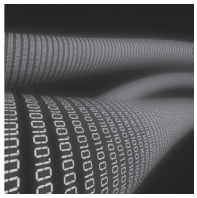

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Smart system integrating modules with particular significance for rail crossings safety

T. HEJCZYK, B. WSZOŁEK, A. GAŁUSZKA, R. OGAZA, G. KAMIŃSKI, D. SURMA
ENTE Sp. z. o.o., Gaudiego 7, 44-100 Gliwice, Poland
EMAIL: t.hejczyk@ente.com.pl

ABSTRACT

This paper presents a prototype system being part of an Integrated System of Supporting Information Management in Passenger Traffic (the polish acronym of the system is ZSIKRP Demonstrator+). The system has characteristics distinguishing it from other products available on the market. The system will be tested on a demonstration scale in real conditions. Currently, a prototype system is being prepared for testing by Mazovia and Wielkopolska Railways. It should be noted that main problems for carriers, rolling stock manufacturers and factories that modernize rolling stock are: multiple installation manuals and ways of maintenance. They lead to confusion during the exploitation of rolling stock. The prototype system offers an integrated solution with a unified service, which guarantees a much lower costs and improves the comfort and safety of passengers. Moreover, ZSIKRP system focuses largely on ensuring the safety of travelers in electric (EMU - type) and diesel (PCS - type) vehicles. It takes into account the possibility of practical implementation of the module allowing automatic detection of an improper behavior of drivers. It is done at rail crossings by continuous image analysis and abnormal situations recording.

Keywords: rail crossing monitoring, safety in passenger railway traffic, collision detection module

1. Introduction

Project target group in Poland include 14 carriers (seven companies are owned by local authorities). Analyzing historical data from 2011 one can note growing trend in passenger rail transport. The increase in transport performance slightly exceeded 1.4%. This was particularly marked in the segment of regional transport. The limiting factor is the cost of access to rail services that is mostly much higher than in case of bus or individual transport.

Therefore, there is a need to compensate the high cost of access to rail services with additional facilities. The ZSIKRP Project provides additional services such as access to the Internet and Intranet.

It should be noted a high competitive road transport [4]. The factor influencing distribution in the transportation tasks, thereby influences also on the transportation task volume in the public transport, is the rate of motorization (the number of passenger cars per 1000 population), which in 2011 amounted to 470 (compared to 447 in 2010). The highest rate in Poland was recorded in the regions: Wielkopolska (531), Mazovia (518) and opolskie (512), and the lowest in podlaskie (409), podkarpackie (417) and warmińsko-mazurskie (418). However, the road carrier doesn't provide such functionalities like: wireless Internet access, collision and risks detection module, sending information about threats to the Crisis Management Center, rail crossings monitoring.

The growth rate of the number of passengers travelling in 2012 was higher than compared to the previous periods 2010/2011 [1]. It should be noted that the number of passengers traveling on shorter distances increased, and the number of passengers travelling on longer routes decreased.

Simultaneously, significantly increased the number of passengers in the carriers providing services for local routes and distances, including one province (Wielkopolska Railways - start-up in 2011 and almost 6-fold increase from 0.6 million to 3.3 million passengers

and 1.2% market share) or on board trains operating within the large urban agglomerations which are complementary transport urban system (SKM in Warsaw initiated additional new connection in June 2012 from the Chopin Airport to the city center). It should be noted that during the EURO 2012 a new line of SKM Warszawa (significant increase of about 5.8 million passengers from 11.45 million to 17.27 million, that is 51%) was very popular and evidenced a high need to run such connection.

The Rail transport very efficient joined to the public transport system in the Warsaw area as an alternative, faster and more convenient form of communication, that can be compared to individual transport. Installation of ZSIKRP system in proposed form may further strengthen the position of rail carriers, offering systems with much better functionality, security and features than existing on the market.

