# Experience with Data Readout from the Event Data Recorder (EDR)

Heinz Burg

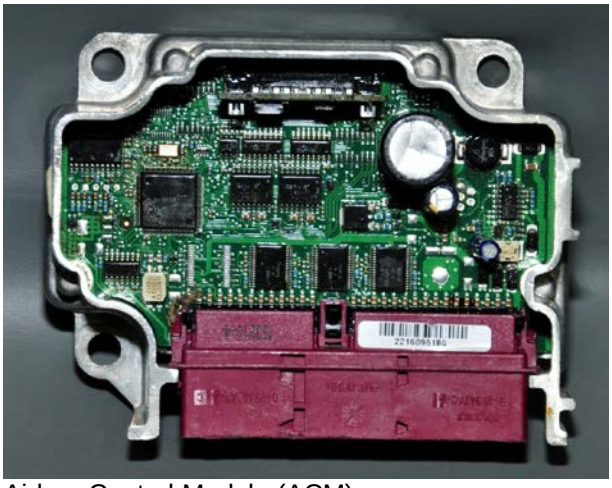
## Abstract

*Because of the electronic systems in our vehicles, the Active and Passive Si safety could be increased enormously. These significant advantages also have disadvantages. The last are reduction or loose of objective measures like traces on the road that might allow the traffic accident experts in their role as helpers of the investigating authorities, courts and insurance companies to assess the Pre Crash Phase. The problem is well known. To overcome this lag, in the USA electronic data storages have been developed since about 1994. At the first years, the industry was focused on the crash phase. Since about 2009, the first 5 s before the accident the most important data such as speed and other driving data are recorded. In addition accident-relevant information about the vehicle occupant, such as the seat occupancy status of the seat belts, etc are recorded. In the US, the current market coverage for new cars is currently 99%, 1 % is still without EDR.*
*If the vehicle manufacturers in the USA and Canada want to bring new models into the market, this models must have an Event Data Recorder (EDR) and the data must be retrievable with a publicly available tool.*
*The possibility of data storage and the readout becomes more and more urgent because the-introduction of the semi-autonomous driving of vehicles objective data is essential for assessing the causes of accidents. When we think about autonomous driving, the problem becomes even more apparent.*
*In the opinion of the author, the readout of accident related data must be primarily done by the investigating authorities (Police), and there must be specialized experts for accident reconstruction, who will be able to assess this data correctly.*

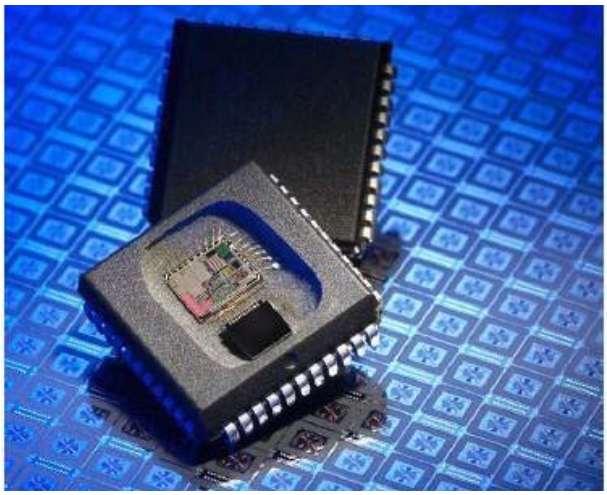
## 1 Introduction

In USA, Canada and in many parts of the world it has prevailed that in passenger cars accident-relevant data is stored. The data is in a memory module in hexadecimal characters, which makes them largely secured of hacking. Only after reading this hexadecimal characters are converted into readable text or diagrams.
When thinking about the problem data manipulation, immediately the question arises: how to ensure that a hard copy report with readable data is not falsified. This is however, a specific but important issue, but not discussed here.

The memory module for accident-related data is the Event Data Recorder (EDR) and is incorporated into the airbag control unit wich is mounted in a well protected place. The memory module gets data from different sources in the vehicle, usually via the CAN bus. This is an important issue for the data interpretation.



