Memorandum

U.S. Department
of Transportation

National Highway
Traffic Safety
Administration 136037

Subject: Submittal of the Final Report of the NHTSA R&D Event Data Recorder (EDR) Working Group to Docket No. NHTSA-99-5218 -4

Date: 8/30/2001

From: Raymond P. Owings, Ph.D.
for Associate Administrator for
Research and Development

Reply to Attn. Of: NRD-01

To: The Docket

THRU: John Womack
Acting Chief Counsel

Attached is the Final Report of the NHTSA Research and Development Event Data Recorder (EDR) Working Group. This report was circulated within NHTSA and has received concurrence for publication.

Research and Development requests that this report be placed in the public docket.

Attachment

EVENT DATA RECORDERS

SUMMARY OF FINDINGS
by the
NHTSA EDR Working Group

August 2001

Final Report

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ID	Identification
IIHS	Insurance Institute for Highway Safety
ISO	International Organization for Standardization
ISO	Insurance Services Office, Inc.
ITS	Intelligent Transportation System
IWI	Independent Witness Incorporated
JPL	Jet Propulsion Laboratory
JPO	Joint Program Office
LMS	Loss Management Services, Inc.
MAC	Mobile Accident Camera
MDB	Movable Deformable Barrier
ms	millisecond
MVSRAC	Motor Vehicle Safety Research Advisory Committee
MY	Model Year
NAS	National Academies of Science
NASA	National Aeronautics and Space Administration
NASS	National Automotive Sampling System
NCAP	New Car Assessment Program
NHTSA	National Highway Traffic Safety Administration
NICB	National Insurance Crime Bureau
NPRM	Notice of Proposed Rulemaking
NCC	Office of the Chief Counsel, NHTSA
NPS	Office of Safety Performance Standards, NHTSA
NRD	Office of Research and Development, NHTSA
NTS	Office of Traffic Safety, NHTSA
NTSB	National Transportation Safety Board
OEM	Original Equipment Manufacturer
PD	Property Damage
PDOF	Principal Direction of Force
PSAP	Public Safety Answering Point - [the 911-call recipient]
R&D	Research and Development
RAM	Random Access Memory
ROM	Read Only Memory
RP	Recommended Practice
RPM	Revolutions Per Minute
RSA	Rail Safety Advisory Committee
SAE	Society of Automotive Engineers
SAMOVAR	Safety Assessment Monitoring On Vehicle with Automatic Recording
SCI	Special Crash Investigation
SDM	Sensing & Diagnostic Module
SIS	Safety Intelligence Systems
SUV	Sport Utility Vehicle
the "Act"	Privacy Act of 1974, 5 U.S.C. §552a ()
TMC	Technical and Maintenance Council
TRB	Transportation Research Board
TRC	Transportation Research Center

UDS	Umfall Data Schreiber (Event Data Recorder)
VCR	Video Cassette Recorder
VIN	Vehicle Identification Number
VRTC	NHTSA's Vehicle Research and Test Center, NHTSA
WG	Working Group
WOT	Wide Open Throttle

Executive Summary

This report documents the findings of the Event Data Recorder (EDR) working group established by the National Highway Traffic Safety Administration's (NHTSA) Motor Vehicle Safety Research Advisory Committee. The guidelines for Committee activity require that the working group members limit their efforts to fact-finding and not make any recommendations.

Event Data Recorders have the ability to profoundly impact highway safety. While simple or complex in design and scope, EDRs collect vehicle and occupant based crash information. EDRs can assist in real-world data collection, better define safety problems, and aid law enforcement's understanding of crash specifics, ultimately improving safety.

In 1997, the National Transportation Safety Board issued recommendations to pursue vehicle crash information gathering using Event Data Recorders. The National Aeronautics and Space Administration, in the same year, recommended the study of "...the feasibility of installing and obtaining crash data for safety analyses from crash recorders on vehicles." In early 1998, NHTSA's Office of Research and Development launched a new effort to form a working group comprised of industry, academia, and other government organizations. The members of the working group participated in the forum to study the state-of-the-art of EDRs. Meetings were held on a regular basis, culminating in this EDR findings report.

The working group developed and adopted the following objective for the group: *To facilitate the collection & utilization of collision avoidance and crashworthiness data from on-board Event Data Recorders.* To develop the objective and gather information, the working group targeted the following eight concentration areas: Status of EDR Technology; Data Elements; Data Retrieval; Data Collection and Storage; Permanent Record; Privacy and Legal Issues; Customers and Uses of EDR Data; and EDR Technology Demonstrations.

The report presents an overview of EDR history, which includes a short description of several European and U.S. studies of EDRs. The U.S. on-board EDR experience is explored for other modes of transportation, where the use of on-board recorders began in aviation and has now spread to other modes; marine and rail. The report also provides some details on a recently completed study in New York where EDRs were expanded to include automatic collision notification system and a current study under way in Georgia where EDRs and other instrumentation are being installed in motor vehicles to research driver habits.

The working group explored various types of EDRs, all of which could be classified as either original equipment manufacturer (OEM) designs or aftermarket systems. OEM systems were varied in their capabilities, with General Motors' vehicles having the most sophisticated systems, including precrash and crash data collection, On Star, and a publicly available tool to download the recorded data from these devices. Aftermarket systems also vary quite widely, most likely being driven by the market to meet a specific need, for example, commercial fleet management and driver training. Some systems collect only acceleration/deceleration data, while others collect these data plus a whole host of complementary data, such as driver inputs and vehicle systems status. Other systems have integrated global positioning systems (GPS), video, and audio data collection systems into the EDRs.

The working group looked into data collection and storage. It found no universal collection and storage system. Some aftermarket companies are offering proprietary data storage facilities for their customers. NHTSA recently started collecting EDR data in its National Automotive Sampling System-Crashworthiness Data System, Special Crash Investigation, and Crash Injury Research and Engineering Network data systems. As of the beginning of 2001, NHTSA had collected EDR data from about 100 real-world crashes.

The working group identified privacy and legal issues as a potential major issue related to EDRs. Generally, there is concern about crash-related data being collected from privately owned motor vehicles that could be used against the owner. Most of the working group members held the opinion that the data (collected and stored in an EDR) belonged to the owner of the vehicle. But with ownership often changing hands after a serious crash, due to the vehicle being totaled because of collision damage, the driver may lose control of the data to the insurance company, salvage yard, or the next owner if the vehicle is repaired and sold. Federal statutes only apply to NHTSA data collection activities, and as such, NHTSA cannot divulge any of its own crash information related to personal identifiers.

The working group reviewed several company demonstrations of EDRs in use today, both for assisting NHTSA in crash and vehicle defect investigations, and for assisting insurance company investigations.

There is a wide range of users of these data already in place, and the working group felt that use of EDRs would expand rapidly. The NHTSA rules under which the working group was convened limited activities to fact finding. The findings were divided into several categories, including safety, data collection, and other observations. The following selected findings present the highlights of the report:

1. EDRs have the potential to greatly improve highway safety, for example, by improving occupant protection systems and improving the accuracy of crash reconstructions.

2. EDR technology has potential safety applications for all classes of motor vehicles.

3. A wide range of crash related and other data elements have been identified which might usefully be captured by future EDR systems.

4. NHTSA has incorporated EDR data collection in its motor vehicle research databases.

5. Open access to EDR data (minus personal identifiers) will benefit researchers, crash investigators, and manufacturers in improving safety on the highways.

6. Studies of EDRs in Europe and the U.S. have shown that driver and employee awareness of an onboard EDR reduces the number and severity of drivers' crashes.

7. Given the differing nature of cars, vans, SUVs, and other lightweight vehicles, compared to heavy trucks, school buses, and motorcoaches, different EDR systems may be required to meet the needs of each vehicle class.

8. The degree of benefit from EDRs is directly related to the number of vehicles operating with an EDR and the current infrastructure's ability to use and assimilate these data.