It should be noted that the improved regional rail offers new and modernized fleet, convenient schedules, renovated stations, common public transport ticket, new investments, e.g. car parks at rail stations (so called Park & Ride). The designed system in it's from is complementary to the structural investment on the Rail. Such a situation may contribute to the gradual formation of new habits of travelers, changing car on suburban rail [1].

Basis on the diagnosis of the rail transport market, it is concluded that it is necessary to take any actions that will bring the industry a key role in the transport system of the country, which will seize the opportunities, threats marginalize and ultimately, it allows to provide of high quality services and profitability. ZSIKRP system with its functionality and in its proposed form would have a support function.

Basis on the above data and analysis it is justified to introduce practical implementation of a prototype ZSIKRP system in Wielkopolska, where the rate of motorization is the highest, while simultaneous the largest, because 6-fold, increase of passengers number and in Mazovia province due to the ability to service very heavy traffic and representative functions in the region.

2. The concept of the ZSIKRP System

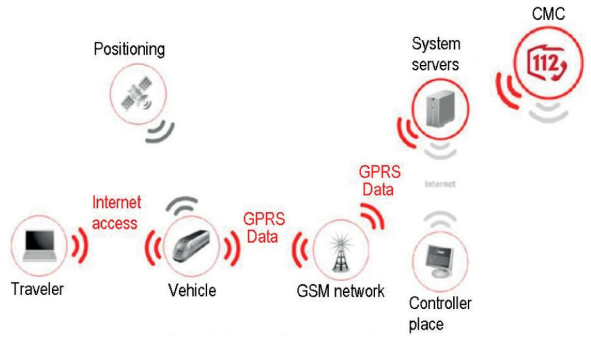

Fig.1. The circulation of information in the ZSIKRP System CPU [3]

ZSIKRP system (Fig. 1) [8] is designed for installation in in electric (EMU - type) and diesel (PCS - type) vehicles. It allows to transmit the current passenger information, GPS vehicle location on a digital map, GSM data transmission [5], monitoring and recording of video in selected areas of the rail vehicle, passenger flows counting, connectivity to the Internet. The system allows to view schedule on the monitor by the driver and the login in the system. The system has a modular structure, therefore, there is possibility of scaling on any number of vehicles.

It should be emphasized that the ZSIKRP Project concerns travelers safety. To achieve this serve an innovative solution consisted collision and threats detection modules [9], fire alarm monitoring [10], rail crossings monitoring. Very important in this place is the functionality of the Supervision Center module, which allows data collection, archiving (Fig. 1 - system servers) [7].

This is significant that it will be possibility to integrate the system with the functioning systems like Crisis Management Centre (CMC). The enhanced functionality Supervision Centre, may enable realizing decision-making center function. The telecommunication infrastructure based on GPRS technology and possibility to transfer data are also important. Experience in the practical implementation of safety systems shows that this type of transmission is the most optimal and reliable. GSM coverage throughout the country enables to implement the system in every corner of the country. Until now, there weren't systems that in such a comprehensive way have taken themes the safety of passengers in terms of directly inform emergency services on the basis of data from the: information passenger module, collision and threats detection module, fire alarm module. Providing all the data on the geographical location of the catastrophe, the number of passenger allows to protect the right amount of forces and resources in reserve to control crisis situation (the event) It should be emphasized that all the necessary data can be transmitted to CMC (Fig 1).

3. The structure of rail crossings monitoring module

The crossings monitoring module enables intelligent detection of vehicles breaking traffic rules at rail crossings by emergency signals activation. Information about the event together with pictures are sent immediately to the Supervision Centre. The module is able to make error-free identification of vehicles independently of weather conditions. This innovative software module doesn't require connection to the controller of traffic lights. The module is also not a part of the railway infrastructure.