Airbag Control Module (ACM)


Flash Memory

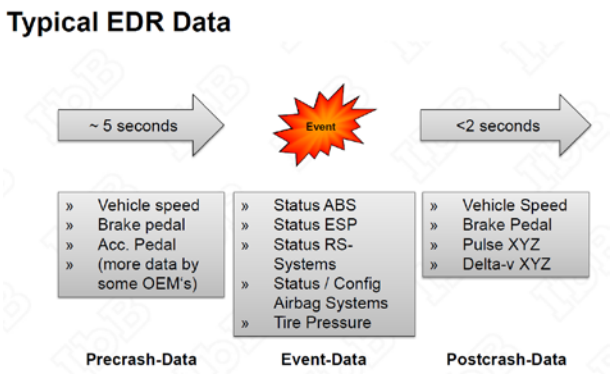
What data is stored for? In the US there is a regulation, which states that if an EDR is installed in a vehicle, certain minimum data must be stored at a certain accuracy.

The Regulation is now available in a in a revised version. Therefore older vehicles satisfy the EDR data with the first prior regulation and newer ones correspond to the recent state of the regulation. In future the next revision will come and that will not be the last release. Technical development is accelerating, especially at our cars.

Why are accident-related data stored? There are many answers to this question. One answer out of the sight of accident reconstruction experts is that the electronic control systems for active safety largely prevent skid marks before the collision. Today you can hardly calculate somewhat about driver behavior before a collision based on objective measures.

Data stored in the Event Data Recorder of the newer vehicles deliver information about what has happend 5 s before the collision until approximately 2 seconds after the collision.

Die im Event Data Recorder gespeicherten Daten liefern bei den neueren Fahrzeugen Informationen über den Unfallhergang ab 5 s vor der Kollision bis etwa 2 s nach der Kollision.




The electronically stored data are objective characteristics, as for example, tire tracks on or beneath the road, paint-particles, fracture surfaces, splinters and rest positions.

## 2 Read out of electronic data

The airbag control moduls (ACM) are developed by the suppliers, manufactured and delivered to the vehicle manufacturers. The manufacturer decide which data are stored. They also decide on the type / methode of readout of the EDR data.

Historic representation manufacturer participation

Most vehicle manufacturers make use of the BOSCH Crash Data Retrieval (CDR) tool.
The figure below shows the current status of read out tools for the US market. This state is world-wide valid. However, some manufacturers have blocked the readout or the data recording for Europe.

In this presentation, only the BOSCH CDR tool is considered. In principle, the explanations are valid also for the other read out tools.

| Manufacturer | 12 months Sales end 2/16 | Market Share | 2016 EDR? | Tool? |
|---|---|---|---|---|
| GM | 3,079,772 | 17.6% | YES | Bosch CDR |
| Ford | 2,634,491 | 15.0% | YES | Bosch CDR |
| Toyota | 2,498,889 | 14.3% | YES | Bosch CDR |
| Chrysler Group | 2,273,230 | 13.0% | YES | Bosch CDR |
| Honda | 1,598,383 | 9.1% | YES | Bosch CDR |
| Nissan | 1,499,020 | 8.6% | YES | Bosch CDR |
| Hyundai | 762,720 | 4.4% | YES | GIT tool co. |
| Kia | 631,531 | 3.6% | YES | GIT tool co. |
| Subaru | 583,617 | 3.3% | YES | Denso 2016+, was Hitachi |
| BMW | 400,064 | 2.3% | 2015 | Bosch CDR |
| Mercedes-Benz | 380,690 | 2.2% | 2014 | Bosch CDR |
| Volkswagen | 342,626 | 2.0% | 2015 | Bosch CDR |
| Mazda | 314,510 | 1.8% | YES | Bosch CDR |
| Audi | 202,774 | 1.2% | 2015 | Bosch CDR |
| Mitsubishi | 95,450 | 0.5% | YES | OTC/Bosch SPX |
| Tata (Jag, LR) | 87,120 | 0.5% | YES | OTC/Bosch SPX |
| Geely (Volvo) | 71,744 | 0.4% | NO | N/A |
| Porsche | 52,532 | 0.3% | NO | N/A |
| Industry Total | 17,509,163 | 100.0% | 99.3% | Bosch CDR 87.0% [6] |
| updated April 4 2016 | | | | Non CDR 12.3% |

