EDR DATA COLLECTION IN NHTSA’S CRASH DATABASES

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ABSTRACT

The National Highway Traffic Safety Administration (NHTSA) has been gathering Event Data Recorder (EDR) information in its data collection programs since the late 1990s. The various EDR data elements collected in NHTSA’s crash databases provide insight into the vehicles’ safety systems and actions leading up to a crash. This EDR data will be a key source as focus on crash avoidance countermeasures increase and crashworthiness countermeasures are optimized in the automotive safety community. The purpose of this paper is to describe the evolution of EDR data collection in NHTSA’s in-depth crash investigation programs leading up to the implementation of the Code of Federal Regulation (CFR) 49 Part 563. Additionally, the paper will discuss the techniques used to collect EDR data, and detail future plans for their coding in NHTSA’s crash databases.

INTRODUCTION

NHTSA is currently imaging EDR data using a commercially available tool in its three field investigation-based data collection programs: the National Automotive Sampling System-Crashworthiness Data System (NASS-CDS), Special Crash Investigations (SCI) and the Crash Injury Research and Engineering Network (CIREN).

NASS-CDS is a nationally representative sample of towed light vehicle crashes with an emphasis on the crashworthiness of the vehicle. The case selection algorithm is gives fatal and severe injury crashes a higher probability of selection than less severe crashes. Data is collected at 24 sites across the country with an annual average of 4,500 cases per year since 1999.

SCI is a collection of approximately 125-150 targeted investigations annually that are utilized by NHTSA and the automotive safety community to understand the real-world performance of existing and emerging advanced safety systems.

CIREN is a hospital-based study operating out of six centers across the country, collecting approximately 300 cases per year. The CIREN process combines prospective data collection with professional multidisciplinary analysis of medical and engineering evidence to determine injury causation in every crash investigation conducted.

EDR data was also collected by NHTSA in a special study using the NASS infrastructure from 2005-2007, the National Motor Vehicle Crash Causation Survey (NMVCCS). NMVCCS was a nationally representative survey of light vehicle crashes that used Emergency Medical Services (EMS) notifications as the primary case initiation criterion. Researchers conducted on-scene field investigations on nearly 7,000 crashes during the project, focusing on the pre-crash phase of the crash.

While the three active data collection programs NASS-CDS, SCI, and CIREN have distinct overall objectives they do share four key data collection areas:

- Examining the crash scene
- Interviewing involved occupants
- Reviewing occupant medical records
- Conducting detailed inspections of crash-involved vehicles

The vehicle inspection involves the documentation and photography of crush deformation, occupant compartment intrusion, occupant contacts, and assessment of the safety systems in the vehicle. Additionally, the vehicle inspections include an attempt to image the EDR if the vehicle is so equipped and supported by the commercially available Crash Data Retrieval (CDR) tool.

As of January 8, 2015 the four investigation-based programs have imaged 13,898 EDRs since 1999. Figure 1 outlines the breakdown of EDRs imaged by each of the NHTSA programs.
BACKGROUND
NHTSA began collection of very rudimentary EDR data in the 1970s. General Motors (GM) introduced the first regular production driver/passenger air bag systems as an option in selected 1974-76 production vehicles. They incorporated electromechanical g-level sensors, a diagnostic circuit that continually monitored the readiness of the air bag control circuits, and an instrument panel Readiness and Warning lamp that illuminated if a malfunction was detected. The data recording feature used fuses to indicate when a deployment command was given and stored the approximate time the vehicle had been operated with the warning lamp illuminated. This information was extracted by the SCI investigators with a GM proprietary tool.

In 1990, GM introduced a more complex air bag control module called the Diagnostic and Energy Reserve Module (DERM). The DERM was introduced with the added capability to record closure times for the multiple electromechanical switches for crash sensing, arming, and discriminating sensors as well as any fault codes present at the time of deployment. Beginning with the 1994 model year, GM introduced a single solid state analog accelerometer and a computer algorithm integrated in a Sensing & Diagnostic Module (SDM). The SDM also computed and stored the change in longitudinal vehicle velocity (deltaV) during the impact to provide an estimate of crash severity. This feature allowed GM engineers to obtain restraint system performance data when a vehicle was involved in a deployment event or experienced an impact-related change in longitudinal velocity, but did not command deployment (i.e. a near-deployment event). The SDM also added the capability to record the status of the driver’s seat belt switch (buckled or unbuckled) for deployment and near-deployment events.

