OBD Data Collection: Methodology and Protocol in Accident Cases

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Abstract:

The main objective of this work is the determination of the methods for the collection of data in accident situations, to better understand the way a certain accident occurred and to make its correct reconstruction. With that objective in mind it is required to record the vehicle live data. That process is done in the Event Data Recorder (EDR), better known as the black box of the vehicle.

The On-board Diagnostics (OBD) port can be used to read the vehicle live dynamic parameters, but it is also possible to read the data that is recorded in the EDR. In order to find the important aspects for these situations it was made an analysis in two case studies resulting from actual accidents, in which it was possible to find the advantages and disadvantages of this system.

The analysis of these aspects allows one to realize that there is still much work to be done and that the solutions found are not ideal. There is a need for a better globalization of concepts and design of the EDR present in vehicles. It is hypothesized to implement an OBD device in the form of an external EDR, for the purpose of continuously reading and recording the parameters of the vehicle. This is a possibility that would bring much objectivity for the accident reconstruction, in order to find the causes and to improve safety on the road environment.

Keywords: OBD, EDR, accident reconstruction, dynamic parameters, data collection

1. Introduction

Nowadays, motorized vehicles are indispensable in the everyday life of the human being. Motor vehicles make up a large part of the mobility of developed countries. They are the main locomotion solution and therefore the accident rate is a very important factor for the development of this industry. There is a need to mitigate the accident rate, finding the causes of the accidents. For this to happen it is necessary to determine the methods for collecting data from the OBD port. The instances before an accident are fundamental for its reconstruction. It is important to determine the fully utility of the OBD port in these cases. It is necessary to explore and characterize all the parameters of the vehicle that can be obtained, especially those of dynamic characteristics. Normally these values are recorded and stored in the EDR, present in the vehicle airbag module. A concept of design for an external EDR is made in this work, allowing more functionality to be developed.

2. On-Board Diagnostic

The On-Board Diagostic system and the available interpreters will be analyzed in this section.

2.1. OBD System

The OBD system can be characterized as the software that monitors emission control and emission-related systems and components as well as certain engine components that provide additional information about the operation of the vehicle. By monitoring and evaluating these systems, the vehicle ECU is able to determine the presence of problems (malfunctioning) due to component deterioration or component failure communication (OBDII). These operating problems can affect engine performance, increase fuel consumption and emissions, and trigger instrument panel lights. In some cases, the problems may not be an obstruction to the operation of the vehicle and are recorded for later diagnosis. The combination of the various component monitoring systems, emissions, engine, dashboard lights and the software itself constitute the OBD of the vehicle. The definition and implementation of functions relating to other non-standard electronic components are at the discretion of the manufacturer [1].

In order to establish communication through the OBD port (also known as diagnostic port) an OBD interpreter is required that is capable of translating the standard OBDII protocols. Most vehicles use the CAN system with ISO 15765-4 to communicate between modules, sensors and PID controllers of the vehicle. The CAN communication architecture allows high-speed communication of the entire OBDII system, making the connection between the various modules of the vehicle and the OBD diagnostic port [2]. There are several OBD interpreters on the market, allowing them to be used on OBD Bluetooth devices.

2.2. ELM327 OBD interpreter

The ELM327 integrated circuit (launched in the market in 2005) is capable of automatically detect and convert standard information from most OBDII protocols. This circuit is designed to function as a bridge between the OBD and a universal interface [3].

The ELM327 circuit is the most popular solution currently being the most compatible with OBDII protocols.

This device is widely used on devices with Bluetooth connection to Android smartphones [4].

The ELM327 is compatible with all OBDII protocols: SAE J1850 PWM; SAE J1850 VPW; ISO 9141-2; ISO 14230-4; ISO 15765-4. In addition, the ELM327 integrated circuit also supports the SAE J1939 protocols (256 kb/s and 500 kb/s).

2.3. STN1110 OBD interpreter

The STN1110 is one of the smallest OBD interpreters in the world and like the rest, allows easy access to vehicle data such as fault codes, Malfunction Indicator Light (MIL) status, inspection and maintenance data, vehicle identification number (VIN) , as well as hundreds of real-time parameters.

