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Integrated System for Car Park Management and Ecall Road Accident Signalization

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Abstract — with the planned deployment of the eCall system in the European Union until 2017, more and more electronic device manufacturers start to develop and test the eCall In-vehicle system devices. The device is in standby mode most of the time, so in order to use its resources in a more cost efficient way a team from the Technical university-Sofia developed an IVS device with additional functions as part of a complete system for car park management and eCall road accident signaling. This paper presents the developed system's specifics and realization.

***Index Terms*—car park management, eCall, fleet tracking, mobile vehicle event data logging.**

I. INTRODUCTION

Lowering the amount of victims and severity of car accidents is a major part of the European Union's 2020 target frame. The measures taken to lower the overall number of car crashes to the moment give positive results in all member states, but the pace it is happening with is not fast enough. To answer this ERTICO-ITS with the supervision of the European Commission developed a pan European automotive 112 based emergency call system – the eCall system [1], implemented in EU under the HeERO, HeERO2 and I_HeERO projects. Using timely signalization and precise GPS positioning the system allows for faster and more adequate rescue force reaction, thus increasing the chance to save more people. In order to do that the car is equipped with an In-vehicle system device (IVS) which monitors constantly for the occurrence of a car crash and automatically dials the 112 emergency centers, sending valuable accident related information to the operator. Prototype of such a device was made by the Technical university-Sofia's (TU) team as part of the HeERO2 project [2]. The experience showed that even on a larger production scale the cost of the IVS device is not negligible. Apart from the said cases of road accidents the device is in a stand-by mode all the time, leading to nearly zero cost efficiency. This is the reason why eCall standards do not exclude the possibility to use the IVS for other purposes, as long as they do not interfere with the main eCall function. Following this TU's team together with Enterprise Communications Group Ltd, developed an integrated system that supports car park management functions in addition to performing eCalls. This paper presents the system's structure, functions and specifics.

II. SYSTEM STRUCTURE AND MOTIVATION

In order for the eCall system to work two components are needed – the IVS device installed in the car and a specialized 112 center PBX, which can decode data sent by the device. According to the eCall system the IVS in a stand-by mode most of the time is activated only by manual triggering or automatic car crash sensing. After completing the eCall the device again return to stand-by mode.

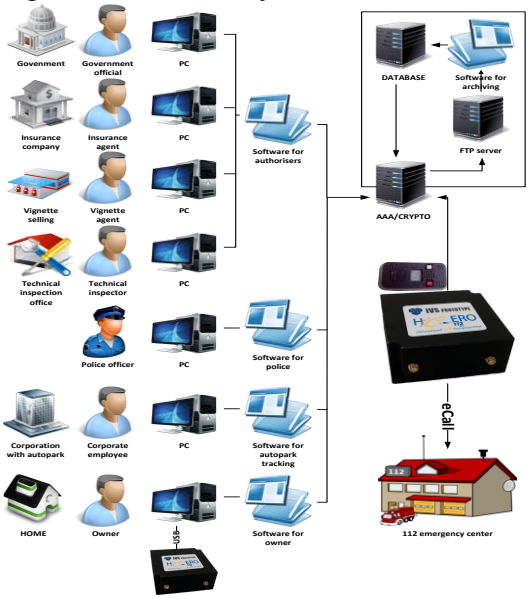

Fig. 1 Block diagram of the system for car park management and accident signaling trough eCall

This means that the device will perform its functions as many times as the car undergoes a car crash or is in a car crash site – most often a few times in the entire lifecycle of the IVS and sometimes even never. This renders the device extremely low cost efficient, taking into account that in order for it to work it needs a wide array of hardware modules – GSM and GPS modems, microcontroller, sensors, memory, audio-visual driver interface, battery, strong casing, etc. This is a widely recognized problem and is one of the reasons for postponing the deployment of the free eCall system from the end of 2015 to the end of 2017 under the influence of the European car manufacturers, which are not "hurrying" to embed the expensive devices in their newly produced cars. When inspected closely the IVS' structure reveals that the device has almost all hardware modules needed to perform many other functions aside from eCall. Starting with this idea and using a fundamental engineering design approach

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and methodology [3] TU's team developed a new IVS device which combines a wide array of functions servicing the car and owner in addition to performing eCalls (IVS+). Using the proposed system the IVS+ device installed in a car with the purpose of making emergency calls is integrated with a broader car park management system. Special attention is paid to some innovative ideas for data analysis and control functions. The system structure is shown on Fig. 1. As the additional functions of the device assume processing, analysis and storing of information, the system incorporates a server part as well as client softwares package.

