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INTELLIGENT AND INTERACTIVE SYSTEM IN RAIL VEHICLES WITH PARTICULAR SIGNIFICANCE FOR RAIL CROSSINGS SAFETY

Abstract

This paper presents a prototype system being part of an Integrated System of Supporting Information Management in Passenger Traffic (ZSIKRP Demonstrator+). The system is tested on a demonstration scale in real conditions. 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 improves the comfort and safety of passengers. Moreover, ZSIKRP system focuses largely on ensuring the safety of travelers in electric EN57 1756 and diesel SA 132 006 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.

INTRODUCTION

ZSIKRP Project concerns travelers safety. To achieve this serve an innovative solution consisted collision and threats detection modules, fire alarm monitoring , 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).

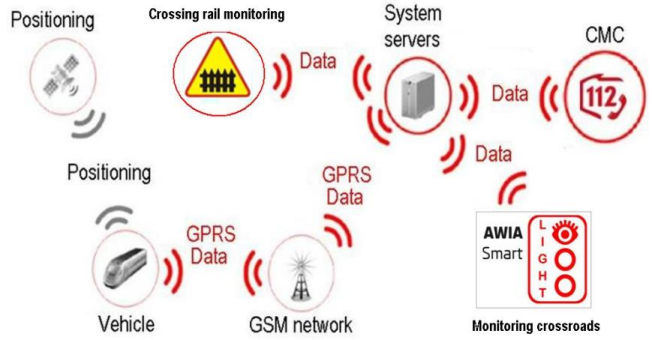

Fig. 1. *The circulation of information in the ZSIKRP System*

ZSIKRP system presented above (Fig. 1) [1-5] is designed for installation in in electric and diesel vehicles. It allows to transmit the current passenger information, GPS vehicle location on a digital map, GSM data transmission [6], 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 [1-5], fire alarm monitoring, rail crossings monitoring [1-5]. This is significant that it will be possibility to integrate the system with the functioning systems like Crisis Management Center (CMC). The enhanced functionality Supervision Center, 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 [6-8]. 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).

1. THE MAIN ELEMENTS OF THE RAIL CROSSINGS MONITORING MODULE

The crossings monitoring module enables intelligent detection of vehicles breaking traffic rules at rail crossings by emergency signals activation [9,10]. Information about the event together with pictures are sent immediately to the Supervision Center and send immediately XML frame to Crisis Management Center (Figs. 10, 11).

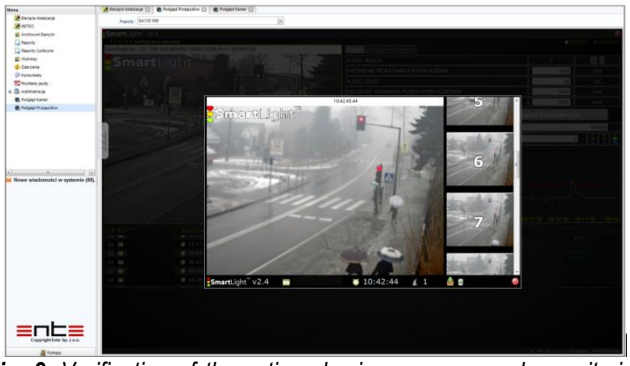

Fig. 2. *Verification of the actions basing on crossroads monitoring module in different weather conditions in real conditions on road crossing*

The module is able to make error-free identification of vehicles independently of weather conditions (Fig. 2). 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. The rail crossings monitoring module includes: communication subsystem (Ethernet), computer, camera, chassis, pole, mast. 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. Recorded events are archived on the server in Supervision Center module after sending them over the network.

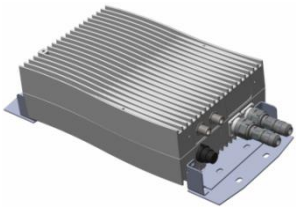

Fig. 3. *Visualization of computable-communication module (containing computer, controller and the communication subsystem - Ethernet)*

System interface allows flexible adaptation to the requirements of environmental parameters related with the conditions and the rail crossing characteristics monitored by module. 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 (Fig 3). 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 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. Before tests at level crossings tests were performed at crossroads (Fig. 4).

Fig. 4. *Visualization of computable-communication module (containing computer, controller and the communication subsystem - Ethernet)*

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. 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 (in Poland) shows this to be a necessity in order to the impact the penalty. Below the testing the system on a real object a rail crossing were presented (Fig. 5).

a) b)

Fig. 5. *Calibration of the system during the test on a real object - checking the detection of red lights, rail crossing in Tychy, Poland a) Registration rail crossing b)*

Monitoring module crossings allows for automatic detection of inappropriate behavior of drivers at level crossings by continuous image analysis and recording of abnormal situations. Information about the event (intrusion of a vehicle with an active traffic light) is sent immediately to the Supervision Center and the train (Fig. 6) is in the area and aimed in the direction of travel, for which there has been a breach of a rule, in order to immediately signal the event drivers. Supervision Center module is sent across the WAN footage. In a similar way operate automatic detection entry to the red light wheeled vehicle in a prohibited place and time. The following are the test-facilities system integration ZSIKPRP system monitoring intersections in order to obtain the actual test signals in an application Supervision Center module.