This circuit is based on a 16-bit processor, which is why it is several times faster than its closest competitor and has much more memory. The STN1110 integrated circuit is based on a robust technology called OBDLink stacking, allowing a quick and low-cost solution for interface operation. This OBDLink stacking technology consists of a set of modules designed to work in parallel.

The highlights of this technology are the data transfer rates, which are up to 4 times faster than the nearest competitor and a configurable power save mode.

This integrated circuit is compatible with all protocols of the ELM327, however it is also capable of serving as interface to the protocols ISO 15765 and ISO 11898.

These OBD interpreters allow the user to log the vehicle parameters and read diagnostic trouble codes (DTC). These are not particularly essential on accident reconstruction data analysis, yet ideas from these features can formulate a better solution for data collection.

3. Data Collection

The collection of the OBD data is made by reading the internal EDR of the vehicle. The solutions available are explained in this section. Lastly, an external EDR is conceptualized.

3.1. Internal EDR

Rechner [5] describes how the EDR, also known as black box, has been used in various modes of transport such as aircraft, trains and automobiles for a long time. This component records the content read by the various sensors of the vehicle and stores it for later analysis after a possible accident. Normally the EDR is activated due to a collision or a rapid deceleration, by sensors for this purpose that reach a limit threshold.

Chidester et al [6] refer that as early as 1974 General Motors equipped in the United States some of its vehicles in production with airbag systems. These early systems recorded the state of the airbag and the severity of the impacts that resulted in the airbags firing. From g-force sensors and diagnostic circuits, the instrument panel illuminated a light when there was an error or malfunction. Since that time there has been a steady evolution of technology, resulting in more advanced sensors and better methods of data recording. These advances in technology make it possible to improve the processing and analysis of accidents.

The EDR is used to record vehicle parameters and occupant information for a short time before, after and at the time of the accident. The EDR starts recording when the vehicle undergoes a rapid speed change (acceleration or deceleration) that exceeds the specific threshold beyond the normal use (trigger). Steady braking does not cause the event to be recorded in the EDR because it is considered as normal use. The violent impact on an obstacle (for example a step corresponding to a sidewalk) can be identified as abnormal and cause the event to be recorded in the EDR, due to the structure of the vehicle undergoing a rapid change of speed [7].

The internal EDR is part of the airbag module (ACM) of the vehicle [8]. It records some parameters like vehicle velocity, steering angle, delta-v, brake pedal operation and yaw rate.

The EDR allows recording several events, however usually the last two events are those that have more information because the more detailed information about the older events is erased to make room for the most recent information.

In order to use the values recorded in the EDR it is necessary to access and extract the recorded information. This can be achieved by using the airbag module reading tools. There are currently no regulations governing the manufacture of the EDR or data that is read and recorded in Europe. The information that the EDR is able to record is at the discretion of the manufacturer (different EDRs record different information). Unfortunately, in addition to the proprietary tools of the manufacturers there is only one commercial solution available today. Bosch offers a tool called the Bosch CDR Tool that allows you to read the EDR data. The data read can later be used in the accident reconstruction.

3.2. Bosch CDR Tool

The Bosh CDR Tool is an important tool in collecting information from the EDR and is the only current way to get the information present in the airbag module. This tool has been available since 2000 in the US and is widely used by the police, insurance experts and independent investigators to collect information from the EDR.

The tool consists of an interface and a set of cables that can be connected to any portable computer on which the CDR Tool software has been installed. The great advantage of this tool is that it is the only one with the ability to operate in multiple automobile manufacturers.

The connection can be made from the vehicle's OBD port or directly to the airbag module if it is outside of the vehicle [9]. The Bosch CDR Tool operating diagram is displayed in Fig. 1.

Fig. 1 – Bosch CDR Tool operating diagram.

