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Gabriel NOWACKI, Anna NIEDZICKA, Małgorzata WALENDZIK

ROAD TRAFFIC DATA RECORDING BY USING EDR - BLACK BOX

Abstract

The paper refers to the Event Data Recorder (EDR) - black box for all types of the motor vehicles. The device will record data concerning the vehicle's technical condition, the way it was driven and RTS. The recorder may be used in private and commercial cars, taxies, buses and trucks. The recorder may serve the purpose of the neutral witness for the police, courts and insurance firms, for which it will facilitate making the reconstruction of the road accidents events and will provide proof for those who caused them. The device will bring efficient driving, which will significantly contribute to decreasing the number of the road accidents and limiting the environmental pollution.

INTRODUCTION

The number of fatal road accidents' victims is in the European Union has been reduced from 34 800 in 2009 to near by 31 000 in 2010 and above 30 000 in 2011 [14]. The European Commission (EC) has adopted an ambitious Road Safety Program which aims to cut road deaths in Europe between 2011 and 2020 (Fig.1). The program sets out a mix of initiatives, at European and national level, focusing on improving vehicle safety, the safety of infrastructure and road users' behaviour.

The statistics are invariably devastating for Poland, which with respect to the number of victims and mortality in the road accidents is always at the end of the list**.** The threat of death in the road accident in Poland is three times higher than in the rest of the EU countries, and the statistics of the fatalities per 100 accidents we are worse even than in Lithuania. For Poland this number is 10,3, in Lithuania 9,9, Greece - 8,8, while the average in the EU is 3. In this context, a shockingly low mortality coefficient is noted in such countries as Germany and Great Britain (1,4), as well as in Austria (1,7) or Italy and Sweden (1,9). The probability of death of the accident participant is in Poland, on average, four times higher.

Moreover, in the statistics concerning the number of people killed per 1 million inhabitants we also hold last place, since the EU average in 2011 was 61, while in Poland - 109 (Tab. 1).

The event data recorder (EDR) can come above mentioned requirements and improve the level of transport safety with the reduction of death number and accident reconstruction.

One of the primary tasks of accident reconstruction is to determine the values of the event participants motion parameters prior to its occurrence. The correctness of their behaviors is assessed on their basis, and then the court makes its decision whether the event participants are guilty or innocent. One of the more frequently encountered tools, which are useful to determine the values of the aforementioned parameters, are the devices recording some

selected parameters of vehicle motion. They are so called event data recorders (EDR) or just the car 'black boxes' (devices used for accident reconstruction) [5].