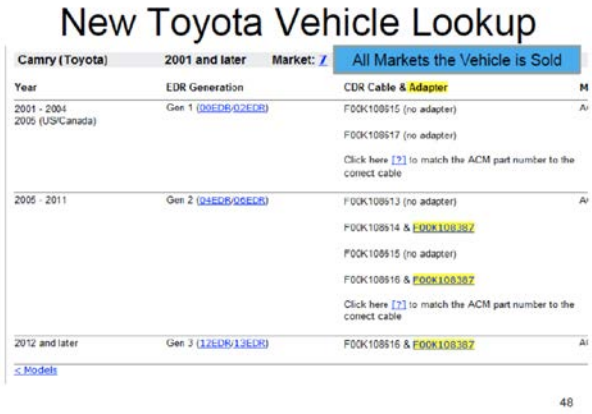
(Source: Ruth Consulting)

## 3 Data read out via OBD connector

In the simplest case, a universal cable is needed, which connects the OBD connector to the DLC BOSCH (green box, modem). The green box is connected to a computer / laptop / tablet. On the computer there is a program of BOSCH (CDR software). The software converts the hexadecimal data into a readable report (CDR Report), which can be sometimes over 100 pages long.

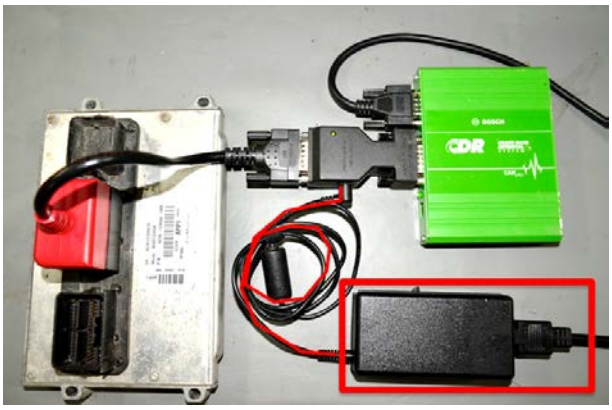
Sometimes an additional adapter is required; if such is needed, the help file of CDR software gives exact instructions.


The cost of the CDR kit are currently 1900 EUR net and for the Software 899 Euro net. It is reasonable to buy the above mentioned adapters too, because these are relatively often needed. The total price is then 3419 euros net.
The figure below shows an excerpt from the BOSCH CDR software, highlighted in yellow are the adapters.




## 4 Data read out directly from the Airbag Control Module (ACM)

When are the power cables are distroyed due to the accident, so that the read out via OBD does not work anymore, the airbag control module should be dismounted. Using a car type dependend special cable connected to the CDR kit allows the data read out.



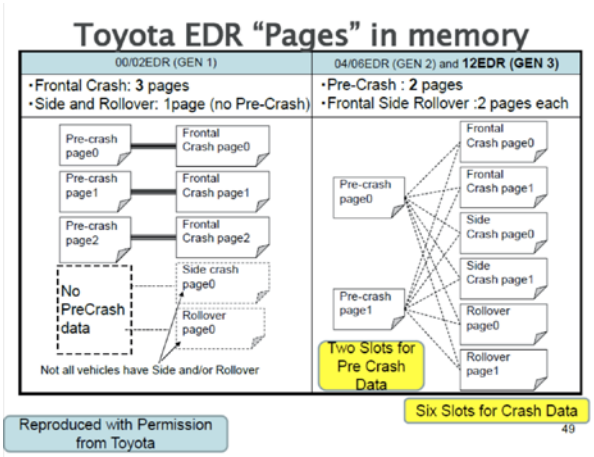

There are two methods, read out the ACM in mounted position also. The ACM can be directly supplied with power when the connection no longer works at the OBD connector. Both methods can cause problems, so it is better, to dismount the ACM and read at a desk or a workbench. An additional advantage occures if the ACM can be kept if possible, since data protection and traceability is ensured (evidence by forensic chain).

