
- Partial detection of pedestrians (camera and radar lead around a contoured object)
- Pattern recognition in the database
- Recognition by multiple cameras.

The most operative speed of the system is the speed of 35 km / h, only under this condition, automakers argue that avoiding of collision is almost 100%. The range of the camera and the radar, according to the manufacturer, is up to 40 meters. Over this distance, recognition errors may occur. At speeds above 35km / h, the driver can-not avoid a collision [6], [7], [8].

Due to scientific literature: from different accidents, as well as calculations of engineers, at a speed of 65km / h the probability of a pedestrian colliding with a car is 85%, and at a speed of 50 km / h the probability is 45%. It is also noted, while reducing speed to 30km / h the probability of a collision will be equal to 5%. Automotive enterprises claim that to mitigate damage in an accident, they install special elastic bumpers and bonnets, as well as a pedestrian safety cushion hidden under the wind-shield and bonnet.

Referring to speed limits of the detection systems operation efficiency, a number of weaknesses arise, such as:

- High requirements for vehicle technical equipment,
- Reduced reaction during bad weather and at night,

- The quality of the system reaction due to the speed of the car,
- The high cost of the vehicles with this type of system [6].

As a result, the main lack of automotive systems is inoperability of the detection system at night time, as well as during bad weather (rain, fog or snow). In such conditions, camera and radar are unable to recognize the pedestrian and often give the false information. This is also influenced by location of sensors and camera, often they are behind central mirror or on the windscreen. Pedestrian detection using infra-red cameras is integrated to the night vision system, but it does not have an active collision warning feature.

Together with the Pedestrian Detection System and Night Vision Assist (NVA) systems, auto industry introduced Line Assist and Light Detection and Ranging system.

To represent advantages and disadvantage of these systems was created comparison table (see Table 1).

Table 1. Comparative table of automotive security systems [6], [7], [8], [9]

System name	Advantages	Disadvantages
Pedestrian Detection System (PDS)	<ul style="list-style-type: none"> - Able to detect the pedestrian on the distance up to 40 meters - At the vehicle's speed 35km/h can stop the vehicle - Detection not only existence of the pedestrian, but also define him 	<ul style="list-style-type: none"> - High requirements for vehicle technical equipment, - Reduced reaction during bad weather and at night, - The quality of the system reaction due to the speed of the car (non-useful at the speed more than 35 km/h), - The high cost of the vehicles with this type of system
Night Vision System (NVS)	<ul style="list-style-type: none"> - The infrared camera sends infrared radiation up to 300 meters. - High resolution cameras. - Cameras are triggered at a distance of 150-250 meters. The system also has thermal cameras. - At a vehicle speed of 45 km / h, it can detect an object at a distance of 80 meters 	<ul style="list-style-type: none"> - High requirements for vehicle technical equipment, - Reduced reaction during bad weather and at night, - The high cost of the vehicles with this type of system (price such of the sensor is 250\$)

- Used not only on expensive car, but also on low-cost,
- Effects on driver by vibrations of the wheel, by sounds, by visual signals and also can stop car without involving driver,
- Analyses road (150°) and the driver's state
- Scanning range 180°
- Efficient distance of detecting 250 meters
- Speed of detection
- Wide sphere of using
- Can be installed on any place of the vehicle
- The system requires clear road markings,
- System is sensitive to the dust road,
- Efficient only for road markings
- Optical sensor is sensitive to bad weather (rain, snow, fog and atc.)
- Uses only with another sensors in system, also install with PDS and NVS.

The systems are not suitable for all conditions of the environment, therefore there is an opportunity to develop alternative system, according to the Table 1.

1.4. The Radio-frequency identification (RFID) system in automotive industry

The RFID system is well-known in most of economic activities. This system find place in transport, finance and safety, veterinary spheres, retail, medicine, manufacturing, sport, consumption goods, airlines, and so on. According to forecasts, in 2024 year the distribution of RFIDs by economic sectors will be in such way (see Figure. 4) [21].