9. Automatic crash notification (ACN) systems integrate the on-board crash sensing and EDR technology with other electronic systems, such as global positioning systems and cellular telephones, to provide early notification of the occurrence, nature, and location of a serious collision.

10. Most systems utilize proprietary technology and require the manufacturer to download and analyze the data.

1.0 Introduction

Event Data Recorders (EDRs) record information related to a vehicle crash, and for the purposes of this working group report, do not include data loggers. EDRs can be simple or complex in design, scope, and reach, and have the ability to have a profound impact on highway safety, ranging from collecting data to formulating the basis for improved automobile safety to aiding law enforcement in understanding the specifics aspects of a crash. These devices collect basic crash related information, mainly vehicle and occupant based, that can provide benefits to crash research and improvements to the transportation system.

In 1997, the National Transportation Safety Board (NTSB) issued recommendations to the National Highway Traffic Safety Administration (NHTSA), indicating that NHTSA should pursue crash information gathering using Event Data Recorders. Further, in 1997, the National Aeronautics and Space Administration's (NASA) Jet Propulsion Laboratory (JPL) recommended that NHTSA "study the feasibility of installing and obtaining crash data for safety analyses from crash recorders on vehicles." During this time, NHTSA's Research and Development (R&D) office was evaluating the use of EDRs for vehicle crash research, including gathering data to support rulemaking efforts and support its Special Crash Investigation (SCI) program. R&D held exploratory meetings to determine the use of EDRs in the automotive industry and with other government and non-government bodies to determine the needs for these data outside NHTSA.

Early in 1998, NHTSA held several internal planning meetings and it was decided to propose creating a working group (WG) within NHTSA R&D's Motor Vehicle Safety Research Advisory Committee (MVSRAC). At the April 1998, MVSRAC meeting, NHTSA proposed creation of the WG. The MVSRAC agreed, and NHTSA R&D started this WG shortly after the meeting, sending letters to the MVSRAC full committee as well as the crashworthiness subcommittee members requesting nominations of individuals to serve on the WG. Based on these nominations, and with the addition of several members selected by NHTSA R&D, the WG was formed. The initial membership held its first meeting in October 1998, and continued to meet about three times per year through the end of 2000. During the conduct of the meetings, several new members were added to replace members who left the WG. Also, several other people informally joined the WG. The data collected and presented in this report is based on a team effort of all the WG members, both formal and informal.

1.1 Objectives of Working Group

The WG struggled with a final overall objective statement. The following objective statement was proposed: **To facilitate the collection & utilization of collision avoidance and crashworthiness data from on-board Event Data Recorders**. The WG developed a set of objectives, which were considered the core objectives of this fact-finding effort, as follows:

1. **Status of EDR Technology** - Description of current EDR technology, including OEM and Aftermarket systems.
2. **Data Elements** - Discussion of data elements listed as desirable by a diverse user set.
3. **Data Retrieval** - Discussion of how data is retrieved from the vehicle or EDR system.
4. **Data Collection and Storage** - Discussion of how data is collected by the users and stored for use by others.
5. **Permanent Record** - Discusses who is responsible for maintaining the permanent record of EDR data.
6. **Privacy and Legal Issues** - Discussions of privacy issues as seen by the various users.

7. **Customers and Uses of EDR Data** - Discusses who the customers are, and what their uses might be as they relate to crash data.
8. **Demonstration of EDR Technology** - Demonstration of current EDR data usages.

A discussion of each of these objectives will form the main body of this report - Sections 3 through 10. Breakout sessions were held during the working group meetings to discuss each of these topics. The notes from the breakout sessions can be found in the public docket for this project (NHTSA-99-5218). The format of each discussion section starts with an overview. The overview is based in part on the breakout session, as well as other inputs to the working group. Some topics were covered in more detail than others, but because these eight topics comprised the original focus of the working group, each is covered in its own section.

During the course of the WG activities, the subject of Automatic Collision Notification (ACN) arose often. While some discussion of ACN was appropriate for the WG, the concept of ACN is notification. Further, development of ACN systems, which may make use of the data stored in an EDR, may be useful to states in making decisions related to deployment of EMS services. While this working group did not specifically focus on ACN, it recognizes the interaction between ACN and EDR systems, especially at the users level, such as police, EMS, states, etc.

1.2 Participants

Members of the MVSRAC and its subcommittee on Crashworthiness nominated the participants for the WG. NHTSA R&D added a few members to those who were nominated to obtain a working group which had representations from many areas, including industry, universities, State and Federal governments, and private citizens. The following lists present the names and affiliations of the participants of the EDR working group subdivided into several major categories based on their interest.

Vehicle Manufacturers, EDR Manufacturers, and Transportation Providers

Company	Name
American Transportation	Bob Douglas
Association of Import Automobile Manufacturers	Mike Cammisa
DaimlerChrysler	Kathleen Gravino
Drive Cam	Sophia Rayner
Ford Motor Co.	David Bauch
Ford Motor Co. (retired)	Joe Marsh
General Motors	Jack Haviland
General Motors	Tom Mercer
Honda	Alex Damman
Honda	Ralph Hitchcock
Independent Witness Incorporated	Luther G. Perkins
Independent Witness Incorporated	Scott McClellan
National Association State Directors of Pupil Transportation Services	Charlie Gauthier
Navistar	Brian Shaklik
Safety Intelligence Systems Corporation	Andy Mackevicus
Safety Intelligence Systems Corporation	John Mackey
Toyota	Chris Tinto
United Motorcoach	Norm Littler
Vetronix	Don Gilman
VDO	Dan May

VDO	Tony Reynolds
Volkswagen	Robert Cameron

Universities, Researchers, and Other Interested Parties

Company	Name
Association for the Advancement of Automotive Medicine	Jeya Padmanaban
Click, Inc.	Thomas Kowalick
Florida Atlantic University	Mary Russell
Florida Atlantic University	Susan Walker
Forensic Accident Investigations	Robert McElroy
Georgia Tech	Jennifer Ogle
Insurance Institute for Highway Safety	Raul Arbelaez
National Academy of Science, Transportation Research Board	Chuck Niessner
State Farm Insurance Co.	Regina Dillard
University of Virginia	Greg Shaw
Worcester	John Carney
Worcester	Malcolm Ray

Government - Federal, State & Local

Company	Name
Federal Highway Administration	Bob Ferlis
Federal Highway Administration	Martin Hargrave
Federal Highway Administration	Carl Hayden
Garthe Associates (Massachusetts)	Liz Garthe
NHTSA, Office of Chief Council	Sharon Vaughn
NHTSA, Office of Safety Performance Standards	Ed Jettner
NHTSA, Office of Safety Performance Standards	Gerald Stewart
NHTSA, Office of Research and Development	John Hinch
NHTSA, Office of Research and Development	Lou Lombardo
NHTSA, Office of Research and Development	Lori Summers
NHTSA, Office of Traffic Safety Programs	Doug Gurin
NHTSA, Office of Traffic Safety Programs	Paul Tremont
National Transportation Safety Board	Sarah McComb
National Transportation Safety Board	Vernon Roberts
Transport Canada	Alan German

1.3 Fact Finding Effort

The purpose of a NHTSA-sponsored working group is to gather factual information, and not to develop consensus recommendations for NHTSA or any other Federal agency. As such, there is no "Recommendations" section to this report. Rather, the findings of this fact-gathering effort will be summarized in a section titled "Findings."

The working group used a two-pronged approach to determine the current state-of-the-art facts related to EDRs. This included: Industry briefings by EDR companies (OEM and aftermarket), users, and customers; and breakout session discussions on the main objectives of the working group. The facts presented in this report are based on data collected through these two methods.