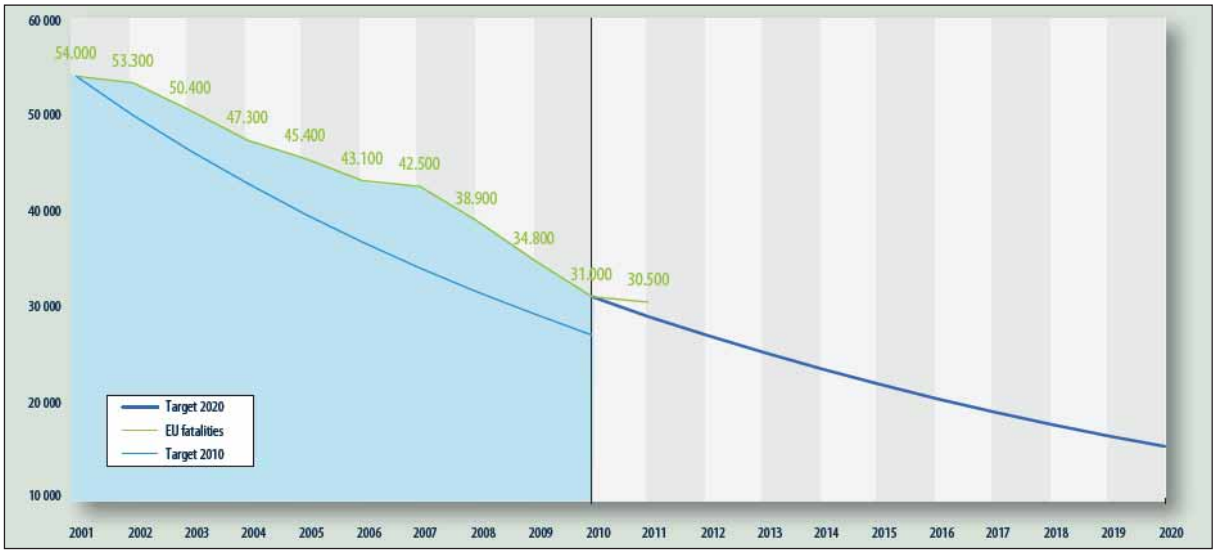

Fig. 1. Road fatalities in the EU since 2001 to 2010

Source: Based on CARE, EU road accidents database, 06.03.2013, http://ec.europa.eu/roadsafety

Tab. 1. Fatalities by population in Member State of EU in 2011

1.	United Kingdom	32
2.	Nederland	33
3.	Sweden	33
4.	Denmark	40
5.	Malta	41
6.	Ireland	42
7.	Deutschland	49
8.	Spain	50
9.	Finland	54
10.	Slovak Republic	59
11.	France	61
12.	Austria	62
13.	Hungary	64
14.	Italy	65
15.	Slovenia	69
16.	Luxemburg	70
17.	Czech Republic	73
18.	Portugal	74
19.	Estonia	75
20.	Belgium	77
21.	Latvia	80
22.	Cyprus	88
23.	Bulgaria	88
24.	Lithuania	92
25.	Romania	94
26.	Greece	97
27.	**Poland**	**109**
The average of EU		**61**

Source: Based on CARE, EU road accidents database, 06.03.2013, http://ec.europa.eu/roadsafety

Event Data Recorder (EDR) “black box” is a device in a vehicle that stores event-specific data (e.g. vehicle speed and driver inputs when a crash, rollover, or other mishap occurs) [13].

Event Data Recorder (EDR) means a device or function in a vehicle that records the vehicle’s dynamic, time-series data during the time period just prior to a crash event (e.g., vehicle speed vs. time) or during a crash event (e.g., delta-V vs. time), intended for retrieval after the crash event [6, 7].

Some authors called mentioned device as the deck recorder of vehicle movement parameters which registers some characteristic data describing the state of the vehicle performing the transport task. The idea behind applying recorders is to determine circumstances on the route where events (collisions, accidents) happened [9].

EDR is a deck recorder of events which in case of an accident or any event registers and saves data describing the movement of the vehicle (speed, acceleration, using the brake etc.) before, during and after the event occurred [3].

The goal is to integrate functions of vehicle's monitoring behaviour pre-crash, during crash and postcrash to the current or developed motor vehicles systems, for the purpose [10]:

- Create an instrument for support to make clear specific road traffic accident (chain accident, etc.);
- Make easer the guilty and innocence clarification;
- Make easer the process of insurance event liquidation;
- Increase the active safety (psychological subconscious of driver about the possibility to documentation behaviour of vehicle);
- Increase the process of legislation to embed system in vehicles (e.g. in police, fire brigade vehicles, driver's school).

1. REQUIREMENTS OF EDR - BLACK BOX

1.1. Characterization of EDR

The first EDRs or *black boxes* were used in the aviation industry in the late 1950s. In 1958, the Federal Aviation Act and corresponding regulations issued by the Civil Aeronautics Administration (the predecessor of the Federal Aviation Administration) made mandatory the use of black boxes or *flight data recorders* for commercial aircraft. In 1976, the National Transportation Safety Board (NTSB) issued regulations requiring the use of EDRs in commercial marine vehicles. In May 1995, the Federal Railroad Administration issued regulations requiring EDRs on heavy rail transportation. While the use of EDRs in automobiles and light trucks is currently voluntary, vehicle manufacturers such as General Motors and Ford have installed EDRs on many of their newer models [6].

The recorder proposed by the Motor Transport Institute, to a large extent, may help to reduce the number of accidents, a significantly shortening of travel time and energy consumption, thereby improving the quality of the environment, and will be useful as evidence in the disputable matters.