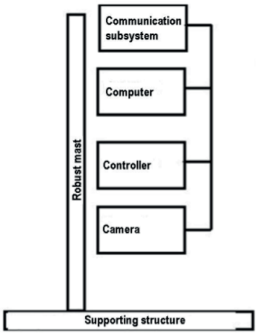

Fig.2. The block diagram elements of the rail crossings monitoring [own study]

The module includes (Fig. 2):

- communication subsystem (GSM modem, Ethernet),
- computer,
- camera,
- chassis,
- mast.

The camera has appropriately selected parameters in order to assure the quality of the image. Due to the fact that the computational and communication unit (that includes a modem, the computer and the controller) works outside the buildings, the housing has a high level of tightness and is vandal-proof chassis. Used components allow to work in a wide range of temperature. For dissipating excess heat serve a radiator that is an integral part of the chassis. The rail crossings monitoring module should be installed at a minimum height of 4 m, on an adequately strong structure.

Block diagram of the rail crossings monitoring module has shown in Fig. 3.

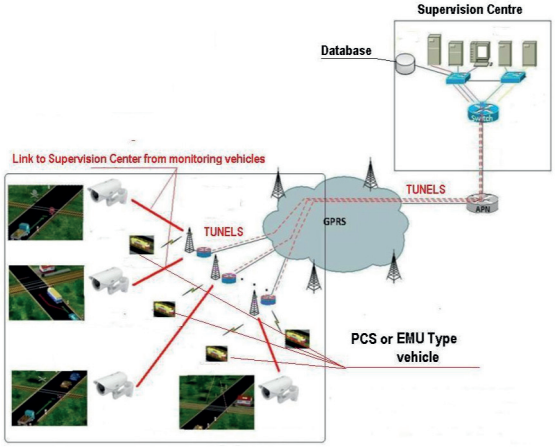

Fig.3. The idea of crossings monitoring module. Patent dated 09.03.2014. application number P.409360. The method of surveillance and alert at railroad crossings [own study]

An analysis of the possible configurations of the system by examining the potential and practical ways to install the system were performed. Below the idea of the installation for crossings with active optical signalling at the double rails, leave railing (Fig. 4) and the crossings monitoring with a red light and the single rail (Fig. 5.) are presented.

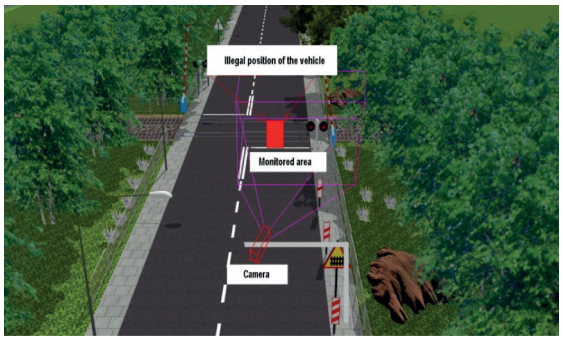

Fig.4. The idea of the crossings monitoring with active optical signalling at the double rails, leave the barrier [own study]

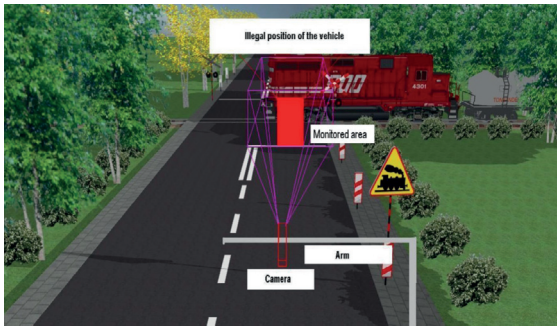

Fig. 5. The idea of the crossings monitoring with a red light and the single rail [own study]

Implementation of advanced image processing algorithms DIP (Digital Image Processing) allows to registration of breaking the traffic rules at turned on traffic lights for logging events. The algorithm uses advanced mathematics methods described in [11]-[14]. Recorded events will be archived on the server in Supervision Centre module after sending them over the network.