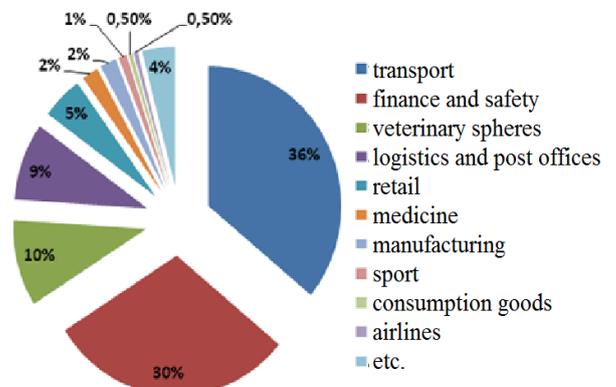


Figure 2. RFID Consumption by Industry [21]

The biggest part of the pie chart accounts for transport, it let us to assume efficiency of RFID technology in this sphere. If we take a look on global distribution due to geographic regions it can be seen that Europe is not on leader position (Figure. 3) [22].

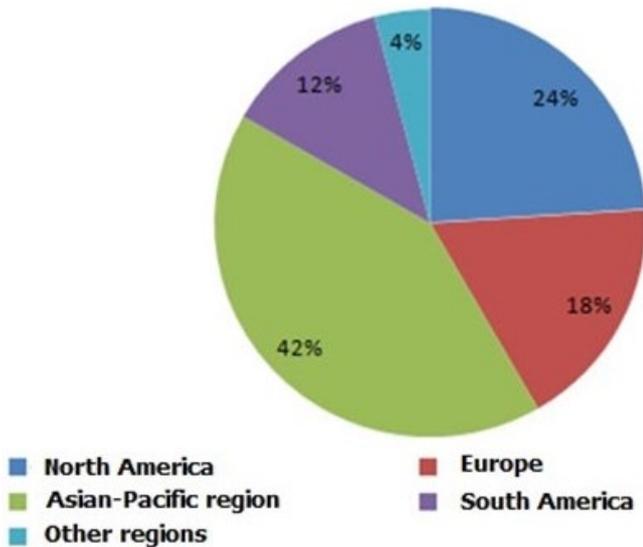


Figure 3. Geographic structure of the global market for RFID products [22]

Asian-Pacific region and North America take leading positions, according to Figure. 3, while Europe is on the third place on the global market. This indicator can be increased by introducing RFID system in new context. Such system can be used as pedestrians detecting system in automotive industry.

The research shows that RFID system was proposed as solution for city management systems before. Should be highlighted the research of Soichi Kubota, Oisín Morgan, D.F. Llorca and their group of scientists [11], [12], [13]. Their scientific articles were issued in 2006, 2015 and 2017 year. Despite the fact that the studies were established at different times - they have common features and their goal was prevention complex accidents on intersections. For example, the research of Soichi Kubota includes RFID tags for every participant of the road traffic, urban tag reader (repeater) and long frequency (LF) generators (see Figure. 4) [13].

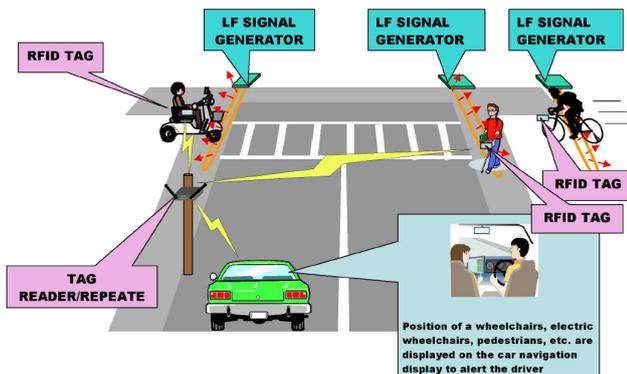


Figure 4. System overview [13]

These three studies undoubtedly have a significant contribution for development of urban infrastructure, but they were designed for city and as existent automotive systems these solutions should to prevent accidents on problematic areas as parking lots, intersections and stop signs. Returning to the statistics of accidents [14], the area of rural highways is still dangerous area and existing auto systems are not efficient enough (Table 1). To offer a suitable system, for these type of roads, should be considered features of movement on it.