If the readout, described here, does not work, possibly the manufacturer of the control unit can help. Here, however, the rules about Privacy and Property have to be noted. If one makes something wrong, he can quickly become problems.
For example, it will be a good decision, to send a control device to a supplier without allowance of the prosecutor. In addition our experience is, that there is only the period between wake up and deployment command stored (acceleration versus time).

## 5 General Remarks

In the data interpretation can be wrong a lot, because the manufacturers comply with provisions of US Regulations, but how they do it is totally different. It is therefore a manufacturer and model-dependent training required. Some important notes:

- With each CDR reading the counter for the Ignition Cycle gets increased by 1. This is an indirect indicator of the mileage of the vehicle.
- The number of readouts (Ignition Cycles) can be increased by Backpowering. Short circuit may lead to several attempts of the controller and several increases of the ignition cycle.
- Some ECUs with external sensors (satellite sensors) the sensors may be not connected and that can set error codes.
- Manipulations can be change the contents of ECUs.
- Problems by data interpretation by complex accidents with multiple events.




(Source: Ruth Consulting)

## 6 US Regulations

EDR -Part 563 Definition

The term "event data recorder" is defined as "a device or function in a vehicle that captures 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 versus time), such that the data can be retrieved after the crash event. For the purposes of this definition, the event data do not include audio and video data.

EDR - Teil 563 - Minimum data set if equipped with an EDR

- Delta-V, longitudinal 0 to 250 ms, every 10 ms
- Maximum delta-V, longitudinal 0-300 ms
- Time, maximum delta-V 0-300 ms
- Speed, vehicle indicated (5 sec, 2 samples/sec)
- Engine throttle, % full (5 sec, 2 samples/sec)
- Service brake, on/off (5 sec, 2 samples/sec)
- Ignition cycle, at time of crash
- Ignition cycle, at time of download
- Safety belt status, driver
- Frontal air bag warning lamp, on/off
- Frontal air bag deployment, time to deploy (driver/passenger/stages)
- Multi-event, number of events
- Time from "event 1" to "event 2"
- Complete file recorded (yes/no)

Part 563 – Table 1 *(partial list)*

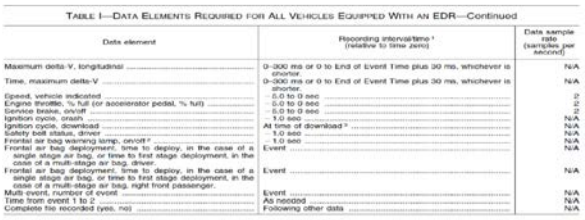


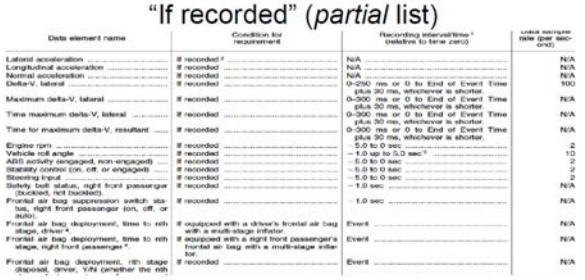
TABLE I—DATA ELEMENTS REQUIRED FOR ALL VEHICLES EQUIPPED WITH AN EDR—Continued

| Data element | Recording interval/time [1] (relative to time zero) | Data sample rate (samples per second) |
|---|---|---|
| Maximum delta-V, longitudinal | 0-300 ms or 0 to End of Event Time plus 30 ms, whichever is shorter. | N/A |
| Time, maximum delta-V | 0-300 ms or 0 to End of Event Time plus 30 ms, whichever is shorter. | N/A |
| Speed, vehicle indicated | -5.0 to 0 sec | 2 |
| Engine throttle, % full (or accelerator pedal, % full) | -5.0 to 0 sec | 2 |
| Service brake, on/off | -5.0 to 0 sec | 2 |
| Ignition cycle, crash | -1.0 sec | N/A |
| Ignition cycle, download | At time of download [2] | N/A |
| Safety belt status, driver | -1.0 sec | N/A |
| Frontal air bag warning lamp, on/off [3] | -1.0 sec | N/A |
| Frontal air bag deployment, time to deploy, in the case of a single stage air bag, or time to first stage deployment, in the case of a multi-stage air bag, driver. | Event | N/A |
| Frontal air bag deployment, time to deploy, in the case of a single stage air bag, or time to first stage deployment, in the case of a multi-stage air bag, right front passenger. | Event | N/A |
| Multi-event, number of event | Event | N/A |
| Time from event 1 to 2 | As needed | N/A |
| Complete file recorded (yes, no) | Following other data | N/A |