The proposed recorder - car black box, can be used to record data concerning the technical condition of the vehicle, the driving technique, and drivers compliance with the traffic rules and road traffic safety in the following cars:

– passenger, service and privileged cars – will allow the registration of the earlier indicated data and will provide evidence in case of accident,
– buses and taxis – apart from the recorded data, it will help to ensure the safety of the driver and passengers, will enable the location of vehicles in the event of theft,
– trucks - will ensure registration of the data on technical condition will enable the localization, will contribute to reduce the number of accidents and ensuring safety of the driver.

A significant disadvantage is the fact that currently there is a few numbers of standards refers to such devices.

The SAE J1698 Standards Committee was established to develop common data output formats and definitions for those data elements that could be used for analyzing vehicle events, including accidents. The standard also specifies common connectors and network protocols to improve data extraction activities [18].

The IEEE P1616 Standards Committee was established to define a protocol for motor vehicle event data recorder output data capability and export protocols for data elements. The committee established these protocols for both light- and heavy-duty vehicles [11].

1.2. Legislation requirements of EDR

The US National Highway Traffic Safety Administration – NHTSA [12, 19] required from the manufacturers who install EDRs to include a minimum standard set of data to be recorded: at least 15 types of crash data including pre-crash speed, engine throttle, brake use, measured changes in forward velocity, driver safety belt use, airbag warning lamp status and airbag deployment times.

NTHSA wants to reconstruct what most vehicles did:

– Use pre-crash data to obtain travelling speed before braking, prior to impact – especially when ABS braking did not leave clear road evidence of braking.
– Use driver throttle and brake inputs to gain insight into driver intent & causation.
– Use Delta V data as a check on momentum analysis or crush analysis for what happened during impact.
– Challenges to establish probable causes of accidents warrant EDRs becoming more common.

The data collected and registered by EDRs reflects accident status but also technical status of the vehicle (fuel consumption, airbag functionality), but they will also register and describe (directly or indirectly) in a dynamic way the driver's behaviour (e.g., brake fluid pressure at the beginning and the end of braking, vehicle speed, including that during braking, engine speed, throttle percentage, use or not of safety belts) [20].

Based on agreements with mobile service providers, EDRs are being linked to onboard communication systems which transmit the relevant information to a remote location when the event occurs. A collision notification system (or in-vehicle emergency call system) can therefore be activated automatically or manually and provide data to emergency services. Initiatives have been launched in the US and in the EU in order to promote the implementation of such systems and to enforce standards across the different transport sectors and applications.

Section 31406 of Senate Bill 1813 has stated EDR as mandatory and it must be installed in all cars in USA starting with the 2015, and outlined civil penalties against violators.

European Commission has determined Quantitative target: 50% reduction of the number of road fatalities by the 2020, starting from 2010 [17].

The EC has decided (Recommendation of 8 September 2011) to equip all cars with an on-board system and ensure the implementation, by the mobile networks operators, of the mechanism serving the eCall reporting indicator in their networks by the 31 December 2014 [2].

Minimum set of data means information that must be sent to the entry point for reports of accidents in accordance with EN 15 722 standard.

Successful implementation in the entire EU of a harmonized interoperable eCall service requires the automatic transfer of voice and audio connection and the minimum data set of the accident, generated by the on-board system, to the appropriate public accidents reporting exchange.

Member States should commit its national authorities to notify the Commission, by the end of March 2012, about the measures that have been applied in response to this recommendation.

Furthermore, according to European Parliament resolution of 27 September 2011 on road safety in Europe for the years 2011 to 2020, there should be following legislative document developed [4] by 2013 - proposals for legislative changes, assuming that each new vehicle must be equipped with a system reminding about fastening the seat belts in the front and rear seats, operating based on acoustic and visual signal.

According to EC statement, EDRs would reduce probability of deaths as well as for serious and light injuries [3], as a result of a collision, by 20%. For the reasons mentioned, the EC recommends eCall pan-European system for the EU [16].

