MECHANIKA
CZASOPISMO TECHNICZNE
TECHNICAL TRANSACTIONS
MECHANICS
WYDAWNICTWO POLITECHNIKI KRAKOWSKIEJ
5-M/2012
ZESZYT 10
ROK 109
ISSUE 10
YEAR 109

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CONCEPTION OF EVENT DATA RECORDER BLACK BOX FOR ALL TYPES OF THE MOTOR VEHICLES

KONCEPCJA POKŁADOWEGO REJESTRATORA – CZARNEJ SKRZYNKI DLA WSZYSTKICH TYPÓW POJAZDÓW SAMOCHODOWYCH

Abstract

The paper refers to the Event Data Recorder – 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.

Keywords: event data recorder (EDR), black box

Streszczenie

Artykuł dotyczy rejestratora zdarzeń – 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.

Słowa kluczowe: rejestrator zdarzeń (EDR), czarna skrzynka

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1. Introduction

According to the World Health Organisation in 20 years time road accidents will take fifth place on the list of the most frequent causes of death in the world. It has been estimated that annual costs of accidents in Europe amount to 130 billion Euros, while in Poland itself – 5 billion Euros. Despite the measures taken to reduce this amount, the number of fatal road accidents' victims is in the European Union exceptionally high – 34 800 in 2009 [11].

The reason for such situation is a significant growth of the road transport, associated with the development of the European economy and citizens demands as far as mobility is concerned, which results in ever growing congestion of the road infrastructure, energy consumption increase as well as ecological and social problems.

European action program for the road traffic safety defines main areas of the activities: promoting more responsible attitudes of the drivers (obeying road traffic regulations and punishing dangerous behaviour on the roads), improving safety of the vehicles by introducing new technical solutions, improving road infrastructure, thanks to the information and communication technology.

The statistical data suggests that the year 2010 was the safest in the last 20 years (Fig. 1) on the Polish roads (lowest number of the people killed). Despite this fact, in the statistics referring to the percentage decrease of the number of accidents in the last decade (2001–2010), we still hold one of the last places. For this period, an average percentage decrease of the number of accidents in the EU was 43%, while in Poland – 29%, in Lithuania and Estonia – 61% and in Latvia – 58%. European Commission regularly publishes reports on the safety on the roads of all countries belonging to the EU.

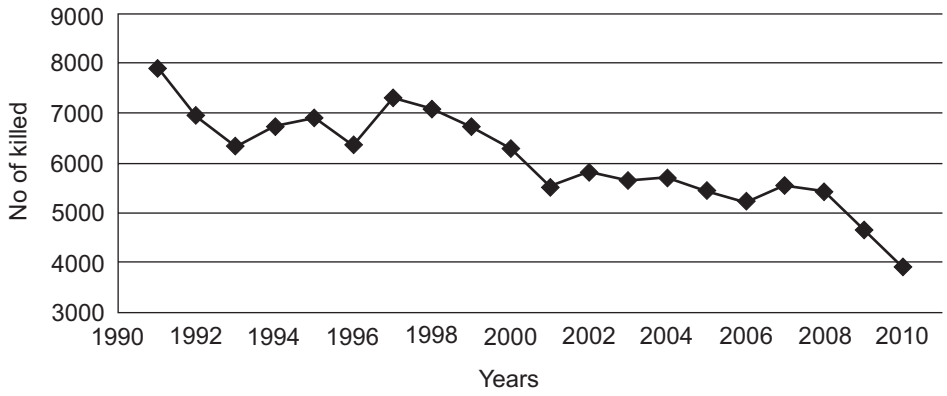

Fig. 1. Number of people killed on the roads during the years 1991–2010

Rys. 1. Liczba zabitych na drogach w latach 1991–2010

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 one of the last places, since the EU average in 2011 was 61, while in Poland – 102, and worse are only Romania – 111 and Greece – 112.