EDR - Teil 563 - Table 2 "If recorded" (partial list)

- Acceleration 0-250ms @10ms intervals
- Lateral Delta V(side impact)
- Passengerbelt status
- RPM
- Roll angle, steering angle
- ABS, ESC on/off, occupant size, and other inputs and outputs of restraints system

Part 563 - Table 2
"If recorded" (*partial* list)



| Data element name | Condition for requirement | Recording interval/time [1] (relative to time zero) | Data sample rate (per second) |
|---|---|---|---|
| Lateral acceleration | If recorded [2] | N/A | N/A |
| Longitudinal acceleration | If recorded | N/A | N/A |
| Normal acceleration | If recorded | N/A | N/A |
| Delta-V, lateral | If recorded | 0-250 ms or 0 to End of Event Time plus 30 ms, whichever is shorter. | 100 |
| Maximum delta-V, lateral | If recorded | 0-300 ms or 0 to End of Event Time plus 30 ms, whichever is shorter. | N/A |
| Time maximum delta-V, lateral | If recorded | 0-300 ms or 0 to End of Event Time plus 30 ms, whichever is shorter. | N/A |
| Time for maximum delta-V, resultant | If recorded | 0-300 ms or 0 to End of Event Time plus 30 ms, whichever is shorter. | N/A |
| Engine rpm | If recorded | -5.0 to 0 sec | 2 |
| Vehicle roll angle | If recorded | -1.0 up to 5.0 sec [3] | 10 |
| ABS activity engaged, non-engaged | If recorded | -5.0 to 0 sec | 2 |
| Stability control (on, off, or engaged) | If recorded | -5.0 to 0 sec | 2 |
| Steering input | If recorded | -5.0 to 0 sec | 2 |
| Safety belt status, right front passenger (buckled, not buckled) | If recorded | -1.0 sec | N/A |
| Frontal air bag suppression switch status, right front passenger (on, off, or auto) | If recorded | -1.0 sec | N/A |
| Frontal air bag deployment, time to nth stage, driver [4] | If equipped with a driver's frontal air bag with a multi-stage inflator. | Event | N/A |
| Frontal air bag deployment, time to nth stage, right front passenger [4] | If equipped with a right front passenger's frontal air bag with a multi-stage inflator. | Event | N/A |
| Frontal air bag deployment, nth stage disposal, driver, Y/N (whether the nth | If recorded | Event | N/A |

EDR - Teil 563 - Table 3 not voluntarily data

Part 563 - Table 3
Data Element Format (*partial* list)