The list of compatible vehicles is extensive, and there are some aspects to highlight. This list includes vehicles from 1994 to 2017. Most vehicles are only marketed in the United States of America. For example, Holden, HSV and Buick vehicles are not commercialized in Europe.

Some of the European brands are not supported by this tool. For example, Peugeot, Renault and Citroen are not compatible with the Bosch CDR Tool.

This software, with the data collected, has as output a report with various vehicle and EDR data. Typically the EDR records events in up to 5 seconds before the accident at 0.5 second time intervals [10].

These data are important for the reconstruction and analysis of the accident, and information such as airbag light, speed and steering angle are the most pertinent aspects.

The data obtained through this tool can be used as admissible evidence in court cases, both civil and criminal.

3.2. External EDR conception

The lack of solutions in the tools available in the market for the internal EDR present in the vehicle makes one think of alternatives for the collection of information of the vehicle in real time, recording them for later analysis [11].

The suggested idea concerns the projection of an external device, similar to the Bluetooth OBD device.

The main function of this device would be to read and record vehicle parameters so that they can later be used for accident reconstruction and as court evidence by connecting it to the OBD port in the vehicles and extracting live information.

This external EDR should have functions similar to those of the internal EDR, such as recording various events, rewriting them over the previous ones when there was no space or when a number of very previous events had elapsed.

Sensors like GPS position, acceleration and GPS velocity would be a great addition to the capacities of the external EDR.

There would have to be an encryption in the recording of this data or access to it because if it was not implemented anyone could erase or edit the data collected by the device.

This encryption would have to be normalized so that it could be used as evidence in court.

This external EDR could work with a microSD card so that it could be removed and read its contents.

The main application of this external EDR would be in the older vehicles, since the internal EDR present in this type of vehicles is more archaic. However these older vehicles are equipped with OBDII and would work with this device.

4. Results and Discussion

It is important to apply the information of the available tools in accident cases.

4.1. Case 1 – Lexus GS300h

In this case a Lexus GS300h (model year 2015) crashed into a small wall and some trees, resulting in the damage seen in Fig. 2.

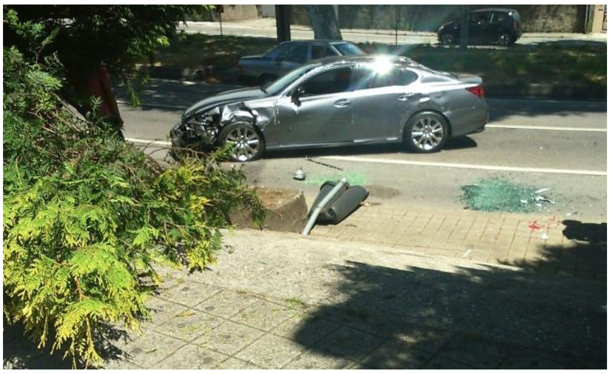

Fig. 2 – Damage to the Lexus vehicle.

The data from the EDR was collected by the Bosch CDR Tool. In the EDR were available 7 crash events, with a trigger (TRG) in each one. The event sequence is available in the Fig. 3.

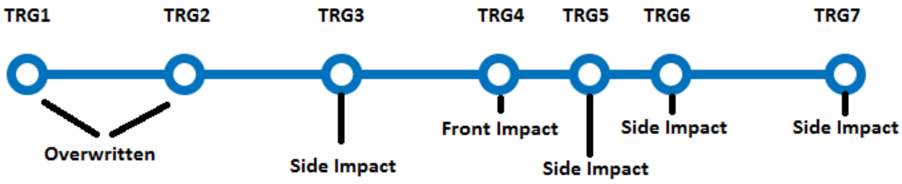

Fig. 3 – EDR event sequence.

The events related to the accident were the TRG4 to TRG7. From the data collected it was possible to obtain various graphs representing the variables recorded by the EDR.

In Fig. 4 it is possible to see a graphic with the information of the longitudinal acceleration of the vehicle, during a 5 seconds period. In some points it was displayed a invalid message.