The Research and Technological Development Framework of the European Union has launched a large number of EDR projects which have been finalized or are still being carried out with a view to enhance the road safety.

Another study based on available practical experiences of EDR concludes that a reduction in the number of accidents by 20% would generate a reduction of 26,1% of lightly injured, of 36,9% of seriously injured and of 50,4% of killed road users [1].

There is evidence that drivers who know that their cars have black boxes drive more cautiously. Case studies from Europe and the US show that the number of crashes can be reduced by 20 to 30 percent [1]. Crash severity is also reduced. The Berlin Police Department reports that deaths as well as serious and light injuries are reduced by 20 % in the crashes of vehicles with EDRs. As a result, all Berlin Police radio patrol cars use EDRs. A similar trial in Vienna led to the use of EDRs in all the city's police cars. In the mid-nineties, a Europe-wide program studied the effect of different types of EDRs in fleets in Great Britain, the Netherlands and Belgium. The overall crash rate fell by 28% and costs by 40%.

1.3. Functional requirements of the recorder

The device will receive data from selected circuits of the vehicle via digital and analogue input ports. Sensors may be possible to be connected e.g. to the doors, lights, turn indicators or brakes.

The electronic system will record and remember the course of acceleration during the collision and remember the result of changing the vehicle speed. In addition, it will remember certain information prior to the accident and immediately after the accident.

The device will interpret digital information transmitted on the CAN bus and the FMS-CAN to record the following parameters (range, depending on the type of vehicle and equipment, such as truck equipped with a tachograph): speed, engine rpm, the position of the brake pedal, clutch pedal position, accelerator pedal position, the state of the cruise control, fuel level, mileage, total fuel consumption, tachograph - operation mode, tachograph - speed, tachograph functioning, dealing with the event status, the mileage remaining until the next tests, engine hours, coolant temperature, the axis load.

Additional sensors will be able to monitor: the time of release (reaction), a longitudinal, lateral acceleration, vehicle speed (the counter), the engine throttle (gas pedal), brake status (enabled or disabled), supply voltage, the position of the ignition, cushions signaling, the number of events, the time between events, horn, light switches, traffic lights, parking lights, turn indicators, the change in the car deflection (car rotational speed with respect to the vertical axis), the driver's seat belt status, events registration time. The actual sensors in car were presented on Fig. 2.