TABLE III—REPORTED DATA ELEMENT FORMAT

| Data element | Minimum range | Accuracy[1] | Resolution |
|---|---|---|---|
| Lateral acceleration | At option of manufacturer | At option of manufacturer | At option of manufacturer. |
| Longitudinal acceleration | At option of manufacturer | At option of manufacturer | At option of manufacturer. |
| Normal Acceleration | At option of manufacturer | At option of manufacturer | At option of manufacturer. |
| Longitudinal delta-V | −100 km/h to + 100 km/h | +/− 10% | 1 km/h. |
| Lateral delta-V | −100 km/h to +100 km/h | +/− 10% | 1 km/h. |
| Maximum delta-V, longitudinal | −100 km/h to +100 km/h | +/− 10% | 1 km/h. |
| Maximum delta-V, lateral | −100 km/h to +100 km/h | +/− 10% | 1 km/h. |
| Time, maximum delta-V, longitudinal | 0–300 ms, or 0—End of Event Time plus 30 ms, whichever is shorter. | +/− 3 ms | 2.5 ms. |
| Time, maximum delta-V, lateral | 0–300 ms, or 0—End of Event Time plus 30 ms, whichever is shorter. | +/− 3 ms | 2.5 ms. |
| Time, maximum delta-V, resultant | 0–300 ms, or 0—End of Event Time plus 30 ms, whichever is shorter. | +/− 3 ms | 2.5 ms. |
| Vehicle Roll Angle | −1080 deg to +1080 deg | +/− 10% | 10 deg. |
| Speed, vehicle indicated | 0 km/h to 200 km/h | +/− 1 km/h | 1 km/h. |
| Engine throttle, percent full (accelerator pedal percent full) | 0 to 100% | +/− 5% | 1%. |
| Engine rpm | 0 to 10,000 rpm | +/− 100 rpm | 100 rpm. |
| Service brake | On or Off | N/A | On or Off. |
| ABS activity | On or Off | N/A | On or Off. |
| Stability control | On, Off, or Engaged | N/A | On, Off, or Engaged. |
| Steering input | +/− 100% | +/− 5% | 1%. |
| Ignition cycle, crash | 0 to 60,000 | +/− 1 cycle | 1 cycle. |
| Ignition cycle, download | 0 to 60,000 | +/− 1 cycle | 1 cycle. |
| Safety belt status, driver | On or Off | N/A | On or Off. |

## 7 Examples for Reconstruction Reports

Sometimes the readout of the EDR data with the BOSCH CDR is enough to say how the accident occurred.

a) mix of accelerator and brake pedals

From the 5 s before the collision can be clearly seen that the driver did not braked, but pressed the gas pedal.

**Pre-Crash Data, -5 to 0 seconds (Most Recent Event, TRG 7)**

| Time (sec) | -4.9 | -4.1 | -3.6 | -3.1 | -2.6 | -2.1 | -1.6 | -1.1 | -0.6 | -0.1 | 0 (TRG) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Vehicle Speed (Mph [km/h]) | 22.4 [36] | 17.4 [28] | 19.3 [31] | 20.5 [33] | 22.4 [36] | 24.9 [40] | 26.7 [43] | 29.2 [47] | 26.1 [42] | 24.2 [39] | 24.2 [39] |
| Accelerator Pedal, % Full (%) | 100.0 | 62.5 | 100.0 | 98.5 | 100.0 | 10.0 | 100.0 | 100.0 | 2.0 | 4.0 | 52.5 |
| Percentage of Engine Throttle | Invalid | Invalid | Invalid | Invalid | Invalid | Invalid | Invalid | Invalid | Invalid | Invalid | Invalid |
| Engine RPM (RPM) | 3,700 | 3,700 | 3,300 | 3,500 | 3,700 | 3,900 | 3,300 | 4,200 | 3,500 | 2,900 | 2,900 |
| Motor RPM (RPM) | 2,700 | 2,100 | 2,400 | 2,600 | 2,700 | 3,100 | 3,300 | 3,500 | 3,400 | 2,900 | 3,000 |
| Service Brake, On/OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF |
| Brake Oil Pressure (Mpa) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Longitudinal Acceleration | 0.144 | 0.000 | 1.035 | 1.364 | 1.795 | 2.441 | 2.225 | 1.795 | -3.158 | -2.267 | -8.973 |
| Yaw Rate (deg/sec) | 56.61 | 36.62 | 35.62 | 26.35 | 12.20 | 8.30 | 1.46 | 21.96 | 36.14 | 38.55 | 40.99 |
| Steering Input (degree) | 309 | 174 | 168 | 102 | 48 | 30 | 15 | 147 | 213 | 237 | 226 |
| Shift Position | D | D | D | D | D | D | D | D | N | N | N |
| Sequential Shift Range | Undetermined | Undetermined | Undetermined | Undetermined | Undetermined | Undetermined | Undetermined | Undetermined | Undetermined | Undetermined | Undetermined |
| Cruise Control Status | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF |
| Drive Mode, PWR | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF |
| Drive Mode, ECO | ON | ON | ON | ON | ON | ON | ON | ON | ON | ON | ON |
| Drive Mode, Sport | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF |
| Drive Mode, Snow | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF |
| Drive Mode, EV | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF | OFF |