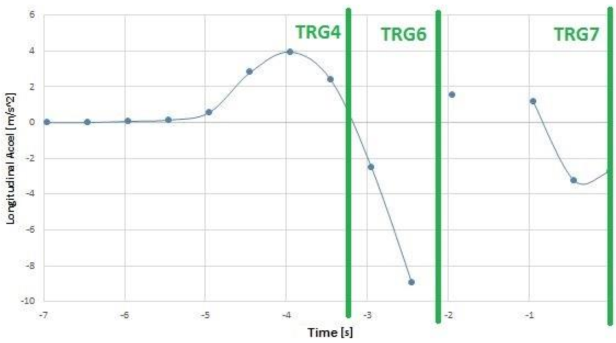

Fig. 4 – Longitudinal acceleration of the vehicle in function of the time.

The EDR present in the vehicle only records data in intervals of 0.5 seconds, in a total duration of 5 seconds per event. A lot of information can be lost in 0.5 seconds.

In Fig. 5 it is possible to observe graphics from the side satellite sensors of the TRG6 (the one which led to the most violent g accelerations)

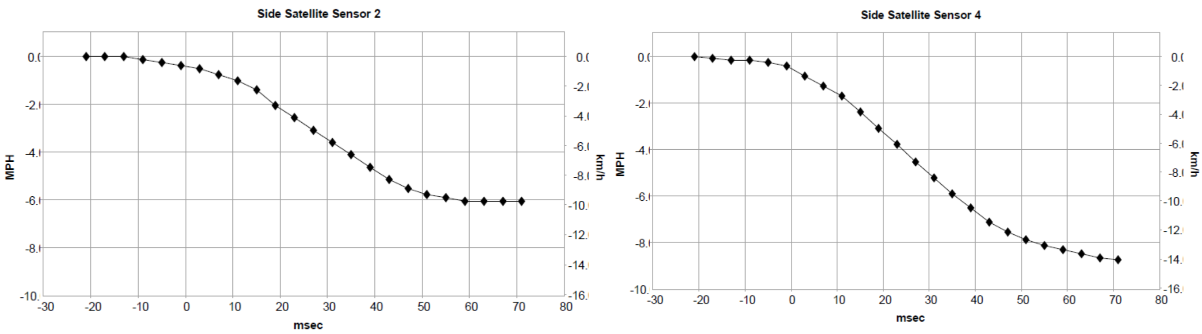

Fig. 5 – Delta-v for the event TRG6 (side satellite sensor nº2 and nº4).

From delta-v of the longitudinal velocities registered in the sensors it was possible to determine the max g accelerations. The vehicle was submitted to accelerations of approximately 7 G's, so it was expected that the side curtain airbags would deploy but that was not the case.

4.2. Case 2 – Mercedes SLK 200

In this case a Mercedes SLK 200 (model year 2005) lost control and crashed into a tree at high velocity, resulting in the damage seen in Fig. 6. The driver did not survive to the crash and the steering wheel airbag was not deployed.

Fig. 6 – Damage to the Mercedes vehicle.

From the analysis of the odometer it was found that the speed shown was not corresponding to the engine RPM´s and gear engaged.

Yuan et al [12] proves that in these cases where the needles operate electronically (being excited with a certain electric current in order to the needle rise or fall) the residual speed corresponds to the actual speed read on the wheels. Yuan et al [12] adds that with speeds higher than 40 km/h and in the case of frontal collisions (which is verified in this case) the speed read by the odometer corresponds to the speed read by the vehicle at the impact.

In this accident it was not possible to use the Bosch CDR Tool because it is not compatible with the 2005 model year of the Mercedes SLK 200.

The velocity which the car was running was faster than the one that the road was suitable for, and it had lost its grip, colliding on the tree with its front. The belt was in place and therefore the driver's airbag would have to fire, which did not happen. It was important to evaluate the vehicle's EDR to find the causes that led to not firing the airbag. The airbags should have deployed, since it is evident the severity of the frontal crash.

This is a case in which the external EDR would make life a lot easier. If there was an external EDR plug into the OBD it would be possible to record data and use it to make the crash reconstruction. This could bring a better understand of the elements that led to the accident, perceiving why the airbag did not deployed.