2. Design RFID pedestrians detecting system

For successful providing long-range detecting of the vehicle RFID detecting system it is necessary to pick up eligible components.

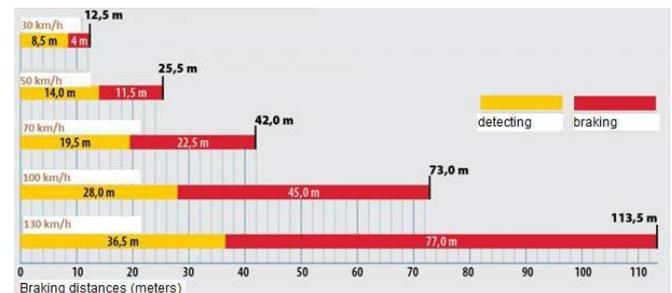


Figure 5. Braking distance of the car [23]

Significance of the long range system is approved by scheme of the car braking distance (Figure. 5). Designing useful system is based on selection of the most appropriate components. According to literature recourses, speed limit in European cities is 50 km/h and suburban medium speed is 90 km/h [23]. Proposed article is aimed on problematic areas, mainly on single carriage ways and express ways, therefore was taken speed 90 km/h for further calculations.

Factors which effect on RFID pedestrian detecting system productivity are:

- Tag
- Antenna
- Reader
- Accommodation of the components.

Main types of RFID tags: Passive low frequency (LF), Passive high frequency (HF), Passive ultra-high frequency (UHF) and Active UHF. Characteristics of these types are shown in below.

Table 2. Types of RFID tags [15]

Understanding RFID Tag Technology Attributes				
Technologies	Passive LF	Passive HF	Passive UHF	Active UHF
Standards	ISO 18000-2	ISO 18000-3 ISO 14443 ISO 15693	ISO 18000-63 EPC Class1 Gen 2	ISO 18000-7
Frequency	125 KhZ 134.2/134.4 khz	13.56 MHz	860 - 960 MHz	433 MHz
Read tags at more than 30 meters	No	No	Yes, with special reader configuration	Yes
Inventory boxes/pallets that contain more than 100 tagged items	No	No	Yes	No
Write a lot of information in the memory of the tag	Up to 8 kbits	Up to 64 kbits	Typically several bits and up to 64 kbits	Around 16 kbits
Well defined reading area	Possible	Possible	Difficult	Hardly difficult
Read stacked tags	Possible	Possible	Difficult	Possible
Read tags with a smartphone	Need an add-on	Native for majority of devices	Need an add-on	Need an add-on
follow GS1 general specifications	No	Difficult	Yes	No
Read tags on metallic items	Yes	Yes with special tags	Yes with special tags	Yes
Use in a humid or wet environment	Yes	Yes	Decreased performance	Decreased performance

Source: Claude Tetelin, National Reference Center RFID



Figure 6. The RFID detection system illustration

RFID tag was selected as appropriate due to its ability to contain text and graphic information. High frequency tags are more efficient in conditions of long range reading (from Table 2).

For RFID detection system is feasible to pick up the components for participants of the road traffic and for vehicle (see Table 3).

Table 3. Components of the system [25], [26], [27], [28]

	Elements	Detection range
For pedestrian	UHF tag OPP130	up to 30 meters
	Active locating tag CMC3606	up to 25 meters
	Tag CMC3609L	up to 100 meters
For car system	Active RFID Reader CMC195N	up to 100 meters
	UHF RFID antenna 5dBm	help to extend the range of the reader's signal (1 antenna has 70°)

For designing RFID system were proposed two types of RFID tags passive UHF and active UHF, it was caused by data from Table 3.

According to the Table 1, the RFID system should cover area on 180°, to support detection of pedestrians on the footpath and to able the braking distance of the car (up to 73 meters) (see Figure. 5).

The Figure. 6 shows the possibility of the components placement. RFID reader will be hidden beneath bumper and it will send a signal to the on-board media player, which will signalize by sound alarm about appearance of the pedestrian on the road. The advantage of such reader based on its small voltage (12 volts) requires. This fact gives an advantage for the RFID system, since does not require additional components or design changes of the car.