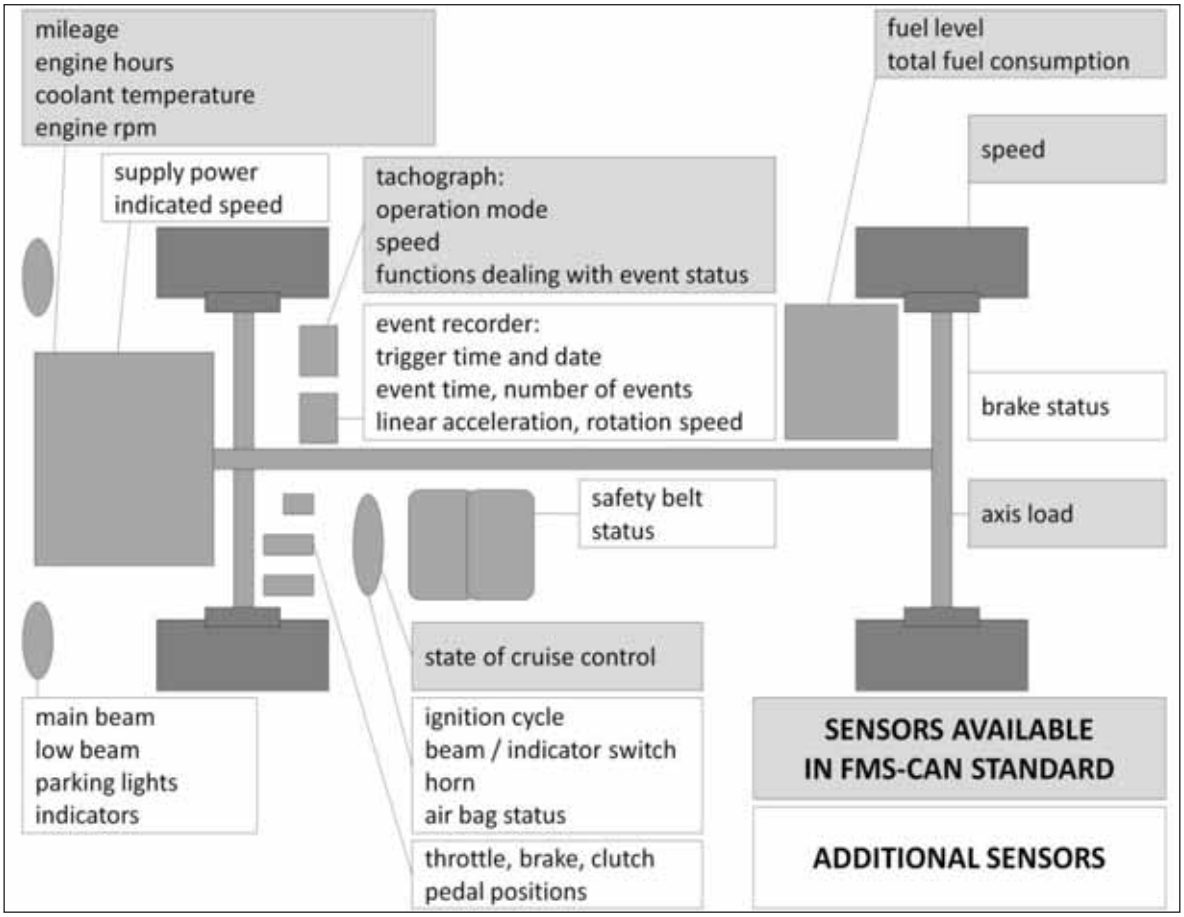

Fig. 2. Monitoring sensors in vehicle

Source: Based on Merkisz, J., Inteligent solutions of information systems in HGV and cars [8].

1.4. Technical requirements of the recorder

One element of accident reconstruction is to recreate the time-space relationships of the event participants. Motion reconstruction process is based on the analysis of records of the parameters characterizing the motion of the car body. The forward motion is recorded as standard in the form of linear acceleration components (components: longitudinal, lateral, and vertical).

The device is designed for installation in all types of vehicles (passenger cars, trucks, buses) to record the driving parameters such as speed, acceleration, braking, use of direction indicators, etc. Such information can be extremely helpful in identifying those responsible for road accidents and will allow reconstructing the accident. They are also to replace the witnesses who are not always reliable.

The recorder will have a small size, will be much smaller than the car radio, and made of durable materials, and the place specially protected in it should be the SD card casing, on which the data will be stored.

The version 1 of device will be equipped with the following elements (Fig. 3):

– Microprocessor module – the element controlling the operation of all other components.
– GPS - to receive the geographical coordinates.
– Module "black box" - memory chips, including SD card, capable of recording the driving and operating parameters.
– Digital inputs module - this module allows connection of digital signals.
– Analogue inputs Module - this module allows connection of analogue sensors.
– CAN inputs module - to connect CAN bus in the FMS standard.

– Battery backup module.
– Housing.