b) Rear accident

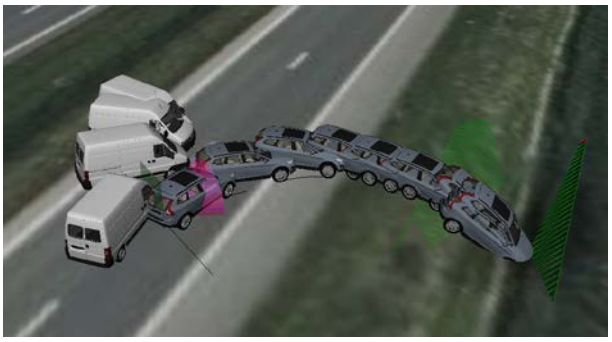
If the data of one of the vehicles can be retrieved, the change of velocity is known. If it was the vehicle in front, one sees possibly also whether it was standing or in motion.

c) Complex accident

In such a case we have to study very carefully the data limiltations and the sign conventions. Also an accurate analysis of the various data must be made. This can include the "Table 3“ data, for example by pedestrian detection. Only in conjunction with a conventional accident reconstruction we can be sure that the EDR data were evaluated and adopted correctly.

It should not be forgotten that in the 5 s the indicated speed is given, that ist he speed we can see on the speedometer, that are the time related values before the collision. Since the speedometer must proceed according with statutory rules and the boundaries, we can specify in which range, the actual speed may have been. There are the following provisions of Directive 2000/7 / EC:

0 <= (V1 - V2) <= 0.1 * V2 + 4 km / h where V1 the displayed speed is and V2 the real speed.



## 8 Education and training

We (IbB and partners) provide various training courses as follows:

a) Operator Training:

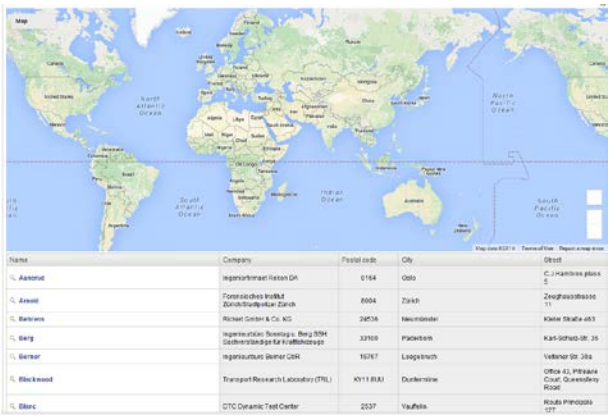
The prticipants will learn how the data readout on site and possibly shortly after the accident can be best carried out with intact power supply. Backup after accidents is primarily a task for the police. Since it is a new way to get backups for later accident reconstruction, it may be that the police are not yet able to work these trainees-lead. It then makes sense to consult the experts already trained and equipped with the necessary equipment. For that these experts should be choosen who, at least on a 5-day basic training have participated. The addresses of these persons can be found on the IbB websites:

b) Five-day basic training for police officers and experts in accident reconstruction.

It is generally difficult to interpret the data from the Event Data Recorder correctly and add the data into a reliable accident reconstruction.

Additionally complicating is the fact that the car manufacturers, as already mentioned, fullfill the US regulations very correct, but they do so in a very different ways.

The vehicle models of each manufacturer are more or less different depending on the model year. It is important when the car models have been developed and what was the state of art at that time. Especially the electronics and the sensors is subjected to an extremely fast change.