In certain GM vehicles beginning in the 1999 model year, the capability was added to record vehicle systems status information for a few seconds prior to an impact. Vehicle speed, engine RPM, throttle position, and brake switch on/off status are recorded for the five seconds preceding a deployment or near-deployment event.

At that time, the information in GM DERMs and SDMs could only be extracted by the manufacturer using a proprietary tool. Therefore, only a limited number of images were obtained by GM at the request of NHTSA to support air bag and EDR research from 1990 to 1999.

In 1999, NHTSA launched a research project with Ford on the real-world crash experience of advanced featured air bags equipped in 2000 Taurus/Sable fleet. For this research, Ford supplied the SCI teams a rudimentary EDR tool for extracting the basic air bag deployment data from the Restraint Control Module (RCM). The RCM also computed and stored a short duration (~80ms) of the change in longitudinal and lateral vehicle velocity during the impact sequence to provide an estimate of crash severity. This feature allowed Ford engineers to obtain restraint system performance data to help “tune” the deployment algorithms.

Beginning in 1999, the various NHTSA field data collection teams were equipped with a commercially available tool called the Crash Data Retrieval (CDR) system, produced by Vetronix Corporation to collect EDR data. Late in 2003, Vetronix, which was the only commercially available supplier of the CDR retrieval tool, was purchased by Robert Bosch GmbH. In the early years, only some GM vehicles were supported by the CDR hardware and software, but in 2003 and 2007, respectively, select Ford and Chrysler vehicles were added to the list of supported models. From 1999-2007, the number of models supported by the CDR tool continued to increase for these three major U.S. manufacturers. Therefore, by the beginning of 2008, roughly half of the vehicles sold in North America since model year 2004 were supported by the CDR system [1].

Based on the outputs from the early EDRs, the subsequent commercially available tool, and NHTSA’s recognition of the safety benefits to the
driving public, a team of experts was formally organized to research the efficacy, collection, storage and imaging of the data. The Summary of Findings by the NHTSA EDR Working Group [2] was published in 2001 and included a recommended set of standardized results.

The final rule addressing EDRs, CFR 49 Part 563 was issued on August 6, 2006 [3] and on January 14, 2008 the response to petitions for reconsideration followed [4]. The regulation does not mandate that EDRs be installed in vehicles, but among other items, it specifies that if a vehicle is equipped with an EDR, the following conditions apply:

1. The EDR must capture crash data in a uniform format (detailed in Part 563)
2. There must be a standardized notification statement in the vehicle owner’s manual
3. There must be a commercially available tool to access the data

CFR 49 Part 563 also defines an EDR as a device or function in a vehicle that records dynamic time-series data just prior to an event (speed versus time or delta V versus time) and the data is intended for retrieval after a crash event. It is important to note that EDR data does not include audio or video. If a vehicle is equipped with an EDR that records data, the following items are required:

- Delta V Longitudinal
- Max Delta V Longitudinal
- Time, Max Delta V
- Speed, vehicle indicated
- Engine throttle %
- Service brake on/off
- Ignition cycle, crash
- Ignition cycle, download
- Safety belt status, driver
- Frontal air bag warning lamp on/off
- Frontal air bag time to deploy – driver air bag
- Frontal air bag time to deploy – passenger air bag
- Multi-event – number of events
- Time from event 1 to 2
- Complete file recorded yes/no

The rule also specifies the interval/time and the sample rate for each element. There are also similar format requirements for additional data elements if they are recorded.