III. IVS DEVICE WITH ADDITIONAL FUNCTIONS (IVS+)

Fig. 2 shows the designed device's structure. In addition to the standard IVS modules are only the inertial sensors, second interface button and a seven segment display, which raise negligibly the total cost.

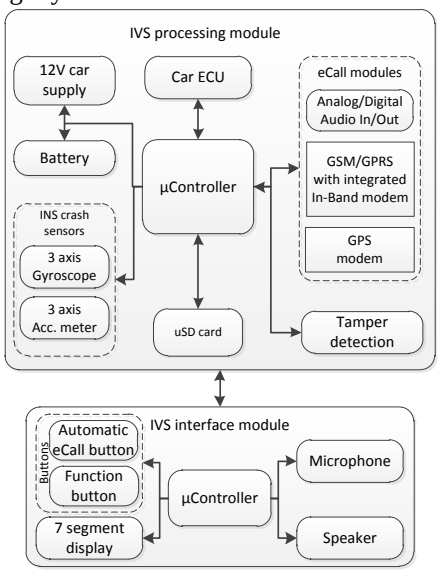

Fig. 2 Structure of the device with additional functions

As can be seen, the device has a distributed structure, composed of two main modules – interface module (IM), which serves as audio-visual connection to the driver and a functional module (FM) which performs all data processing, network connection, data storage, etc. functions and operations. From one side this gives higher data security because the functional module can be installed in a more protected car location, and from another side the driver has more comfort while working only with the smaller interface module, installed at a more convenient place. The functions of the device are:

A. Automatic and manual eCall

When an airbag deploys or the IM's panic button is pressed, an eCall is initiated to the nearest 112 center. This function has the highest priority and is performed even if other operations are in the middle of being processed. In the IVS+ device the automatic eCall is made even when no airbag data is available. For these situations the TU team incorporated custom car crash triggering methods similar to the ones from the IEEE1616 standard [4].

B. Inertial data recording after automatic eCall

When an automatic eCall signaled accident takes place the device records inertial data from the gyroscope and accelerometer with 200Hz scanning frequency for the time interval from -8 seconds before to +5 seconds after the crash. After the completion of the emergency call between the car occupants and 112 operators the inertial data is sent over GPRS to the system's server for archiving and analysis, along with the exact GPS location and time of crash.

C. Administrative duty deadline signaling

In the scope of the designed system for administrative duties are considered all regularly payable car fees – insurances, vignettes, government taxes, annual technical inspections, etc. Every time the device connects to the server it checks for a raised flag indicating that an administrative duty deadline is approaching. In that case the device signals the with a long beep driver so he may take the appropriate actions.

D. Point of interest management (POI)

In every moment in which no other operation is under processing the driver may manually trigger the recording of a personal POI by pressing the second button on the IM. When approaching the recorded POIs later on the device signals that to the driver with two short beeps. The signaling radius of the POIs can be adjusted using one of the client softwares later on.

E. Car route recording

Periodically the IVS+ device checks and records the car's current GPS position and saves it in a file on the memory. When the file reaches a predefined size the device connects to the server and sends it along with all previously unsent files, including the ones containing inertial data. If the sending fails the file will be send in the next session. The period for position recording is configurable from the device. Fig. 3 shows the developed device, installed in the service compartment of a test car.