1.4 Public Documentation Process

All materials provided to the working group were placed in the Department of Transportation's Document Management System (DMS). This included final meeting minutes and attachments to the minutes. Final minutes are those which are approved by the working group. The docketed information for the EDR working group can be found in docket NHTSA-99-5218. These dockets are viewable and printable from the DMS, which can be located using an Internet browser at http://dms.dot.gov Search for docket 5218.

1.5 Meetings

The EDR working group held seven meetings at NHTSA's headquarters in Washington, D.C. A summary of each meeting is presented below:

1.5.1 October 2, 1998

The first meeting of the EDR WG was held in 1998. The first meeting had several objectives: 1) understand the status of EDR technology; 2) understand the needs for crash data; 3) review the privacy issues; and 4) develop the working group. During this meeting members of the WG provided their inputs regarding EDRs. NHTSA R&D presented operating rules for a MVSRAC working group, which included the public documentation process, a background presentation of EDRs, and a short discussion on privacy. A detailed data element list was circulated for the members to consider.

1.5.2 February 17, 1999

Meeting number two was held in early 1999. The second meeting objectives were: 1) refine working group objectives; 2) review WG members' input for data elements; 3) review of WG's privacy issue white papers; 4) other discussions regarding systems and data. A set of objectives was developed by the WG. Manufacturers, the government, and others presented short "white papers" regarding their individual company's privacy policies. The WG also continued its effort to quantify data elements, including selecting a set of "Top-Ten" data elements which should be considered when developing a new EDR. Presentations included: EDR Validation, NHTSA Research in Vehicle Crash Speed and Loss Management System's Eye Witness EDR.

1.5.3 June 9, 1999

Meeting number three was held in mid 1999. The third meeting objectives were: 1) review of the working group objectives; 2) review WG members' input for data elements; and 3) review of WG's privacy issue white papers. During this meeting, the WG continued to refine its position on data elements and privacy issues. Presentations included: Information regarding an upcoming NTSB symposium on data recorders, Automatic Collision Notification, recent activities in ISO related to EDRs, and current and recent activities at Ford regarding EDRs.

1.5.4 October 6, 1999

Meeting number four was the third meeting of 1999. The fourth meeting objectives were: 1) discuss insurance company issues; 2) continue to learn about EDR systems; and 3) hold two breakout sessions – Data Elements, and Privacy and Legal Issues. The session on data elements reworked the WG's top ten data elements list from individual elements to categories of data elements. The privacy and legal issues session discussed WG members concerns and company and government practices related to EDRs. Presentations included: the I-Witness EDR system, VDO North America, potential for EDR or EDR/ACN use in Massachusetts based on a study of fatal level crashes.

1.5.5 February 2, 2000

Meeting number five was held in early 2000. Meeting objectives included: 1) Review OEM EDR systems and 2) breakout sessions – Status of EDR Technology, and Who Are the Customers. At this meeting, NHTSA announced that the MVSRAC had been terminated because the charter under which it operated had expired and that all activities within MVSRAC would need to be halted. Because the nature of the WG was that of fact finding, NHTSA R&D agreed to continue the WG efforts under a R&D-sponsored WG. Both breakout sessions discussed the two objectives and their outcomes were shared with the WG. Presentations included: OEM discussions of EDR technologies and a NHTSA demonstration of the Vetronix crash data retrieval tool.

1.5.6 June 7, 2000

Meeting number six was held in mid 2000. The meeting included four breakout sessions – How Should the Data be Collected and Stored?, How Should the Data be Retrieved?, Who Should be Responsible for Keeping the Permanent Record?, and Demonstration of EDR Technology. Breakout sessions considered how different uses affect collection and storage, and evidence and traceability issues, as well as the benefits related to collection and storage. Issues related to data retrieval from a vehicle EDR, including current systems, near future systems, and future needs, were discussed. Who was currently storing EDR data, and possibilities for storing data in the future were reviewed as well as discussions regarding electronic collection of EDR data and the need for central repositories. The final breakout session generated a list of possible EDR demonstration sources. Presentations included: Crash Data Collection using EDR Technology at Georgia Tech, Ford and NHTSA SCI on an Advanced Restraint Program using EDRs, and an updated discussion on Manufacturer Data Elements.

1.5.7 December 6, 2000

Meeting number seven discussed the draft final report. The draft report was circulated to the members prior to the meeting. Editorial and content changes were made or recommended.

2.0 Background

2.1 National Highway Traffic Safety Administration Activities

2.1.1 Early Event Data Recorders

EDRs have been used for many years to record crash related metrics, including the crash deceleration of the vehicle. Early efforts conducted by NHTSA included a device, circa 1970s, which used analog signal processing and recording devices to analyze and store the crash data. This recorder was known as the Disc Recorder, and was installed in about 1,000 vehicles in several fleets. During 1973 and early 1974, the fleets equipped with these recorders accumulated about 26 million miles. During that time, 23 crashes were analyzed, which included delta-Vs up to about 20 mph. Actual deceleration-time histories were collected.[1] These devices were expensive to manufacture, and because installation of these recorders in a vehicle was a prerequisite to collection of crash data, data were limited to a few crashes.

2.1.2 Jet Propulsion Laboratory Report

In 1997, NHTSA, under a joint agreement with the National Aeronautics and Space Administration (NASA) contracted with the Jet Propulsion Laboratory (JPL), to

> "evaluate air bag performance, establish the technological potential for improved air bag systems, and identify key expertise and technology within NASA that can potentially contribute significantly to the improved effectiveness of air bags."

In the final report on this project[2], JPL recommended that NHTSA investigate EDRs, stating in recommendation number (6):

> "Study the feasibility of installing and obtaining crash data for safety analyses from crash recorders on vehicles. Crash recorders exist already on some vehicles with electronic air bag sensors, but the data recorded are determined by the OEMs. These recorders could be the basis for an evolving data-recording capability that could be expanded to serve other purposes, such as in emergency rescues, where their information could be combined with occupant smart keys to provide critical crash and personal data to paramedics. The questions of data ownership and data protection would have to be resolved, however. Where data ownership concerns arise, consultation with experts in the aviation community regarding the use of aircraft flight recorder data is recommended."

2.1.3 Petitions for Rulemaking

NHTSA's Office of Safety Performance Standards (NPS) has received (in 1998 and 1999) two petitions for rulemaking which request the government to require EDR technology on all new passenger vehicles.[3] One petitioner based his petition on a crash, where family members were fatally injured. The petitioner believed that EDR technology could have provided evidence that would have been valuable in determining the crash scenario. The agency agreed with both petitioners stating "...recording of crash data can provide information that is very valuable in understanding crashes, and which can be used in a variety of ways to improve motor vehicle

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1 Teel, Peirce, and Lutkefelder; *Automotive Recorder Research - A Summary of Accident Data and Test Results*; NHTSA; 1974

2 Phen, Dowdy, Ebbeler, Kim, Moore, and VanZandt; *Advanced Air Bag Technology Assessment*; JPL Publication 98-3; April 1998. The report can be found on the JPL web site - http://csmt.jpl.nasa.gov/airbag/contents.html

3 See **Federal Register** 63 FR 60270 (Nov. 9, 1998) and 64 FR 29616 (June 2, 1999).

safety." The agency denied the petitions "...because the motor vehicle industry is already voluntarily moving in the direction recommended by the petitioner." Further, the agency believed ".... this area presents some issues that are, at least for the present time, best addressed in a non-regulatory context."

2.1.4 Automatic Collision Notification Systems

Automated Collision Notification[4] (ACN) is technology that will provide faster and smarter emergency medical services (EMS) response in an attempt to save lives and reduce disabilities from injuries. However, ACN in itself is not related to EDRs. This ACN project combined notification equipment with recording technology, and hence, is included in this report.

This ACN system consisted of an in-vehicle system that determined that a crash had occurred, initiated a request for assistance, determined the location of the vehicle, and utilized a wireless communications system to send the crash notification to the appropriate Public Safety Answering Point (PSAP) for emergency response dispatch.