The regulation, which applied to vehicles manufactured after September 1, 2012, had a positive effect on the number of manufacturers standardizing their data and being supported by the Bosch CDR data retrieval tool. Several major Japanese and European manufacturers partnered with Bosch to make their EDR data retrievable using the CDR tool. By October 2014 the following manufacturers have some or all of their models supported:

- General Motors
- Nissan
- Ford
- Volvo
- Chrysler/Fiat
- BMW
- Toyota
- Daimler
- Honda
- Volkswagen
- Mazda
- Suzuki

The current Bosch CDR system (Version 14.1) costs about $11,400 and includes approximately seventy (70) different cables and connectors and a one-year subscription to the software. The software must be upgraded yearly at a cost of $900 per user. In addition to the equipment and software, extensive training for the field personnel is required for both the imaging and interpreting of the data.

Some manufacturers, Hyundai/Kia and Subaru for example, chose not to partner with Bosch and developed their own commercially available tool for EDR data collection in their vehicles. A few other manufacturers have elected to forego the recording of EDR data so they are not subject to Part 563. Although NHTSA has purchased some of the manufacturers proprietary EDR kits to image high interest cases, at the present time it is not cost effective to equip every field investigation team with those tools.
HISTORICAL EDR DATA COLLECTION

Figure 2 shows the number of EDR’s imaged yearly as of January 8, 2015, in the four NHTSA investigation-based programs (NASS-CDS, SCI, CIREN, and NMVCCS). In total they have imaged 13,898 EDRs since 1999.

As the number of vehicles supported by the CDR software has increased in the fleet, the number of EDRs imaged by the programs has generally increased yearly. However, the graph shown in Figure 2 has several fluctuations that require explanation. Aside from the general upward trend, a spike occurred from 2005-2007 due to the addition of the NMVCCS special study which was conducted during the time period. The sharp decrease from 2008-2010 was due to significant cuts that were made to the NASS system, eliminating the NMVCCS program and forcing significant cutbacks to the infrastructure. In an effort to reduce costs, NASS field offices were reduced in staff and EDR equipment was reduced to one complete CDR kit per field office.

Realizing the importance of EDR acquisitions as the effective date of CFR 49 Part 563 approached, late in 2010 NHTSA conducted a simple analysis to determine reasons NASS-CDS Technicians were unable to image the EDR data when the vehicle was supported by the CDR tool. Figure 3 depicts the reasons why the EDR data in supported vehicles could not be obtained in 2009-2010 NASS-CDS cases.

Among the reasons the EDR data could not be obtained, the largest percentage (45%) were because the vehicle owner denied permission to image the data. This included both outright owner refusals to the NASS-CDS Technician, and also the owner not wanting any additional damage to the vehicle to obtain the data. In cases where the On Board Diagnostic (OBD) plug was damaged, or there was no power to the vehicle, the Technician would need...
to go direct to the module. This would include disassembling the vehicle’s console or cutting the carpet to gain direct access to the EDR module. As Figure 3 indicates, damage prevented the Technician from obtaining the data in 16% of the cases. Vehicle damage included situations where the electrical system was compromised and the Technician could not access necessary connections and/or damage prevented access to the module.

“Other” reasons accounted for 34% of vehicles where the EDR data could not be obtained. These “other” reasons included:

- The Technician was allowed an exterior inspection only (evidentiary reasons) or the vehicle was locked and no keys were available
- The Technician only obtained photographs of the damaged vehicle
- The EDR was removed prior to the NASS-CDS vehicle inspection (usually by law enforcement)

A combination of software and hardware issues were cited as the reason the remaining 5% of supported vehicle downloads were unsuccessful. Software issues generally occurred when the Technician’s CDR tool could not successfully communicate with the EDR module. Hardware issues were related to plugs, connectors, and laptop problems.

As mentioned earlier, owner permission was not limited to refusals to the NASS-CDS Technician to image the EDR data. “Refusal” also included a large percentage of owners who would not permit any additional damage to the vehicle in the process of imaging the EDR data. There are three basic ways to image an EDR:

- Through the On-Board Diagnostics (OBD) port
- Direct to the EDR module
- Removing the module and imaging later on a bench top

To successfully obtain an image of the EDR through the OBD port, generally the electrical system cannot be compromised and the OBD connection plug (usually located beneath steering wheel under instrument panel) port cannot be damaged. NASS-CDS cases are intentionally sampled at a higher rate for towed vehicles with severe damage and injuries. Therefore, the electrical system will sometimes be damaged either during the crash or during post-crash extrication activities.