Data of the National Police Headquarters [12] shows, that in 2011 there were 40 065 accidents (38 776 – 2010) on the Polish roads, as the result of which 4189 (3907–2010) people died and 49 501 (48 872–2010) people were injured. In comparison to 2010 there was an increase of the number of accidents by 1 233, i.e. by + 3,2%, increase of the number of fatalities by 282 people, i.e. by + 7,2%, and increase of the number of people injured by 549, i.e. by + 1,1%.

In Poland, accidents are regarded at present as one of the largest public health problems. More so, their consequence is not only a trauma of the injured ones and their families but also a significant burden to the public finances.

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 [1].

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 documents developed [3]:

– by the end of 2012, proposals for legislative changes to implement in the corporate and private vehicles, the integrated system for recording data immediately before, during and after the accident,
– 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.

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) [4].

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) [8].

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 [5, 6].

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 [7].

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 [2].

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).

2. Characterization of black box

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 [13].

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 [9].

2.1. 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.

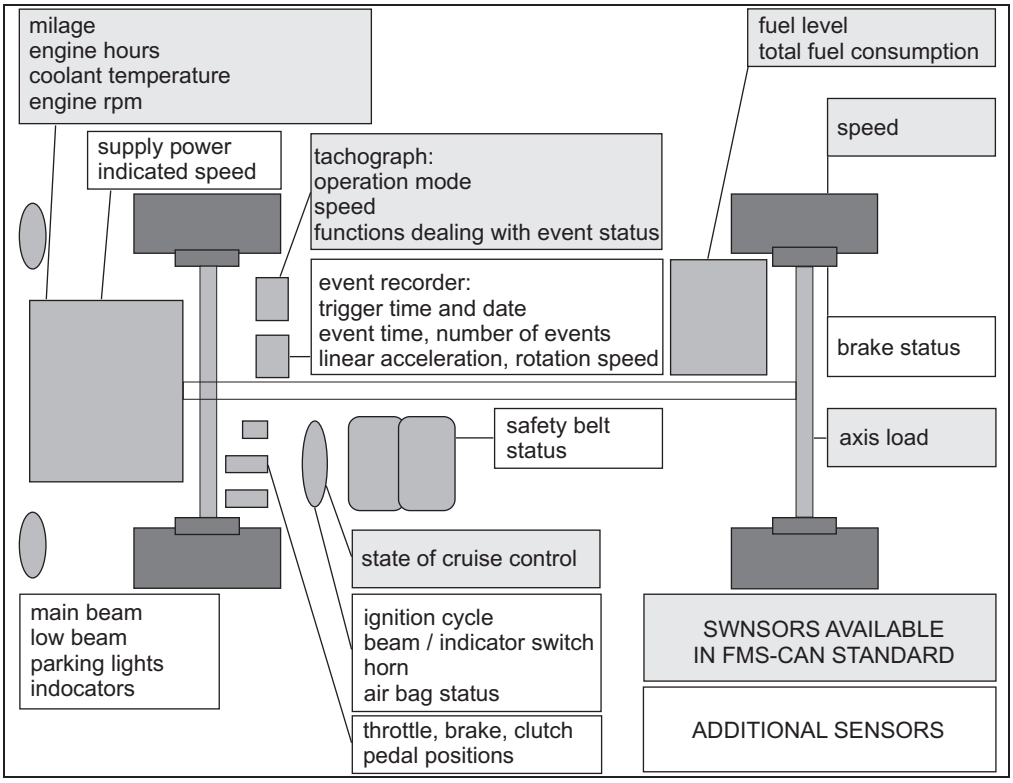

Fig. 2. Monitoring sensors in vehicle

Rys. 2. Czujniki monitorujące w pojeździe

2.2. 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.
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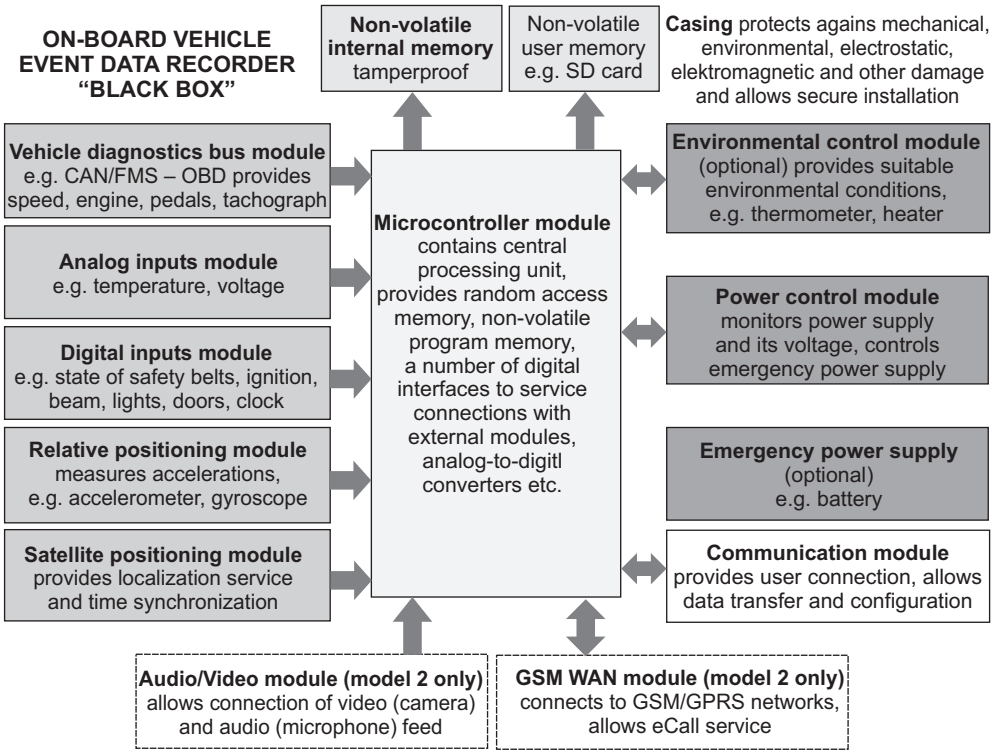