5. Discussion

The Bosch CDR Tool is the only commercial tool available for reading the data present in the vehicle's EDR. In Europe there is still no legal regulation for the implementation of the EDR. There is a need for legislative measures to regulate and implement this tool.

The reports generated by the Bosch CDR Tool display various graphs and data about the parameters read from the vehicle's EDR, however they have some flaws. The existence of invalid values is common, introducing gaps in the sequences of events [13]. Each event is categorized in relation to the type of impact (lateral, frontal, etc.) depending on the accelerations readings from the sensors It is necessary to analyze the accelerations with attention because sometimes they are reactions to inverse forces.

The internal EDR normally records for 5 seconds, which for most cases this recording duration is sufficient.

The internal EDR records information at intervals of just 0.5 seconds, much of the information is lost between these instants. The write step should be smaller, and a step of 0.1 or 0.05 seconds would allow much more information to be read. This fact makes the graphics plotted with a smaller pitch more accurately represent the reality of what happened.

The implementation of an external EDR is important for the development of vehicle data recording tools and in some cases the maximum reading range could be increased. It would be important to regulate the functionalities of external EDR and the legal regulation of its operation, so it can to be used as evidence in court. This recording would have to be regularized by standards in order to be agreed upon the best way to read and write the data externally. Sensors like GPS position, acceleration and GPS velocity would be a much welcome addition to the functionalities of the external EDR.

The external EDR would be ideal for use on older vehicles not supported by the Bosch CDR Tool. For the vehicles that are not supported by the Bosch CDR Tool and the ones which do not have a recent

EDR this is the only way to apply a method of reading and recording vehicle crash events, adding functional improvements from sensors mounted on the external EDR. This form would be important for the determination of the causes of the accidents and their reconstitution.

From this analysis it could be important to put the hypothesis of an OBDIII. This would be needed due to the constant technological increase of the vehicles and their systems and mainly due to the inevitable expansion of the autonomous vehicles. It is necessary to define the rules of operation of these vehicles and to interrelate with other road users.

6. Conclusions

The appearance of OBD standards results from the need for analysis and control of emissions from the vehicle, being that most of the sensors and controllers in the vehicle are linked to this objective.

From this work it is possible to take some measures for the automotive industry. The introduction and implementation of an external EDR for older vehicles with sensors in the EDR itself is a major step towards accident mitigation. This external EDR would function like a constantly video recording (widely used today to identify those responsible for human-induced accidents) that continuously records vehicle parameters.

The main functions of the external EDR would be the ability to read and write the parameters of the vehicle in greater detail (greater sampling over time for each event), the implementation of new sensors in the external EDR (the addition of GPS sensors and acceleration sensors would be indispensable) and the encryption of the files for use in court.

Through the analysis of the Bluetooth OBD devices it was possible to verify that they cannot be used in court because the data is easily edited. The impossibility of these devices reading the internal EDR parameters also contributes to the exclusion of this tool as an analysis for the reconstruction of accidents. The only relevant capabilities in this device are the logging and reading of the error codes of the vehicle.

With the analysis of the internal EDR of the vehicle it is possible to identify that there are many difficulties in the implementation and regulation of this device. It is necessary to define standards in Europe, improve the functions available and increase solutions for reading data. The Bosch CDR Tool, while helping significantly, reveals gaps in both vehicle compatibility and the information collected.

Without the addition of new hardware in vehicles, the Bosch CDR Tool is currently the only solution available in the market for OBD data collection in case of an accident. However its limitations mean that this is not the ideal solution to the problem.

The design of the external EDR is a constantly developing topic, and this is a tool that has to be more explored at the design level, so that it can be implemented consistently and definitively. This device can bring competition to the available solutions.

New solutions can be implemented that collect information from the internal EDR of the vehicle, lowering the cost of these tools, so that the analysis costs of this component of the vehicle are smaller.

It would be interesting to see a OBDIII emerging to match the current developments of the automotive industry.

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