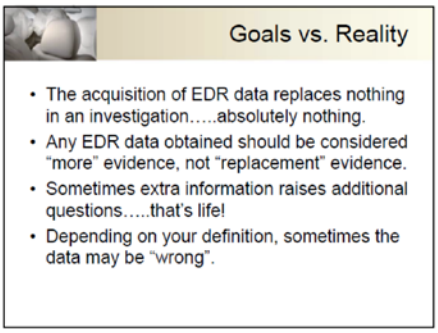


List of those who attended a 5-day course

Data interpretation is only reasonably unproblematic when the 5 s were recorded before the collision, the crash and post-crash and it is a "simple" accident, such as a rear-end collision. For the most types of accident good skills in accident reconstruction and vehicle dynamics are neccessary. For example, to consider is:

- How work sensors for active and passive safety?
- What types of electronic data transmission are in use?
- To calculate the actual speed at collision you need know-ledge of the wheels: size, wear, air-pressure, load, tire slip when using ABS or skidding vehicles before impact (ESP).
- Recorded is only the "Indicated Speed", which is the tacho revealed speed, the allowable deviations are given in the relevant EU directive.
- Difficult are multiple triggers, overlaped events, hidden events (rollover).

CDR data do not replace an accurate conventional scene survey and accident analysis. This is the opinion of the CDR specialists around the world.




**Wesley Vandiver, ACTAR**
**Orange County District Attorney's Office**
**Vehicular Homicide Investigations**

WREX Conference 2016, Orlando

- The technologies are escalating, an example is the automated driving. Permanent training is indispensable. We therefore offer a training of three days per year as part of a quality assurance management (QM).
- Those who join this QM may use the name "IbB CDR Specialists" and get an identity passport. These people can also be found on our websites.

- Since 2014, we organize at yearly intervals, the "European CDR User Summit". This is for one a part of the QM training on for the other to the public for precise informations about EDR. The documents developed thereby are generally free and accessible via our website.

- As we are responsible for Europe, the Commonwealth of Independent States, the Middle East and Africa, we need subcontractors to fullfill our tasks.

## 9 Privacy and Rights on the Files

The technology around the Event Data Recorder is quite complicated, the legal issues are still more complicated.
It is to distinguish in criminal and civil matters.
In criminal law, the problem seems to be fairly straightforward. If an accident happens and this is picked up by the police, the seizure of the vehicle or the vehicles by the prosecution may be requested. If this way is gone, the vehicles can be investigated and objectives may be ensured without the driver or the owner can do something about it. Since electronic data can be considered as objective measures, the data can be ensured by reading.
A good example are the data from the electronic speedometer-graphs on trucks.

After proper readout of data and report printed or stored on a data carrrier these evidents are part of the investigative files. The data can than, if neccessary, be used later for an accident reconstruction report.
If none of seizure with data readout was carried out, the persons involved may themselves seek to readout. Which way must be passed in order to obtain the results of the reading in the investigation file, is still unclear. Lawyers advice is recommended.

The experts are advised to document the process of readout very accurate inclusive the boundary conditions (for example, tires, software status, extent of damage, etc.). A trained expert CDR should such work take over. Depending on the procedural situation second opinion may be neccessary. Such a further expert should have all evidence for verification.

In civil proceedings various personal rights of issuance of the data can prevent the use of it.
First, there is the question of who owns the data?

If someone buys a car, he is the owner of the car and the owner of the data generated by built-in electronic devices and recorded. The EDR collects and stores personal data oft he driver.

If the driver is not the owner of the vehicle, it must be clarified whether he also has a right on this information. Upper Court judgments are missing in many countries. It should also be noted that the legal systems in the countries of our contract territory is very different.

The declared aim of the German legislation is to protect person related data and the constitutional rights of individuals, which can be hurt by unauthorized use of these data, see BDSG,.

## Literature

1. Real World Experience with Event Data Recorders, Chidester, A. and Hinch, J. NHTSA 2001
2. Analysis of Event Data Recorder Data for Vehicle Safety Improvement, NHTSA 2008, DOT HS 810 935
3. Digitale Spuren in Fahrzeugen – die Zukunft ist bereits Realität. Arnold, Jörg, Forensisches Institut Zürich, Kriminalistik Heft 12, 2015

## Contact

Heinz Burg, PhD
IbB Engineering GmbH
Hohlweg 2
54472 Burgen, Germany
e-mail: drb@ibb-info.de
tel: 0049 6534 949930
www.ibb-info.org