Fig. 3 IVS+ device installed in the service compartment of a test car

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IV. SERVERS, ARCHIVING SOFTWARE AND DATABASE

As fig. 1 shows the server architecture consists of an FTP server, database and archiving software, protected from unauthorized access by a AAA/Crypto module, which restricts the access to the resources to authenticated users only and in addition encrypts the entire session's data stream. The FTP server is used as a data buffer when transferring information from the IVS+ to the database. Devices upload their data files in their own folders on the FTP. On the other side the archiving software constantly monitors all folders and when data files are found it archives the information from them in the database. Duplicating data is analyzed and combined and the file is deleted. In addition when an IVS+ folder is opened the archiving software checks the administrative duties data from the database and if needed raises a flag file, which is used by the IVS to signal the driver for nearing deadlines. Aside from the session encryption done by the AAA/Crypto module, the archiving software encrypts the vulnerable data in the database, like personal, inertial and administrative duty data using a custom patent pending encryption scheme, called IDA [5]. The database stores all system data. It contains information regarding the registered users, cars, owners, administrators, administrative duties, IVS+ devices, POIs, archived car routes, inertial data from automatic eCalls, as well as service information for the client softwares.

V. CLIENT SOFTWARES

The last part of the system is the client softwares. Their purpose is to present the user with tools for visualization and administration of the data in the database. The softwares incorporate some common elements like logging to the AAA/Crypto module, maintaining an encrypted session and IDA decryption, but are divided mainly by the type of information they operate on and the type of users they are intended for as shown on fig. 1.

A. Software for authorizers – Fig. 4

In the scope of the system authorizers are all data administrators that have rights to change and enter new data in the system, related to cars, owners, etc. In the general case these are employees of the company selling and installing the IVS+, insurance agents, government officials, etc. The software for authorizers is intended to serve them by providing an interface in which they can easily review and change the information for cars, owners and administrative duties. Every function of the software is available only to the corresponding type of data administrator and to ensure greater information security the software tracks and archives the history of all taken actions.

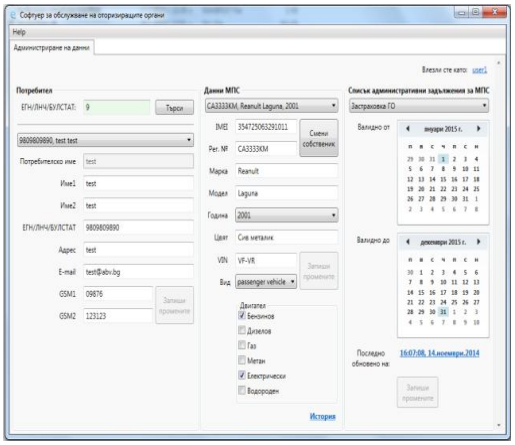

Fig. 4 Software for authorizers interface

B. Software for car park tracking – Fig. 5

This software is intended to be used by car owners, typically corporations with large car parks, for whom it is of great importance to know exactly where the cars are, what routes they have traveled, their speed, etc. The software gives the ability to show one or several vehicles from the logged user's car park on an interactive map and to filter positions by time period. In addition when selecting a certain interval of the visualized positions the software calculates statistical information for the selected period – total time, distance travelled, average and maximum speed. The software does not exclude the its use from normal non-corporative users, as long as they are willing to pay the extra charge of GPRS data transfer by the mobile network operator.

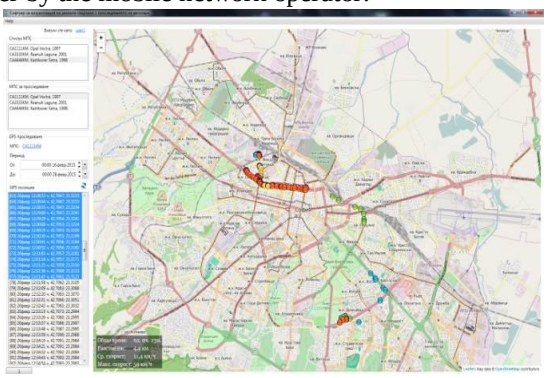

Fig. 5 Software for car park tracking interface

C. Software for car owner – Fig. 6

This software is intended to be used by end users. With it they can see the currently entered information in the database regarding their profile, cars and administrative duties. The software gives the ability to see all POIs on an interactive map and to edit their position and signalization radius. As the POI information is recorded and stored in a simple text file on the IVS+'s memory it can be easily downloaded by USB to the PC's hard drive and opened with the software. This also gives the ability to easily backup the file or share it with another person.