Going direct to module is possible when the electrical system is compromised, however, this process involves:

- Determining module location
- Removing consoles, instrument panel parts, or seats
- Cutting the carpet

This process can be complicated by crash damage and in situations where power seats are obstructing access to the module and the vehicle has no power. Oftentimes, owners will not allow the additional damage to their vehicle that is required to access the EDR.

The final way to access the EDR data is to remove the module from the vehicle and image the data later at another location. This method is not permitted because strict NASS-CDS policies are in place forbidding retention of any vehicle component.

After NHTSA reviewed the results of the analysis it was apparent the number of EDR images in the programs could increase significantly if retrieval techniques could be employed that would:

- Cause no further damage to the vehicle
- Allow the EDR to be imaged when no keys are available
- Increase successful attempts on severely damage vehicles

A natural increase in the number of cases with EDR data would also be expected due to the greater penetration of EDRs into the fleet.

One advanced EDR imaging technique, commonly referred to as the Fuse Block Method (FBM), involves supplying power to the EDR through the vehicles fuse panel and imaging the data through the OBD port. Although not always successful, this method eliminates the need to dismantle consoles, disassemble vehicle components, and cut carpets. In addition, when vehicle keys are not available, powering the EDR through the fuse block allows for OBD download.

In December 2010 NHTSA conducted EDR update training and provided the necessary additional equipment for all field personnel to begin using the FBM when other data imaging techniques failed. The agency also instituted tighter quality control measures within the NASS software and placed additional emphasis on successful EDR retrieval. The field personnel began using the new
method of collection in 2011 and improved EDR acquisition results followed.

**CURRENT EDR DATA COLLECTION**

The 2012-2013 NASS-CDS revealed that about 45% of the over 7,000 vehicles inspected were supported by the Bosch CDR retrieval tool. With CFR 49 Part 563 in place and the increased number of manufacturers supported by the commercially available tool, that percentage will likely continue to grow as EDRs become more widespread in the fleet.

The renewed emphasis on EDR data acquisition and implementation of the FBM had a major effect on the number of EDRs imaged by the NASS Technicians. Figure 4 shows the success rate roughly doubling the three years after the FBM EDR training compared to the two years prior. The two most recent years of data shows the NASS-CDS Technicians successfully imaged the EDR, when the vehicle was supported, 74% of the time.

![Figure 4](image-url)  
**Figure 4**  
NASS-CDS Successful EDR Image % (When vehicle supported)

In the current NASS-CDS system EDR data is available to the public in two formats. An Acrobat .pdf of the CDR file is available for each vehicle with a successful image. The reports can be found at ftp://ftp.nhtsa.dot.gov/NASS/EDR_Reports/. Secondly, the coded EDR data is available for clinical review within each individual NASS-CDS case. The case viewer for 2004-2013 data year NASS cases is located at http://www-nass.nhtsa.dot.gov/nass/cds. 1999-2003 NASS-CDS cases are available at http://www-nass.nhtsa.dot.gov/BIN/NASSCaseList.exe/SETFILTER?CASETYPE=PUBLIC.

Query tools are also provided in the NASS-CDS case viewers to narrow areas of focus down to specific makes, models, delta V ranges, injuries, and deformation types, among many other filter criteria.

Figure 5 shows that after the training in late 2010 there was a decrease in unsuccessful EDR data retrieval. The figure also shows the associated reasons for lack of success by year. As discussed earlier, the FBM dramatically decreased the number of times damage prevented the EDR imaging, that permission was denied, and/or there were other reasons cited as the reason the EDR could not be imaged.