Fig. 3. On-board vehicle, event data recorder functional structure

Rys. 3. Struktura funkcjonalna pokładowego rejestratora zdarzeń

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.

3. Conclusions

The 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.

References

[1] 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.

[2] Cost-benefit assesment and prioritisation of vehicle safety Technologies. European Commision Directorate Energy and Transport, Final Report, 2005.

[3] European Parliament resolution of 27 September 2011 on European road safety 2011–2020, P7_TA-PROV(2011)0408, Brussels 2011.

[4] Guzek M., *Car 'black boxes' in road accident reconstruction analysis*, Transport, No. 82, Warsaw 2012.

[5] Kowalick T.M., *Protects the security, integrity and authenticity of vehicle crash data*, Georgetown University Law Center 600 New Jersey Ave NW, Washington 2011.

[6] Kowalick T.M., *Motor vehicle EDR' global standardization and related issues*, National Research Council/National Academies, Keck Center, 500 Fifth St., NW, Washington 2010.

[7] Merkisz J., Tarkowski S., *Selected aspects of using deck recorders in automotive vehicles*, Reliability and Maintenance, No. 2, 2011.

[8] 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 by Messerschmidt Safety Consultants*, Birmingham 2011.

[9] Motor Vehicle Event Data Recorders Institute of Electronic and Electrical Engineers (IEEE), IEEE P1616 Standards Committee, February, 2005.
[10] Plíhal J., Pípa M., *Blackbox*, National Highway Traffic Safety Administration, MD ČR, Praha 2010.
[11] Report on accidents, Care & national data. European Commission, Brussels 2012.
[12] Symon E., *Prophylactic and Analyze Group of BRD KGP*, Warsaw 2012.
[13] Vehicle Event Data Interface – Vehicular Output Data Definition Society of Automotive Engineers (SAE), J1698 Standards Committee – J1698–1 Standard, SAE, December 2003.
[14] 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.