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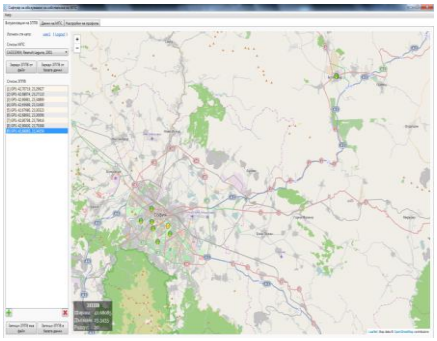

Fig. 6 Software for car owner interface

D. *Software for police – Fig. 7*

This software is intended to be used by road control police officers for accident inspection and drivers control. The software gives access to all car, owner and administrative duty related information. The most important function however is the visualization of the inertial data sent after automatic eCall. The software illustrates the gyroscope and accelerometer sensor measurements as vectors mapped on a car model in a 3D scene. The thirteen seconds of data are visualized as animation in which the user has the ability to rotate the camera in order to better analyze the crash dynamics from all angles. The software for police and inertial data recording are the most innovative and promising aspects of the developed system. Only seconds after an accident occurs the police already has access to valuable crash related data and a preliminary crash severity assessment can be made.

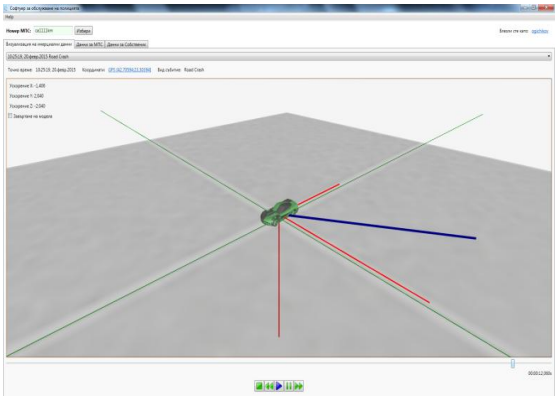

Fig. 7 Software for police interface

VI. FUTURE DEVELOPMENT

TU's team continues to work on further developing the system. The plans follow few directions which can be categorized by the subject to which they are most useful.

A. *Assisting the police*

The software for police will be developed so it would be able to independently analyze the data and reconstruct a 3D animation of the entire path of travel of the car during the crash. This would extremely help the police when making preliminary assessments of the crash severity and damage only seconds after the accident occurs. Subsequently the same data could play a key role when determining the guilty driver in a complex crash scenario.

B. *Assisting the rescue forces*

The eCall function will be developed by adding an additional radio module to the IVS+, equipped with specialized sensors. The module will be installed on dangerous goods and will constantly monitor their state. When it senses that the container is damaged it would trigger an automatic eCall. In that case information about the dangerous goods' type, amount and damage will be added to the data sent to the 112 emergency centers. This will help the rescue teams to prepare properly for the accident.

C. *Assisting the insurance companies*

Taking into account the said mechanisms for guilty driver determining and using the dangerous goods module for monitoring high value cargo the designed system can also be of great help to the insurance companies when settling insurance claims. In addition a special low power mode will be developed for the functional module of the IVS+ [6]. It would allow for recording of a limited sensor data when the engine is off. This will allow for determining false insurance claims for parking damage.

VII. ACKNOWLEDGEMENT

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VIII. CONCLUSION

This article presents a solution for integrating the eCall system with a car park management system, which solves one of the biggest problems of eCall – the extremely low cost efficiency of the IVS devices. The described system was realized successfully with the support of Enterprise Communications Group Ltd. The lab and real world test prove that the system is ready for operation. The plans for future development include promising perspectives for further assisting the police, insurance companies and rescue forces.

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