The in-vehicle system determined location using a Global Positioning System (GPS) receiver, sensed a crash with accelerometers dedicated to the ACN function, and communicated with the PSAP via a cellular phone. Additionally, the in-vehicle system applied the output of its accelerometers to an algorithm that computed a measure of the severity of a possible crash based on the vehicle acceleration history. The ACN notification threshold varied depending on the change in velocity of the vehicle and principal direction of force for the crash. The ACN device stored these data.

The ACN system underwent a Field Operational test (FOT), where the devices were installed in about 700 vehicles. The ACN in-vehicle system worked as expected, including the data storage system. It was able to sense that a crash had occurred, determine the vehicle's position, and deliver a crash notification message to the FOT 9-1-1 dispatch center via a cellular telephone call that was then switched to a voice line.

A major institutional issue, relative to EDR's, noted during the ACN FOT that could impact the development and deployment of ACN systems, was access to ACN data. This issue was raised during the planning phase of the FOT and was based on the fact that the ACN system for the FOT collected data that could provide information concerning collisions and the operation of the vehicle (e.g., position, velocity, heading, and acceleration). There was a concern that the data collected during the FOT would be subpoenaed during litigation involving ACN-equipped vehicles in an attempt to establish fault in a crash.

While this issue did not arise during the FOT, it remains a potential concern for future ACN deployments. Because of this concern, Veridian Engineering developed a Disclosure and Warning Statement and Waiver using proper legal terminology to be signed by owners of ACN-equipped vehicles and a witness. The disclosure and warning statement granted Veridian Engineering the right to use any and all data gathered from the FOT, with the exception of revealing the participant's identity or personal information to persons other than the participants in the program.

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4 For additional reference to this topic, go to NHTSA Web site at: http://www-nrd.nhtsa.dot.gov/include/summaries/its_13.htm
or the Calspan Web page at http://www.calspan.com/mayday.html

Other approaches to mitigating liability for ACN systems noted during the project included the development of accepted operating standards, dispatcher and notification center certification standards, and accepted procedures and protocols for interfacing and coordinating between private and public emergency response systems. It was also recommended that as requests for ACN data are to be expected, the architecture of future ACN systems should either support the provision of this information, or the ACN systems should not collect or save data that could be used against drivers. In the former case, it was suggested that the recruitment/sales literature should state the information that is available and the policies and procedures for the provision of this information.

2.1.5 R&D on Quantitative Properties of the Relationship between Speeding, Aggressive Driving, and Crash Risk

NHTSA is interested in determining the extent to which drivers who engage in speeding and aggressive driving are over-involved in crashes, and in determining the specific characteristics of these behaviors that lead to crashes. An understanding of the relationship between driving speeds and crashes across a broad range of conditions is needed to allow for the development of countermeasure programs that can be efficiently directed at controlling speeds in those situations where the risks of crashing are greatest. Data are also needed to aid in making informed judgments on speed limits as more states and localities raise their limits.

In a research project being conducted for NHTSA by the Georgia Institute of Technology, data on operating speed and location will be continuously recorded, from 1,100 vehicles, during each trip taken over a two-year period. This study will utilize the Safety Intelligence Systems' (SIS) MACBOX. Crash and other extreme accelerations will also be recorded using tri-axial accelerometers. The data will be used in conjunction with a geographic database to identify the locations, roadway types and class, and posted speed limits where the recorded speeds and extreme accelerations occur. Methods for classifying drivers according to the extent and nature of their speeding and acceleration profiles will be developed and related to crash involvements and driver history.

2.1.5.1 Participants

Participants for this study will be recruited through a cooperative agreement with the Atlanta SMARTRAQ Household Travel Survey. SMARTRAQ, short for Strategies for Metropolitan Atlanta's Regional Transportation and Air Quality, is a comprehensive travel survey of 8,000 households in the Atlanta area sponsored by several organizations including the Georgia Department of Transportation, Atlanta Regional Commission, Federal Highway Administration, Center for Disease Control, and the Turner Foundation. SMARTRAC uses random samples based on income, household size, and residential density. A subsample of 1,100 respondents will be asked to participate in the NHTSA study. Participants will be stratified by age, and up to two vehicles per household will be instrumented.

Several geographically distributed installation facilities will be chosen across the study area to provide convenience for the participants. Installations are expected to be completed in two hours, but to reduce logistical concerns, the vehicles will be kept for one day. Rental cars will be provided at no cost to participants on the installation day.

2.1.5.2 Equipment Package

The 1,100 vehicles will be equipped with an instrumentation package designed to detect and report crashes as well as provide comprehensive and continuous on-road driver and vehicle operating characteristics. The instrumentation package (MACBOX) is being developed by

Safety Intelligence Systems Corporation, formerly Loss Management Services, Inc. in conjunction with Georgia Institute of Technology. This device contains a global positioning system (GPS) receiver with differential corrections (DGPS), a tri-axial accelerometer, a digital cellular transceiver, and a central processing unit (CPU). The GPS receiver provides vehicle position and speed data at 1 Hz; the differential corrections receiver will provide 1-3 meter accuracy levels in GPS position readings; the accelerometer is used to detect crashes and aggressive accelerations/decelerations; the cellular transceiver (transmitting at 9,600 bps) transfers position, speed, aggressive accelerations and crash data to Georgia Tech and also to a Public Safety Answering Point in the event of a crash. The CPU contains the control logic and storage required to manage the data processing, logging, and transfer requirements for this project.

The system components will be kept as small as possible with a minimal amount of external wiring to facilitate installation. The equipment itself will typically be installed under the rear seat (or under the driver's seat in the case of a van or sport utility vehicle), with cabling running under the carpet or behind plastic moldings. External connections are limited to power access, integrated GPS and cellular antenna, DGPS antenna coupler, speaker/microphone button, and an ignition sensor.

2.1.5.3 System Functionality

Data will be transmitted from the participating vehicles for two distinct purposes: first, for the transmission of operating characteristics on a periodic basis, and second for emergency notification calls in the event of a crash of the equipped vehicle.

The periodic transmission of operating characteristics data (speed and location at 1 Hz) from the vehicle will contain information regarding driver behavior in the form of selected trip routes and speeds collected by the GPS component. This data transmission will be triggered by the unit in the vehicle whenever the quantity of data stored in the system's on-board memory reaches a specified level or after a specified time period, whichever occurs first. This level will be finalized during the course of the initial unit testing to provide confidence that data will not be lost due to memory limitations. The data will be transmitted to a central server at the Georgia Institute of Technology where it will be processed, analyzed, and archived.

An emergency notification transmission will occur upon crash detection. The system will transmit a detection message to a computer located within the Fulton County Public Safety Answering Point operations center where an appropriate response will follow. Simultaneously, a second message is sent to the Georgia Tech data server and one or more mobile devices, such as pagers or two-way message devices. This message will inform Georgia Tech researchers that a crash has occurred so that a crash investigation team can be immediately dispatched to the crash site. Following the short messages, a detailed message is sent to Georgia Tech containing the sub-second accelerometer information collected several seconds prior to and following the first impact.

Data analyses will include comparison of driving patterns between crash-involved and non crash-involved drivers on several dimensions and will be used to answer questions regarding the role of speeding and aggressive driving in crash involvement.

2.2 Commercial Highway Vehicle Activities Related to Data Recorders

2.2.1 Federal Motor Carrier Safety Administration Activities Related to Data Recorders

The Federal Motor Carrier Safety Administration (FMCSA) was established in January 2000, as a result of the Motor Carrier Safety Improvement Act of 1999 (the Act). Prior to this time the federal motor carrier safety program was carried out within the Federal Highway Administration (FHWA).