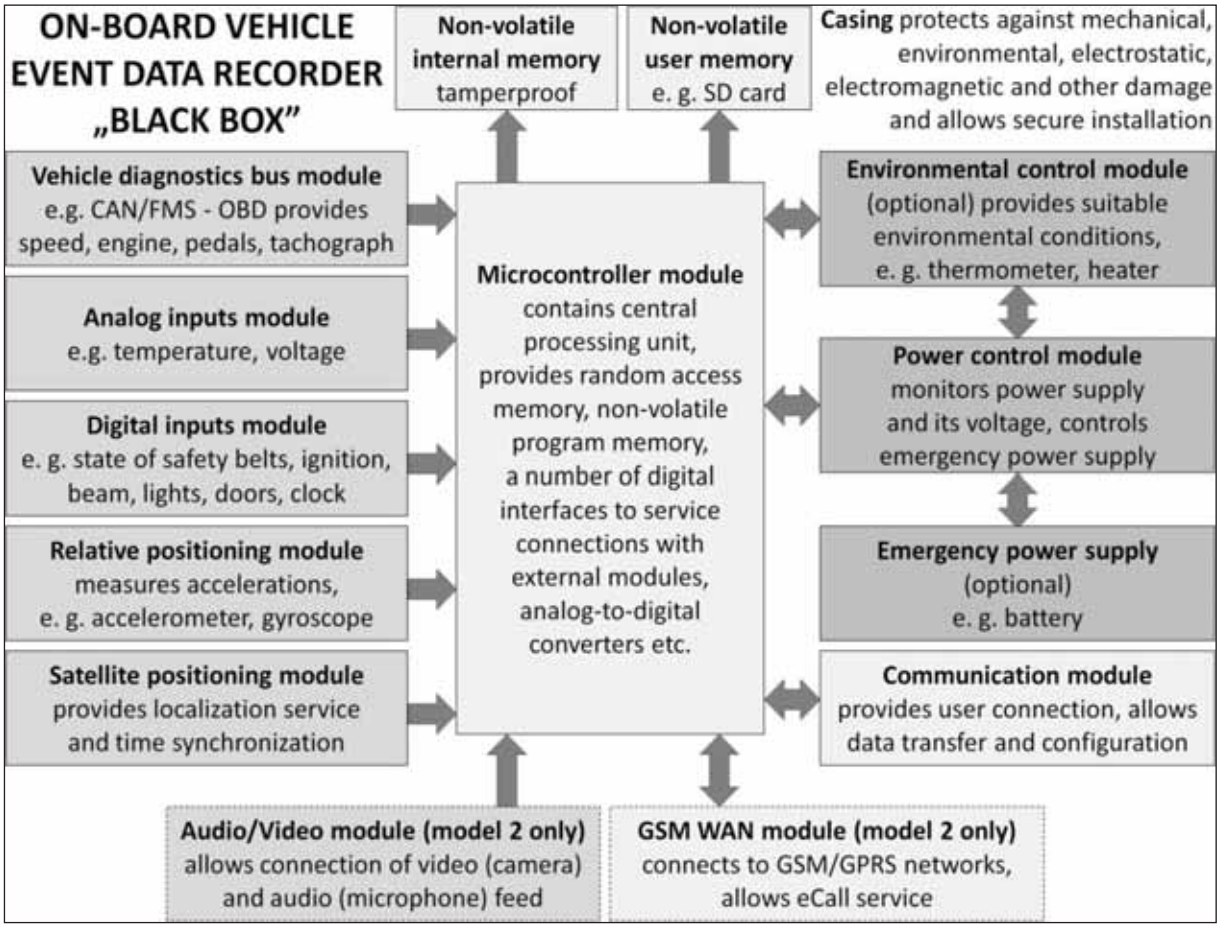

Fig. 3. On-board vehicle, event data recorder functional structure

Source: Based on study and work of G. Nowacki, A. Niedzicka.

Version 2 will be equipped with communication module GSM/GPRS, for data transfer and entry to install the camera and the ability to record audio and video.

Intelligent algorithm for data collection will allow, at the moment of detecting an excessive acceleration by the built-in sensors, to switch to a continuous recording of all available parameters. In version 2, in the event of an accident, the automatic emergency call function will be activated in order to provide the assistance to the victims as soon as possible, and the GPS receiver will allow pinpointing where exactly the car is and sent, via the GSM network, the location data to an external server.

The device will save the measurement data on the SD card, and in the version 2, if the camera is installed, the unit will record audio and video, for a few seconds before the accident and a few seconds after the accident. The card can later be inserted into your computer to recall the data.

The device will be designed for commercial vehicles powered by 12V DC or 24V. The possibility of using backup battery is envisaged, to ensure continuity of work, e.g. in the case of basic voltage cut-off, for example, after a traffic collision.

Equipment must be installed in a protected, dry place. These places include the vehicle cabin. The optimal place is the area behind the dashboard.

Selecting the installation place must also be dictated by the visibility of satellites by the GPS antenna, in a place not covered by bodywork.