Three antennas will provide wide angle of detection a hundred meters away (Figure. 7).

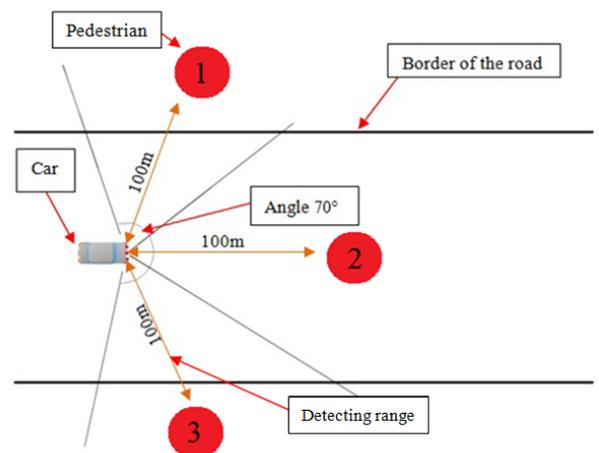


Figure 7. Detecting range of the RFID car system

Scheme (Figure. 7) shows the ability of the system's detecting range (red circles 1,2,3 are imagined pedestrians). Every antenna provides 70° reading angle. Such parameters of the system make this system more competitive than analogue automotive detecting systems. Antennas are able to detect on more than 180° angle and on the long distance (Figure. 7). Expected that RFID

system will approve the best features of the modern systems and exclude their weakness.

Testing of the speed abilities of RFID system was made by Xiaoqiang Zhang and Manos Tentzerisin [16]. Scientists said RFID system is efficient at the speed 150 km/h, this fact approves opportunities of vehicle RFID systems.

The brake distance of the car at the speed of 100 km/h is 73 meters (Figure.5), so it is reasonable to assume that RFID technology will be effective due to its reading range (100 meters). Cannot be rejected fact that RFID system should to fulfil the conditions of the tag charging.

Every RFID tag should receive energy from the reader and send the information signal back. This fact cannot be rejected, that is why should be determinate effective reading range (ERR) of the system. Where ERR of the system represents equation bellow (ERR of the system, ERR_r and TD_t are in meters). Where ERR_r is ERR of reader and TD_t is tag trigger distance.

$$ERR \text{ of the system} = ERR_r - TD_t \quad (1)$$

According to (1) there can be quantified the ERR of the proposed components due to their technical parameters [25], [26], [27], [28], [29]. There were selected the UHF tag OPP130 and Active RFID Reader CMC195N from Table 2.

100 – 30 = 70 meters – ERR of the system

The calculations enable assertion that ERR fulfils the requirements of the braking distance scheme. This statement is based on the European High Speed Restriction Act for single carriageways (90 km/h) [24] and Scheme of the braking distance (Figure. 7). This speed limit was the main condition for calculations bellow, because the top places of the road traffic accidents are single carriageways and expressways [14]. Due to the fact that roads have roughness, further research will be aimed on determination of the system effectiveness in conditions of road roughness as well as the efficiency of reading the number of pedestrians in real conditions of urban traffic.

3. Conclusions

The evolution of the technologies and innovations in the smart city concept encouraged researches on decrease of the road traffic incidents on problematic areas. The research has shown the bottlenecks of the modern preventive solutions of the road accidents. Thanks to existent researches of the scientists, was proposed more mobile system, than existed before. The advantages of proposed vehicle system are:

- 180° readout
- detection at a distance of 80 meters
- mobility of the system
- pedestrian tag contains graphic and text information
- tags are less bulky than in previous versions
- the system is not difficult to install and is suitable for any vehicle with a CPU.

The quality of such a system will not depend on weather conditions and should provide pedestrian detection at the braking distance at a speed of 90 km / h. There will be possible pedestrian detection not only at a crosswalk but also on a footpath. Communication between media-player and reader will produce the sound and visual alarm (depends on player) when pedestrian will be funded on the detecting distance. Expects that proposed RFID detection system not only decrease a number of the road accidents on studied type of roads but also will create new preventive solution for pedestrians and vehicles. Further research will include testing the proposed system in real conditions with related measurements.

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