The FMCSA is responsible for the safe operation of commercial motor vehicles (CMVs) used in interstate commerce on our nation's highways. The agency carries out this responsibility through development and enforcement of federal safety regulations, supporting the development of new technologies to enhance CMV safety and information, and by increasing awareness of CMV safety through public outreach programs. The FMCSA is dedicated to preventing truck and bus related injuries and fatalities, and has a major goal of reducing these 50 percent by 2010. In 1999, there were 5,362 fatalities and 142,000 persons injured as a result of large truck involved crashes.

Recognizing the important role that new technology can play in improving CMV safety, the FMCSA has been involved in a variety of activities to explore the use and benefits of electronic recorders.

Although not the primary focus of this discussion, the FMCSA first explored the use of electronic recorders relative to CMV driver hours-of-service (HOS). Research has shown that fatigue is a significant safety problem among CMV drivers. Federal regulations govern the maximum number of CMV driver duty hours, and drivers and carriers are required to document and retain HOS records. However, hand-written paper records are subject to falsification. Electronic recorders can provide a less burdensome method for recording HOS, and a more tamper-resistant record for federal and state enforcement officials. Current federal regulations now allow the use of electronic recorders by motor carriers for documenting driver HOS.

In 1997, the FMCSA also began to focus on the use of Event Data Recorders which can record a variety of vehicle parameters and critical events surrounding the time of a crash or near-miss incident. The information gathered through EDRs can better identify the causes of such events, and thereby help to prevent future crashes. In addition, the use of EDRs has shown in some applications to improve driver behavior, when the driver is aware of its presence onboard the vehicle. Through a contract with Sandia National Laboratories, Albuquerque, New Mexico, the FMCSA gathered information on the status of EDR technology, the types of data that would be most useful, minimum EDR technical parameters, and alternative uses such as monitoring driver alertness.

Since October 1998, the FMCSA has participated in the NHTSA Event Data Recorder Working Group. FMCSA is also participating on a task force established in March 2000, by the Technical and Maintenance Council (TMC) of the American Trucking Associations, Inc. Similar to the NHTSA Working Group on Event Data Recorders, the TMC task force participants include a wide cross-section of government and industry officials. However, in addition to gathering information on EDRs, the task force objective is to specifically develop a Recommended Engineering Practice (RP). The RP will apply to onboard vehicle EDRs for gathering data to be used in post-crash analysis. It will stipulate data collection, storage, and retrieval practices to ensure that comparable EDR parameters are generated by all vehicles.

In the FY2000 Senate Appropriations Committee Report, the Committee requested that FMCSA "...work with interested parties to explore a standard of protocol for access to and the relevant data to be recorded in this area and report back to the Committee..." The Committee further stated that its expectation is "...that in the development of any such safety enhancement tool, any standards or protocols would follow high standards of privacy and would only apply to instances in which law enforcement had secured a warrant with the intention of investigating a serious crash." The FMCSA is currently preparing a report in response to the Committee's request.

2.2.2 American Trucking Associations Activities Under the Technical and Maintenance Council

The TMC of the American Trucking Associations (ATAs) offers the trucking industry an opportunity to address trucking maintenance and equipment issues in a noncompetitive, noncommercial setting. The TMC's task forces write recommended practices (RP) pertaining to specific issues for the trucking maintenance community. The TMC has recently addressed vehicle event data recorders (EDRs) in two of its task forces, with two separate, associated RPs. One RP is up for approval and the second is still in draft.

The first task force in TMC suggested in its RP (TMC RP1212) an interface for retrieval of the event data. RP1212 recommends that an event output page be added to the user interface from the engine ECU. The output page will be password protected so that the information can be controlled by the vehicle owner. RP1212 does not define what information to collect and store, but it offers a standardized location for the output data. A second task force is addressing what data will be stored there.

The goal of the second TMC task force is to define what event data will be made available in the output location of RP1212. It is the view of TMC that the information currently available in engine ECUs is sufficient for the purposes of event recording. Adding sensors would add complexity and therefore increase both initial and maintenance costs. Although some increased costs will be associated with event data recording, keeping costs to a minimum will be an ongoing goal.

Some of the specific efforts in the second task force include defining the terminology, identifying data elements that are recorded or could easily be recorded, and working on the draft recommended practice. Terminology under discussion includes items like acceleration, brake status, gear selection, speed, engine speed, steering position. Not all of these data elements are readily available from all vehicles. Some of the difficulties that the task force encountered were in agreeing on definitions for some terminology, agreeing on the importance of certain data elements, and wording the RP so that all were satisfied. These difficulties are to be expected since different manufacturers are sensing and transmitting the same data element by different means. Discussion continues as the task force seeks agreement on many of these EDR issues.

TMC has started defining terms related to EDRs. To date, the following definitions have been proposed by their current task force:

- An EVENT is anything of interest that may occur during the operation of the vehicle.
- An INCIDENT is any event in which the safety of the vehicle or any person is threatened.
- A TRIGGER is either any data parameter that exceeds a predefined threshold or external input. A trigger initiates the capture of data.
- CAPTURE is the process of saving recorded data.

2.3 National Transportation Safety Board Activities

2.3.1 National Transportation Safety Board Recommendations Related to EDRs

In 1997, the NTSB issued recommendations to NHTSA, based partly on a public hearing held on March 17-20, 1997, Public Forum on Air Bags and Child Passenger Safety, indicating that NHTSA should pursue crash information gathering using EDRs. The NTSB safety recommendation H-97-18, NTSB stated:

> "Develop and implement, in conjunction with the domestic and international manufacturers, a plan to gather better information on crash pulses and other crash parameters in actual crashes, utilizing current or augmented sensing and recording devices."

In NHTSA's response to the safety board, it indicated that it was currently obtaining data from EDRs through the cooperation of the manufacturer, for use in crash investigations. This cooperation is needed since the technology to "download" data from these devices is only available to the manufacturer.

NTSB has continued to support EDRs by holding two important recent symposia, International Symposium on Transportation Recorders and Transportation Safety and the Law.[5]

2.3.2 On-Board Recorders in Other Modes of Transportation

2.3.2.1 Aviation

Aviation has long been the proving ground for on-board recording devices. Crash-protected flight data recorders have been around since the early 1950s, while cockpit voice recorders were introduced in the late 1960s. Significant improvements in safety have been realized in aviation as a direct result of flight data and cockpit voice recorders. For example, in the case of an ATR-72 that crashed in 1994 in Roselawn, Indiana, the 98-parameter data recorder provided sufficient information to prompt recommendations only eight days after the collision regarding operations of that aircraft in icing conditions.

With advances in technology, current recorders have transitioned from the earlier foil-based analog recorders and then tape-based digital recorders to solid-state technology, ultimately providing more information and greater survivability. New flight data recorders now have the capability of recording hundreds of parameters for at least 25 hours, while two hours of audio can now be recorded on cockpit voice recorders. Further, the government and industry, through international working groups, are now looking toward the implementation of cockpit image recorders as a method of documenting the cockpit environment prior to a collision including electronic displays, crew selections, and crew nonverbal communications.

Many in the airline industry are now taking advantage of recorded data by using it as an operational tool. Flight Operations Quality Assurance (FOQA) programs are in place at major carriers such as British Airways and United Airlines for the purpose of monitoring day-to-day operations and implementing necessary maintenance or changes in training to prevent crashes and incidents before they ever occur.

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5 Detailed information for these symposia are available at the NTSB web site at the following locations: http://www.ntsb.gov/events/2000/symp_legal/default.htm and http://www.ntsb.gov/events/symp_rec/symp_rec.htm

2.3.2.2 Rail

In the rail industry, event recorders were first implemented in the late 1970s for management purposes. Since then, event recorders have also contributed to crash investigations by providing more accurate accounts of the circumstances leading up to crashes, corroborating witness statements, and helping to eliminate much of the guesswork that had previously been involved in investigations. However, current recorders cannot answer questions dealing with train crew actions, they record a minimal number of parameters, and they do not meet any crash and fire survivability requirements. In nearly a dozen major railroad incidents, the locomotive event recorders were seriously damaged, making it virtually impossible to retrieve any meaningful data.