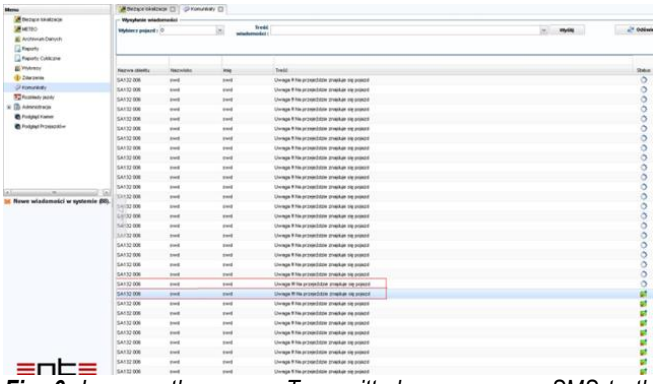

Fig. 6. *Logs on the server. Transmitted messages as SMS to the terminal driver*

Information about the event (drive by the vehicle in prohibited place (situation incorrect) with active traffic on red light) is sent immediately to the Supervision Center module and the Supervision Center module sends information of all the trains in the area and aimed in the direction of travel, which has been a violation, the purpose of immediate alarm about event for drivers in rail vehicles. A module applications in Supervision Center module implemented the algorithm that 800 meters (Fig. 7) from designated crossing sends information as SMS message on terminal in cab driver in rail vehicles.

The following is a message sent in the form of the inscription "Vehicle on a level crossing, Attention!" (Fig. 8).

The following step is generation an email to the address indicated in the Supervision Center module with information of an alarm from the crossings monitoring module (Fig. 9).

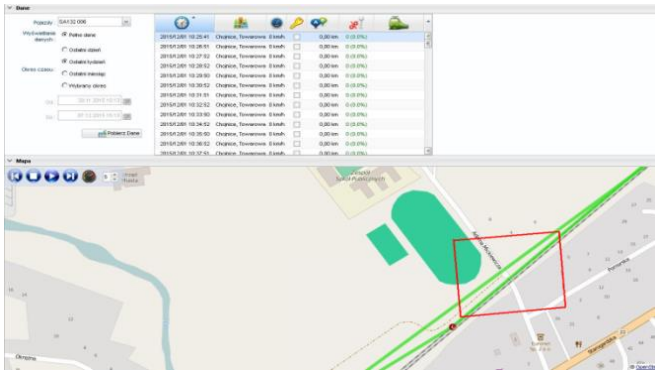

Fig. 7. *Visualization of application designated to test the algorithm on a level crossing in the city Czarna Woda, Poland*

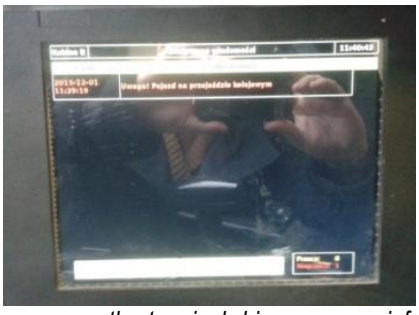

Fig. 8. *A message on the terminal driver appears informing about the danger: "Vehicle on a level crossing, Attention!"*

Fig. 9. *Mail with notification of alarm occurrence from the crossings monitoring module*

The next stage is generating frame XML from server in the Supervision Center module to Crisis Management Center - System SWD with the ID number of the device (@ rlid @) the crossings monitoring module and the exact date of the system (@ date @) in target the enforcement of penalties for road traffic offenses committed at railroad crossings. The communication protocol between the system and the integrated computer system Crisis Management Center (CMC, Fig. 1) in the form of existent dispatch systems - Supervision Support System (SWD) is based on communication using XML frames. Frame SWD system is generated when an overload higher than, for example. 2g in any axis of any accelerometer, occurrence of fire, traffic offenses. The message is send on specified in the configuration of the IP address and port of the system. The transport layer is realized based on the connectionless UDP protocol. The message requires confirmation, otherwise it will be a sequence of frames every 5 seconds until the exhaustion of the number of times specified in the configuration.

The following is a part of the frame describing ID of appliance and exact time and date of accident.

A part of XML Frame

```
<object>@oName@</object>
   <objectID>@oID@</objectID>
   <longitude>@lon@</longitude>
   <latitude>@lat@</latitude>
   <date>@date@</date>
...
      <redlight>
         <ID>@rlid@</ID>
      </redlight>
      <optional>
         <speed>@speed@</speed>
         <din>@din@</din>
         <train_number>@trainNO@</train_number>
      </optional>
</Event>
```

This two way protocol enables to send to potential Crisis Management Center, responsible for the area of administrative necessary data on a rail vehicle collision with another vehicle or crash (using collision and threats detection module and the central module SIP – central processing unit module) in the form of necessary data such as: name of the vehicle, the exact identity vehicle, the exact location (Passenger Information and Dynamic Timetable Module), the number of passengers at the time of the crash (information from the Passenger Flows Counting Module), vehicle speed at the moment of impact (information from vehicle diagnostics module / Fuel Consumption Optimization Module - speed information), indicate the accelerometers and other sensors, for example. gyroscope, strain gauge bridge (collision and threats detection module detection option in the side of the vehicle) [1-5]. Generate notifications (frame XML) to the module Crisis Management Center - the system SWD (existent dispatch systems) server Supervision Center module, the module implementing the algorithm monitoring module crossings which notice dispatcher, eg. police, emergency services, guard the city, officials of SOK, fire brigade of the occurrence of the offense and the possibility of a potential accident.