Devices will be connected to the CAN bus and to the selected electrical circuits of the car.

The design may not allow for manipulation or external sensors, such as their exclusion. It will be deprived of the possibility of changing the stored data, connected directly to the accident.

The device must be designed so as to minimize the reconstruction error of the motion parameters, in particular trajectory of the movement. This error should to the smallest degree be dependent on the vehicle load.

The unit will have an airtight case ensuring resistance to a short-term immersion in water and service liquids (fuel, oil, hydraulic fluid).

It will withstand exposure to direct flame and high overload for a period of several milliseconds.

Equipment should be protected against shock and vibrations in accordance with the standard defined in the EN normative documents (environmental conditions, electromagnetic compatibility). All mobile devices should withstand the following exposure: a one-time shock and falls from a height of 1 m. The devices should be able to withstand vibration, both sinusoidal and random.

For safe and reliable operation of all electrical and electronic equipment in the car it is necessary to ensure the electromagnetic compatibility of the recorder - the black box.

The device should be compatible with all environmental specifications, physical and compatibilities defined in the CEN, ISO and ETSI standards. It should meet all requirements, relating to this group of products, of the EU Council Directives, European standards and national legal regulations.

CONCLUSIONS

he end result of the conception will be turning out two devices: the economic, universal simple event data recorder - black box, the economic, universal event data recorder - black box for all types of vehicles, taking into account the eCall reporting.

Recorder - car black box can be used to record data concerning the technical condition of the vehicle, the driving technique, and the driver’s compliance with the traffic regulations and maintaining the road traffic safety in all motor vehicles.

The European Commission is currently considering the implementation of legislation in this area, prescribing the mandatory installation of black boxes in all vehicles.

Psychological impact of the black box will revolutionize road safety. Drivers will be more cautious, knowing that their every maneuver may be recorded, so in the event of an accident they will not be able to make false statements.

The device, connected to the vehicle monitoring sensors, will be installed behind the dashboard or under the driver's seat. Each sudden change of speed or opening of the airbag will activate it so that way also the collisions involving pedestrians will be recorded. In order not to violate privacy, car black boxes will store the data recorded 30 seconds before the accident and 15 seconds after it. The machine will automatically alert the emergency road services about the accident. In Britain, black boxes are standard equipment in many privileged vehicles. When in 1999 the London police installed them in a 3.5 thousand of company cars, within 18 months, the costs of road accidents fell by 2 million pounds. The devices are also placed in some newer car models.

In the U.S., black boxes are quite commonly used, and right now they belong to a standard equipment of over two thirds of new cars. U.S. Senate approved the bill, under which from the 2015 all new vehicles must be equipped with digital driving parameters recorders, known as black boxes. The failure install such equipment will result in punishment.

The studies conducted in the U.S. and the UK have shown that drivers who drive with black boxes, were 20% less likely to have participated in the fatal cases, the failure rate and

repair bills for their cars fell by 25 percent. In Poland, the annual cost of road accidents alone are 5 billion, so if that gets reduced by about 20%, one will get the savings for the state – amounting to 1 billion annually.