Fortunately, other recorders did survive these crashes and provided some limited information. As a result, government and industry are participating in the Rail Safety Advisory Committee (RSAC) Locomotive Event Recorder Working Group to develop the draft specifications for locomotive event recorder crashworthiness. It is expected that these specifications will be drafted into a notice of proposed rulemaking (NPRM) by the Federal Railroad Administration in the near future.

The addition of a voice recorder is also being considered for use in locomotives. Voice recorders would provide key information about crew communications, train coordination, and the environment in the cab that would otherwise not be available.

Similar to the progression of recorder technology in aviation, the recording of images is already being practiced by members of the rail industry. Some railroads have installed cameras and recorders to record the view of the track in front of their locomotives. This use of video is a promising tool for documenting the outside environment in front of trains, including the status of the track ahead, and the status of equipment and other vehicles at grade crossings.

2.3.2.3 Marine

In the marine industry, the advantages of on-board recorders are just now being fully realized. Current voyage recorders remain very rudimentary and are of limited use in determining the causes of collisions. Similar to other modes, this has resulted in long, expensive investigations, such as that of the *Estonia* that sank in the Baltic Sea in 1994, taking 800 people with it. Millions of dollars and a significant amount of work were spent trying to re-create the circumstances of this collision.

Fortunately, noticeable progress is now being made to improve voyage recorders so that they will become a more valuable tool. An international standard for improved voyage data requirements was approved and became effective in March 2000. Further, in 2000, the International Maritime Organization decided to require voyage data recorders on board all ships over 3,000 gross tons and built on or after July 1, 2002. Passenger ships manufactured before that date must be retrofitted with voyage data recorders by January 2004.

2.4 Event Data Recorder Issues - One State's Perspective

One member of the WG represented the State of Massachusetts. While the views provided in this section are based on current trends in data collection and analysis in Massachusetts, they may have application to many states. Emergency response to motor vehicle crashes is a service usually rendered at the local rather than federal level. Police, fire, and EMS responses to motor vehicle crashes are not coordinated at the state or federal levels. Some states will have a special need for real time access and use of crash severity and other crash-related data – data which could have been transmitted by an ACN or stored in an EDR. Localities and states have a historic new opportunity to use crash data in real-time to enhance EMS response to serious crashes.[6] However, medical uses of crash data for activation of EMS services and triage are new and this dynamic use requires immediate post-crash access to the data. Many of the traditional applications of crash variables for crash investigations and engineering refinements are uses where the time frame in which the data are collected is not critical to the user (within the bounds of a few days or weeks).

If the public perceives that these new and unique data are being used to help them survive a crash, there may be a higher level of support than if it perceives the data are being used against them. However, if the public perceives that crash data are being used primarily by law enforcement to prosecute individuals, such as, police officers responding to the scene of a crash, then this situation could seriously jeopardize the use of the crash data for medical purposes.

There is a strong argument to be made by the state governments that real time use of crash data should be protected for the purpose of saving lives or reducing injury extent. This would prevent a situation where conflicting users of the data are at a crash scene. Everyone responding to a crash would have a common goal: using the data to lessen crash related injury and death. After the fact, law enforcement use of the data would still be possible, but it would be after the medical emergencies had been taken care of and would be subject to the normal search and discovery procedures (warrants, etc.). Routine state data access and disclosure issues would need to be resolved.

States need data collected and studied to help support decision-making about the optimal uses of ACNs and EDRs. States have a different perspective about the use of crash data than the federal government. The federal government traditionally collects data on crashes for research, and, while States could make use of these data in a similar manner, they can go beyond that use into the realm of supporting real-time EMS decision-making processes. This makes sense because 911 and EMS services are provided at the states.

State courts also have a stake in crash data access to minimize litigation and expedite cases that go to trial. State DOTs might use these data to determine smarter responses for rescue and clean-up crews.

There is a need for new real-time EMS protocols for responding to motor vehicle crashes where crash data are available. Current EMS protocols do not contain instructions for how to appropriately dispatch EMS services based on the severity of a crash as defined by ACN and/or EDR data. The opportunity exists for states to reduce response time and optimize the level of service that is provided - from the moment the crash severity data are reported.

Provisions need to be made to add ACN and/or EDR data into appropriate state data bases. Protection of private data must be maintained in a similar manner as currently done with other

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6 ACN systems transmit crash-related data from a vehicle to a receiving agency, such as an emergency medical service or a service provider. While the ACN data may be produced exclusively by the ACN system and not stored in the vehicle, the ACN system may acquire some of the data it transmits from an EDR. ACN and EDR data may be used by States in making EMS-related decisions. While this working group did not specifically focus on ACN, it recognizes the interaction between ACN and EDR systems, especially at the users level, such as police, EMS, States etc.

data collected at the crash scene. Depending on the state, 911 data may be private, public or quasi-public. A set of privacy concerns exists with the EMS and Hospital records, and protocols need to be established early as the transition to ACN and/or EDR data collection is made. States may want the Federal government to play a role to develop models for the collection of these data. Due to the very limited collection of EDR and/or ACN crash data thus far, it is not possible to determine the optimal variables to record and/or transmit to save lives or reduce disabilities at this time.

2.5 Other EDR Related Activities

With the introduction of air bags into the motor vehicle fleet, advanced technologies have been incorporated into the vehicle, including crash analyzers to determine if and when the air bag should be deployed. Early air bag controllers used analog devices, such as Rolomite and ball-in-tube crash sensing switches, to make the deploy/no-deploy decision, based on preprogramed sensor characteristics. As these devices evolved, electronic, often single point sensors, replaced the analog units, and a new generation of crash analyzers were introduced. These electronic devices analyze the actual deceleration-time characteristics of the crash to predict if the air bag should be deployed. As these electronic devices continued to evolve, manufacturers installed electronic memory systems capable of storing information on the air bag deployment system. Early systems recorded air bag status, and other diagnostic data. As this capability grew, manufacturers enhanced the system to store more crash characteristics, such as deceleration and delta-V. Further enhancements have included storage of pre-crash data, including vehicle speed, seat belt status, brake status, etc.

There are other recording devices available on the market. These devices are sold in the aftermarket, for owners, companies, and/or fleets to install in their own vehicles. Generally these devices measure, collect, and store crash-related data, such as deceleration, pre crash vehicle dynamics and other important data related to crash reconstruction. Most of these devices analyze the vehicle's deceleration to determine if the vehicle has been in a crash and start the collection process. Depending on the crash severity and design of the system, they can summon help via cell phone technology. Manufacturers also use EDRs to record the status of other items, such as the air bag diagnostic lamp.

2.5.1 European EDR Activity

The following review (the entirety of section 2.7.1), of the recent history of EDRs in Europe, was extracted from a paper supplied by VDO, titled "The Accident Data Recorder, A Contribution to Road Safety."

In spite of slightly decreasing numbers of crashes, there is still a total of 1.3 million traffic crashes with personal injuries in the EU with 45,000 people killed and more than 1.6 million people injured. The social damage caused by traffic crashes in Western Europe amounts to approximately 145 billion ECU per year. In Germany, about 90 percent of the recorded accidents are a result of human failure of the parties involved. Only 10 percent are caused by technical defects or the condition of the roads. These numbers indicate that action is essentially required in the area of driving behavior.

For this purpose, EDRs are being evaluated to determine their effectiveness in crash mitigation and investigation.

- The analysis of crashes is provided with a new qualitative basis. Entry and recording of speed and movements of the vehicle as well as actuation of brakes, direction indicator, light, and horn during a short period of time immediately before, during, and after a crash make it possible to objectively determine the causes of a collision.

- The use of event data recorders in European fleets shows that a considerable preventive effect can be achieved, i.e. a reduction of the number of crashes and costs. Crashes are reduced between 20 and 30 percent as can be illustrated by some examples.