System interface allows flexible adaptation to the requirements of environmental parameters related with the conditions and the rail crossing characteristics monitored by module (Fig. 6.).

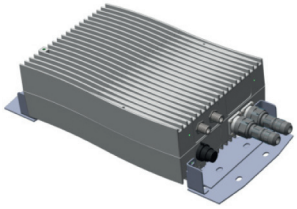

Fig 6. The design of computable-communication module (containing computer, controller and the communication subsystem) [own study]

The crossings monitoring module allows:

- automatic detection of inappropriate behavior of drivers at crossings by continuous image analysis and recording of abnormal situations,
- immediately sending information about the event (unfounded drive on a railway crossing at the moment of leave barriers or active traffic light) to Supervision Center module,
- sending pictures over the network to the Supervision module,
- identification of the vehicles in various atmospheric conditions without necessity connection to the traffic light controller,
- the generation of information about a vehicle's entry at the avid, flashing red light and transfer records to the Supervision Center module,
- implementation of advanced algorithms for image processing and detection of vehicles on impermissible areas of the road at the avid, flashing red light on the railway crossing,
- archive video (with the imposition of a timestamp) by the rail crossings monitoring module,
- automatic transmission of an information about offence to proper emergency services systems,
- reliability and operation over a wide range of temperatures and harsh weather conditions,

- time synchronization through an embedded GPS,
- communicate using Ethernet,
- communication via GSM network (wireless data transmission) in case of unavailability of Ethernet-based network.

Fig. 7. Configuration menu project crossings monitoring module [own study]

The module involve:

- client built -in: ftp, email, scp,
- graphical configuration interface (Fig. 7). Configure the required parameters, eg.: the number of lanes on which detection is to be made, the number of pictures, the delay of registration, the length of pictures, IP configuration, email, etc.,
- encrypted data channel for files,
- robust mast.

ZSIKRP system doesn't interfere directly into the security and infrastructure systems. But it enables monitoring of rail crossings without interference in rail infrastructure. This is a module that allows the registration of improper behavior of drivers of vehicles, which are related to the violation of traffic regulations.

Structure of the system therefore allows not only monitoring, but also to inform the appropriate emergency services about traffic offense, which may cause a catastrophe [2].

Information are transmitted to the appropriate services in order to recognize the identity of the driver (based on the registration number of the vehicle). It would allow, as a consequence, the enforcement of penalties. UTK report shows this to be a necessity in order to the impact the penalty [1].

4. Conclusion

The main target and the most important benefit from the application of the rail crossings monitoring module is to increase safety at crossings.

Unfortunately, the national statistics is unfavorable, i.e. every year in accidents at level crossings approx. 35-45 people are killed. Our country ranks fourth in Europe in terms of this kind of accidents.

Most of these accidents happen at unguarded crossings, but also to ten people a year are killed at level crossings guarded (approx. 1/4 of the total number of accidents at level crossings), as a result of motor vehicle collisions on the turnpike, sometimes as a result of negligence of railway workers [6].

Most of these accidents take place at unguarded crossings, but also to ten people a year are killed at level crossings guarded (approx. 1/4 of the total number of accidents at rail crossings), as a result of car collisions with the rail turnpike, sometimes as a result of negligence of rail workers.

The rail crossings are dangerous places on the road due to the converge of rails with the traffic lines of different users and also due to the non-respect rules by users. In the case of a collision of train with another vehicle (car), the latter hasn't chance due to the difference of the masses. Thus, placing recording equipment on the most dangerous places undoubtedly contributes to improving safety at rail crossings and limits the negative effects. These conditions will be ensured by the rail crossings monitoring, integrated with ZSIKRP system, providing individual identification of the place, the time, the vehicle and driver.

Acknowledgments

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The Polish Patent Office received a patent describing manner of on rail crossings monitoring, dated 09.03.2014, the number of the P.409360, "The method of surveillance and alert at rail crossings."

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