![Figure 5](image-url)  
**Figure 5**  
Reasons for Unsuccessful EDR image (When vehicle supported)

Figure 6 shows the final overall percentages of EDR acquisition in inspected NASS-CDS vehicles from...
2012-2013. One third of inspected vehicles have imaged EDR data, 55% are not supported by the CDR tool, and the remainder are split among the various unsuccessful reasons. Those 55% that were not supported requires clarification. Although all light vehicles equipped with EDRs sold in the United States after September 1, 2012 are required to meet CFR 49 Part 563, and almost 2,500 year/make/models are supported in version 14.1 of the Bosch CDR software released in October of 2014 [5], one must keep in mind that NASS-CDS is not limited to late model year vehicles. Since it serves as a multi-purpose nationally representative database, a large percentage of the sample are older model year vehicles.

SCI cases are another valuable source of EDR data available to the public, and the cases can be viewed at http://www.nhtsa.gov/SCI. In addition to the data available in a NASS case, the SCI cases also feature a technical report which includes a detailed discussion of the EDR findings. The SCI investigators have attended EDR interpretation courses and are experts in advanced imaging techniques. In 2012-2013, the SCI investigators successfully imaged the EDR when the vehicle was supported 80% of the time.

FUTURE EDR DATA COLLECTION

NASS was initially designed in the 1970s, and the system needed to be updated to meet the data needs of the transportation community that have increased and significantly changed over the last three decades. In Fiscal Year 2012, Congress appropriated funds for NHTSA to modernize NASS. The formal project, known as Data Modernization, was launched in January 2012. The goal of Data Modernization is to affirm NHTSA’s position as the leader in motor vehicle crash data collection and analysis, by collecting quality data to keep pace with emerging technologies and policy needs. The multi-year project is set for implementation to begin in January 2016.

Congress was specific in their request to modernize NASS and NHTSA is looking to improve upon the following practices:

- Increase the sample size
- Expand the scope of its data collection to possibly include large trucks, motorcycles, and pedestrians
- Assess the need for more data from the pre-crash, crash, and post-crash phases of the crash sequence
- Review the crash data elements to be collected
- Solicit input from interested parties including suppliers, automakers, safety advocates, research organizations, and the medical community

The replacement to NASS-CDS has been named the Crash Investigation Sampling System (CISS). New nationally representative data collection sites have been selected using a sample design approach similar to NASS-CDS. The new sites were chosen using the most recent census and vehicle registration data and the goal is to better reflect the nation’s overall crash picture and increase the availability of newer model vehicles and severe crashes at the data collection sites.

NHTSA believes that EDR data collection will continue to be a point of emphasis in CISS, as well as in the other field investigation-based data collection programs. Crash Technicians collecting data at the CISS sites will be trained on the various EDR imaging techniques and be equipped with the most current versions of the CDR software and connection cables.

Public access of EDR data in CISS will be an improvement from previous program. Current plans call for the original imaged .cdr file to be made available along with coded EDR data entered in the case viewers. Data from the Table 1 and Table 2 of CFR 49 Part 563 will also be available in SAS files and other analysis formats to enhance end user accessibility.
CONCLUSION

EDRs will likely continue to be an important source of information as focus on crash avoidance countermeasures increase and crashworthiness countermeasures are optimized in the automotive safety community. Over the past 16 years, investigation-based data collection programs sponsored by NHTSA have accumulated one of the most extensive libraries of real-world crash EDR data in the world. Largely due to the implementation of CFR 49 Part 563, the vehicles in the fleet equipped with EDRs, and correspondingly the number of EDRs imaged by NHTSA, will increase even more rapidly in upcoming years.

Through the years EDR imaging acquisition rates in NHTSA’s investigation-based programs have continually improved because of up-to-date equipment, the training of advanced imaging techniques, and the emphasis by the Agency to make the successful retrieval of EDR data a priority. The data collection programs are at the point now if the field personnel conduct an inspection of a vehicle equipped with an EDR, there is a high likelihood the data will be successfully imaged.

NHTSA’s Data Modernization project should have a positive effect on EDR data collection, particularly in CISS which is set to begin in 2016. Plans are to equip each of the Crash Technicians with the CDR tool to image EDRs. The EDR data will be more accessible for end users through additional file formats, and the new data collection locations are projected to have increased percentages of EDR-equipped vehicles selected in the sample.
References