For some years, the event data recorder represents a suitable system that has been called for by experts and the Deutsche Verkehrsgerichtstag (German Traffic Court Conference) under the aspect of road safety and legal certainty. According to the experiences on hand, it is to be expected that the use of this device has a positive effect on the behavior of the driver. Without doubt, the noticeable contribution to road safety connected with the introduction of the tachograph can also be obtained by means of the event data recorder.

2.5.1.1 Preventive Effects of Event Data Recorders

The use of event data recorders in fleets has shown that the number of collisions and the frequency of damage could in some cases be considerably reduced. The following provide some examples:

a. **Berlin Police Department**: The installation of EDRs in all 62 radio patrol cars of a Berlin police precinct in 1996 resulted in a total reduction of crashes through one's own fault of 20 percent. These positive results occasioned the Berlin police to equip all radio patrol cars of its squadron with EDRs, more than 400 vehicles in all 7 police precincts. See Figure 1.

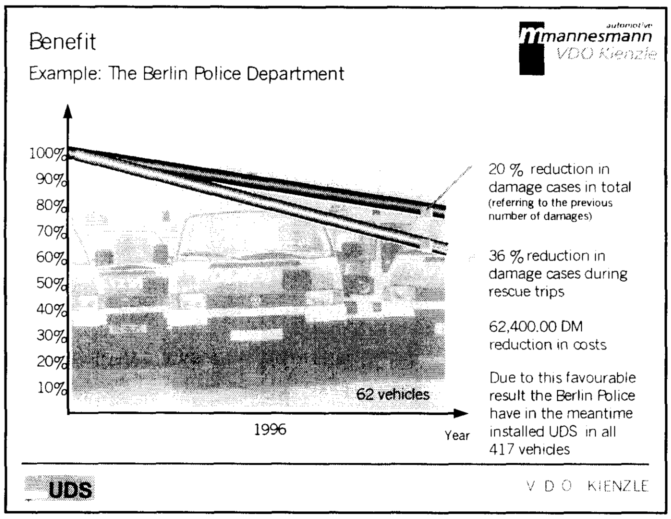

Figure 1. Effect of installing EDRs in 400 radio patrol cars of the Berlin police department, 1966.

b. Viennese Police Department: The Viennese police department equipped a total of 175 vehicles with EDRs. Due to the positive experiences of the Viennese police department, all newly purchased radio patrol cars of the Austrian police were equipped with event data recorders.

c. Samovar: In the SAMOVAR (Safety Assessment Monitoring On Vehicle with Automatic Recording) research program executed in the scope of the European Union Drive II, Project V2007, Great Britain, the Netherlands and Belgium took part with 9 fleets and a total of 341 vehicles that were equipped with different types of vehicle data recording technologies. Together with a control group used in comparable experiments, 850 vehicles participated. The data were recorded for a period of 12 months. The overall synthesis of the results shows that the use of EDRs reduced the crash rate by 28 percent and the costs by 40 percent.

d. WBO Pilot Test: 123 buses equipped with EDR technology took part in this pilot test sponsored by the Ministry of Transport of the German Federal State of Baden-Württemberg. Depending on the company, crashes were reduced by 15 to 20 percent with the buses equipped with EDRs.

e. WKD Security GmbH: All cars (approx. 100) of this company that are used by different personnel for guarding of company premises and buildings etc. are equipped with event data recorders. By virtue of the more conscious and situation-adjusted driving technique of the employees, the number of crashes decreased by 30 percent. Trivial damage was even reduced by 60 percent. In addition, loss adjustment was also simplified thanks to the convincing documentation of damage. Furthermore, due to the existence of objective data, the company climate was considerably improved since disagreements with the drivers were eliminated.

f. Kötter Security: 200 of the 850 vehicles of the Kötter security services are equipped with EDRs. Each of the vehicles covers between 8,000 and 15,000 kilometers every month and is driven in shifts by different employees almost 24 hours a day. The collision damage was reduced and the expenditure for repair decreased.

g. Hatscher Taxi Company: The 15 vehicles of this company cover approximately 150,000 km per year each. Every week, each vehicle is used by frequently changing drivers in an average of 17 shifts. As a result, a reduction of trivial damage was noted after one year only and the collision rate decreased by 66 percent. All in all, the vehicles were treated with more care and the company image was improved. See Figure 2.

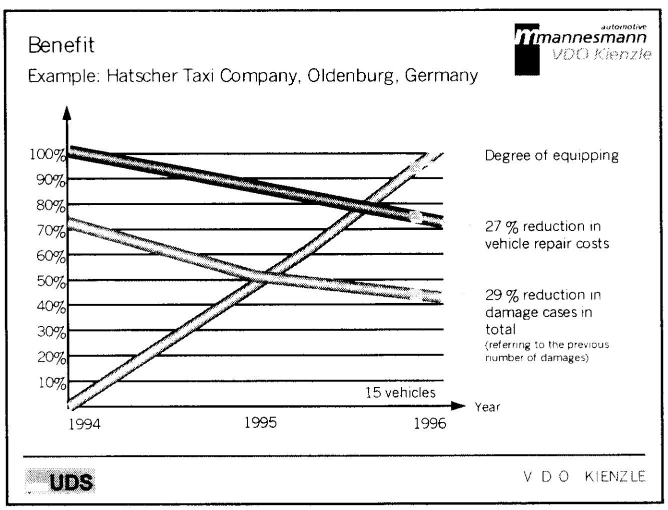

Figure 2. Taxi company experience using EDR technology, 1994-1996.

2.5.1.2 Collision Clarification with Event Data Recorder / Research Findings

The following provide two examples of using EDR data in crash analysis:

a. Bundesanstalt für Straßenwesen Study "UDS as a Source of Information for Accident Research in the Pre-Crash Phase:" The Bundesanstalt für Straßenwesen (bast, German Federal Highway Institute) that has been charged with the study "UDS as a Source of Information for Accident Research in the Pre-Crash Phase" by the German Minister of Transportation, presented the final report in June 1997. The report is based on the collection of data of 42 actual crashes in which vehicles equipped with EDR technology, using an UDS system, were involved. With EDRs, the ratio of collection was increased to 100 percent compared to classical data sources in the pre-crash phase as well as in the other collision phases for individual characteristics that can generally not be completely collected without an EDR. This includes reactions and responsiveness of the driver, speed development over a period of 30 seconds before the collision or the chronological order of series rear-end collisions.

b. EU Study: Samovar: In the research program SAMOVAR (Safety Assessment Monitoring On Vehicle with Automatic Recording) carried out by order of the European Union, data of the 341 involved vehicles were also evaluated as to the achievable quality of the collision analysis in comparison to the options of classical crash reconstruction. The report establishes the result that in comparison to classical ways of crash analyses, event data recorders can be used to provide detailed results with higher accuracy in less time. Event data recorders are thus a suitable means to provide fast and highly accurate, detailed answers to questions of crash analysis.

2.5.1.3 Demands on Road Safety Policy

Event data recorders contribute to road safety under two essential aspects:

- Clarification of crashes is provided with a new quality. Important statements on the cause of the crash and the conclusions drawn on the avoidability of crashes can be made quickly and in a qualified manner. This results in a considerable advantage for crash evaluation also under aspects of civil and criminal law.

- In sufficiently large long-term studies, the preventive effect in fleets has been shown to be from 20 to 30 percent; whereas, these same affects with private users of UDS[7] systems have not been established.