BIBLIOGRAPHY

1. Bach, H. (2000) The use of drive data recorders and accident data recorders and their socio-economic evaluation, Technische Universität Dresden. www.roadpeace.org
2. *Commission Recommendation of 8 September 2011* on support for an EU-wide eCall service in electronic communication networks for the transmission of in-vehicle emergency calls based on 112 ('eCalls'). 2011/750/EU**)** L 303/46, Brussels, 2011.
3. Cost-benefit assessment and prioritization of vehicle safety technologies in particular 142 seq. (144) and p. 8). European Commision Directorate Energy and Transport. Final Report ww.ec.europa.eu/transport/roadsafety_library/publications/vehicle_safety_technologies_final_report.pdf.
4. *European Parliament resolution of 27 September 2011* on European road safety 2011-2020. P7_TA-PROV(2011)0408. Brussels, 2011.
5. Guzek, M., *Car 'black boxes' in road accident reconstruction analysis.* Transport No 82, Warsaw, 2012.
6. Kowalick, T. M., *Protects the security, integrity and authenticity of vehicle crash data*. Georgetown University Law Center 600 New Jersey Ave NW, Washington, D.C. 2011.
7. Kowalick, T. M., *Motor vehicle EDR' global standardization and related issues.* National Research Council / National Academies. Keck Center, 500 Fifth St., NW, Washington, D.C. 2010.
8. Merkisz, J., Inteligent solutions of information systems in HGV and cars. No 602 Transport and Logistics Problems. No 12, 2010, p. 169-172.
9. Merkisz, J., Tarkowski, S., *Selected aspects of using deck recorders in automotive vehicles*. Reliability and Maintenance. No 2/2011.
10. Messerschmidt, W., Smith, B., Messerschmidt, K., *Minimizing the Risk of Losing Valuable Forensic Data When Downloading the Electronic Control Modules (ECMs) of Heavy Commercial Vehicles Technical White Paper*. Messerschmidt Safety Consultants Birmingham, 2011.
11. *Motor Vehicle Event Data Recorders*. Institute of Electronic and Electrical Engineers (IEEE), IEEE P1616 Standards Committee, February, 2005.
12. NHTSA 49 CFR Part 563 Issued 2006, amended 2008. Effective Sept. 2012 New NHTSA EDR Part 563 rule for Sept 2012 standardizes EDR minimum data set, insures public access to data, and that data survives in severe crashes. http://www.nhtsa.gov/EDR.
13. Plíhal, J., Pípa, M., *Blackbox - project V&V*. National Highway Traffic Safety Administration. MD ČR, Praha, 2010.
14. *Report on accidents, Care & national data*. European Commission, Brussels, 2012.
15. Symon, E., *Prophylactic and Analyze Group of BRD*. KGP, Warsaw, 2012.
16. The European Union *eCall: Time for Deployment*, Brussels, 21.8.2009, COM(2009) 434 final; http://ec.europa.eu/information_society/activities/esafety/ecall/index_en.htm.
17. Towards a European Road Safety Area: Policy orientations on road safety 2011-2020. EC 2010.
18. *Vehicle Event Data Interface – Vehicular Output Data Definition Society of Automotive Engineers (SAE).* J1698 Standards Committee – J1698-1 Standard, SAE, December, 2003.
19. Westbrook, R., Evaluation of electronic data recorders for incident investigation, driver performance, and vehicle maintenance project Bd549-50. Final report. University of South Florida, September, 2009.

20. Working Paper. Event Data Recorders (EDR) on Vehicles. Privacy and data protection issues for governments and manufacturers. EDR: Definitions and facts. 49th meeting, Montreal (Canada) 4-5 April 2011.

REJESTRACJA ZDARZEŃ DROGOWYCH PRZY WYKORZYSTANIU EDR - CZARNEJ SKRZYNKI

Streszczenie

Referat dotyczy pokładowego rejestratora zdarzeń (EDR) - czarnej skrzynki dla wszystkich typów pojazdów samochodowych. Urządzenie będzie rejestrować wiele danych nt. stanu technicznego pojazdu, sposobu jego prowadzenia oraz BRD. Rejestrator może być wykorzystany w samochodach osobowych, służbowych, taksówkach, autobusach, samochodach ciężarowych. Rejestrator może pełnić rolę neutralnego świadka dla policji, sądów i firm ubezpieczeniowych, którym ułatwi rekonstrukcję przebiegu wypadków drogowych i dostarczy dowodów na temat jego sprawców. Urządzenie przyczyni się do zgodnej z przepisami i ekonomicznej jazdy, co w znaczny sposób ograniczy liczbę wypadków drogowych oraz zanieczyszczenie środowiska.

Authors:

Gabriel NOWACKI – Prof. at Military University of Technology, Cybernetics Faculty, Warsaw.

Anna NIEDZICKA – Specialist at Motor Transport Institute/Transport Management and Telematics Center, Warsaw.

Małgorzata WALENDZIK – Deputy Manager at Transport Management and Telematics Center/Motor Transport Institute, Warsaw.