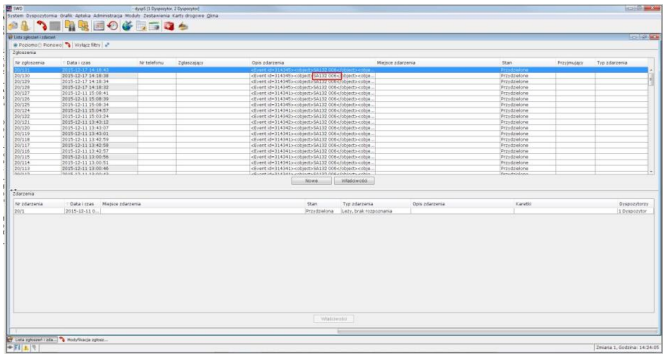

Fig. 10. *The list of entries generated from the server Supervision Center module to Crisis Management Center - SWD system for vehicle SA 132-006*

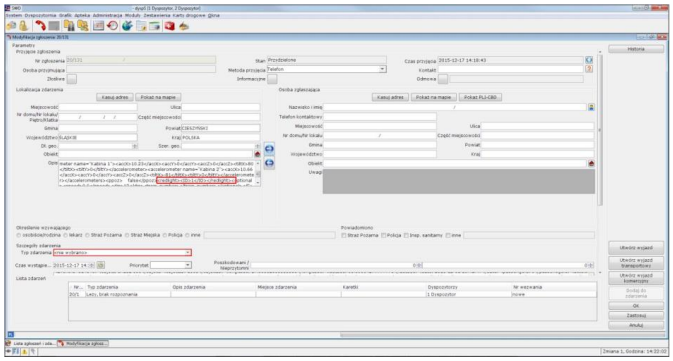

Fig. 11. *Open frame application module Crisis Management Center - SWD system after generating frame XML from Supervision Center module, with a parameter - the ID number of the device monitoring module crossings, a form also includes a time frame acceptable XML, meaning the time of acceptance of the notification*

CONCLUSIONS

The crossing rai monitoring module is used to register vehicles crossing on the stop light on rail crossings, according to earlier defined boundaries conditions. Implementation of the advanced processing algorithms of the image (DIP - Digital Processing Image) allows for the intelligent detection of vehicles being in protected areas of the crossing rail, in the moment of the appearance of the stop light on the indicator, for example S1 or S2 described. Every registered event is being archived in the form of photographic material and the film presenting the course of car. The system automatically is sending the registered offence to systems of the Services responsible for the road safety or eg. rail safety (service railway security - SOK).

The interface of the system lets for elastic adapting environmental parameters to requirements associated with these conditions. The crossings rail monitoring module is an autonomous system and doesn't require integration with the controller of rail traffic lights, eg. S1, S2. He consists of the analytical-communications module and the anti-theft camera. The communications module transfers data on-line to Supervision Center module and immediately send necessary (registration number, date and exact time) information to Crisis Management Center in target the enforcement of penalties.

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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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INTELIGENTNY I INTERAKTYWNY SYSTEM W POJAZDACH SZYNOWYCH ZE SZCZEGÓLNYM UWZGLĘDNIENIEM BEZPIECZEŃSTWA NA PRZEJAZDACH KOLEJOWYCH

Streszczenie

Artykuł przedstawia prototypowy system będący częścią zintegrowanego systemu wspomagającego zarządzanie informacją w ruchu pasażerskim (ZSIKRP Demonstrator +). System został zweryfikowany w skali demonstracyjnej w rzeczywistych warunkach. Należy zauważyć, że główne problemy dla przewoźników, producentów taboru kolejowego i fabryk, które modernizją tabor kolejowy to: powielane instrukcje instalacyjne i procedury utrzymania. W konsekwencji prowadzą one do nieporozumień w trakcie eksploatacji taboru. Prototypowy system oferuje zintegrowane rozwiązania dla ujednoliconych obsług i usług, co wpływa na poprawę komfortu i bezpieczeństwa pasażerów. System ZSIKRP skupia się głównie na zapewnieniu bezpieczeństwa podróżnych w pojazdach EN57 1756 i SA 132 006. Uwzględniono również możliwość praktycznego wdrożenia modułu umożliwiającego automatyczne wykrywanie nieprawidłowego zachowania kierowców. Realizowane jest to dzięki modułowi ciągłej analizie obrazu i rejestracji nietypowych sytuacji na przejazdach kolejowych..

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