Both aspects directly influence the costs caused to our national economies by crashes, injured and killed people, clarification of these events and subsequent claim settlement.

a. European Union: Within the scope of the work program for the promotion of road safety in the European Union (EU) 1997 - 2001, the EU commission stated under Point 3 "Clarification": "Accident data recorders record important data on the collision and thus considerably facilitate crash analysis. The use of UDS results in less collision because the drivers drive more carefully."

b. Deutscher Verkehrssicherheitsrat (DVR)(German Council for Road Safety): The entire managing board of the German council for road safety, DVR, advocates a request of all vehicle drivers to equip their cars with EDRs of their own accord in the interest of road safety. They also demand that the equipment of vehicles with EDRs in the sense of the law on dangerous goods on the road (Gefahrgutverordnung - Straße (GGVS)) and for busses should be prescribed by law in the EU.

c. Interessengemeinschaft für Verkehrsunfallopfer Dignitas (Traffic Accident Victims Association): In Germany, the Traffic Accident Victims Association Dignitas in line with the respective European federation of road victims demand that the equipment of cars with EDRs should become compulsory. Their objectives are better protection of crash victims by means of just clarification of collisions.

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7 The UDS EDR system is discussed in detail in Section 3 of this report.

d. Deutsche Verkehrswacht (German Road Traffic Safety Organization): The Deutsche Verkehrswacht (DVW) sees its most important task in finding and executing suitable measures to positively influence the behavior of the road users and in this context speaks for the establishment of clear legal rules regulating the exclusive evaluation of EDR data for the clarification of collisions and exclude the use of these data for other purposes.

2.5.2 Event Data Recorders and School Buses in the United States

At the present time, EDRs are not used in school buses. Unlike passenger vehicles that are equipped with air bag systems and crash sensors, which can provide data to be recorded and used to develop a better understanding of the crash severity, school buses currently have no sensing devices that would provide any information about crash conditions or severity. School buses often have electronic engines, transmissions, and anti-lock brakes which employ electronic control systems, which could provide some data for collection. There are some aftermarket EDR systems that could be installed on school buses, but mostly these tend to be in the areas of driver management.

There are ongoing questions within the school bus community as to the potential benefits of developing and installing EDRs on school buses. Given the rarity of serious school bus crashes and the already outstanding safety record of school buses, the school bus community believes that the cost of gathering EDR data may not be offset by the potential benefits. This belief is reinforced by comments made by NHTSA in recent years when the agency considered applying some new Federal Motor Vehicle Safety Standards to school buses. Specifically, NHTSA stated: "NHTSA is increasingly concerned that requiring these vehicles [school buses] to absorb a large additional cost with little benefits would cause more schools to delay purchase of new vehicles or to use non-school buses. This would result in a loss of benefits in other areas that would offset the extremely small benefits of this rule." For this reason, any rulemaking action would need to be carefully reviewed for both its benefits and potential disadvantages.

The school bus community also believes there are technical issues that need to be resolved. These technical issues apply to any large motor vehicle, not just school buses. For example, in a large school bus, it may be necessary to install multiple sensors, since the occupants in the various locations will likely experience different crash severities, particularly in side and multiple-impact crashes. Multiple sensors increase the cost of these devices.

It is important to note that the school bus industry (both manufacturers and users) are committed to explore any means that may further improve school bus transportation. To that end, the school bus industry is an active participant in the study of EDRs, including the technical, privacy, and cost issues associated with placing this type equipment on school buses.

2.5.3 Other Background Information

2.5.3.1 Recent Dissertation Citing a Short History of EDR Initiatives

A recent dissertation provides a review of the worldwide initiatives to implement EDR's. Titled "*Validity and Reliability of Vehicle Collision Data: Crash Pulse Recorders for Impact Severity and Injury Risk Assessments in Real-Life Frontal Impacts,*" it was written by Andres Kullgren as a thesis for a degree of Doctor in Medical Sciences, Department of Clinical Neuroscience, Section for Personal Injury Prevention, Karolinska Institute, Stockholm, Sweden in December of 1999. This dissertation provides a good overview of EDRs.

2.5.3.2 OTA Assessment

The Office of Technology Assessment (Washington, DC) issued a report in February of 1975 titled "*Automobile Collision Data: An Assessment of Needs and Methods of Acquisition.*" The study was requested as an evaluation of the automotive crash recorder program proposed by NHTSA. Although this assessment is dated, a review of the paper reveals that many of the problems and concerns expressed then are still relevant. The assessment addressed the following issues:

- Further data on the characteristics of automobile collisions
- An evaluation of the type of data being produced by existing crash recorders
- The consequences associated with obtaining the data in different ways
- Legal questions associated with the existence of actual physical data from a crash

The following presents some premises from this paper which are specific to crash data analysis today:

- Current national crash databases are inadequate to resolve the uncertainties
- There is a major deficiency in data relating collision forces and actual fatalities and injuries
- A comprehensive crash data program is needed
- The federal Government, not States, manufacturers or insurance companies, should support the central data collection activities
- EDRs provide data that may be admissible in a court of law

2.5.3.3 Using EDRs to Promote Seat Belt Use

Professor Thomas Michael Kowalick authored a paper discussing the possibility of using EDRs to encourage seat belt usage. A copy of this paper "Proactive Use of Highway Recorded Data via an Event Data Recorder (EDR) to Achieve Nationwide Seat Belt Usage in the 90th Percentile by 2002," can be found at the NTSB web site.[8]

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8 http://www.ntsb.gov/events/symp%5Frec/proceedings/authors/kowalick.htm

3.0 Status of EDR Technology

3.1 Overview

The working group found that the current use of EDRs in highway vehicles was generally limited to one OEM (GM) and a few small aftermarket suppliers. During the 2½-year working group process, other manufacturers made EDRs available, but the market penetration is still less than ½ of the new vehicles produced. The WG also found that GM was in the lead in developing EDR technology and by far, comprised the majority of vehicles equipped with EDRs. There were several aftermarket companies in the EDR business, which varied from a European company with many years of experience to new start-up companies.

The WG also found that the type of data collected varied widely from manufacturer to manufacturer. OEM companies have all taken a similar approach, in that, they have incorporated their recording devices into the airbag controller. This has occurred because these systems incorporate sensors and memory devices which are directly applicable to crash data. Aftermarket providers have produced a wide variety of EDR systems, from simple acceleration collection devices, to video collection devices, to devices which are capable of collecting pre-crash, crash, and post crash data using "instrument grade" fidelity.

Downloading EDR data has also been improved over the past few years. Early downloading of data was done solely be the OEM or aftermarket company. Recently, with the public introduction of the Vetronix CDR system, which can download GM EDR systems, these systems can be read by anyone who has been trained. Aftermarket systems have also become simple to operate, with one company offering a system which downloads the stored data via a video link to a TV monitor. Other systems are more complicated, requiring interaction, via an Internet connection, between the user and provider. There is a need for a standardized extraction connector for downloading EDR data, as well as protocols for how to maintain the data in the EDR after the crash. SIS' MACBOX offers an alternative transmission and downloading procedure. With the MACBOX, encrypted crash data are transmitted over a digital wireless network then decoded and downloaded to a secure crash data storage facility.

One clear finding was that there are no standards associated with EDRs. Each company defines how they will collect data and in what format. The WG feels there is a need to clarify EDR technology. Further, the group agrees that a list of data elements needs to be complied for collective use by all EDR developers and manufacturers. Common data element definitions are needed. There was wide concern in the WG over how the car buyers would benefit from this technology. There was also a lot of discussion regarding the privacy of EDR data. This section of the report presents an overview of the OEM and aftermarket systems which were identified during the program.

3.2 Original Equipment Manufacturer (OEM) Systems

3.2.1 Summary of OEM Systems

Several of the OEMs worked together to develop a cross reference which provides tabular information regarding their EDR technology. This table is found on the next few pages. The table references high priority data elements selected by the working group, as well as other data elements that may be recorded in the near future.

Event Data Recorder Summary and Comparison 11/27/2000								
Category/Data Item	**NHTSA EDR Working Group**	**Use of data. Why record data?**	**GM**	**Ford**	**DCX**	**Honda**	**Toyota**	**Volkswagen**
Application*	TBD-Final Fact Finding Report due in 2001	From NHTSA Working Group List-use data to improve: Crash Reconstruction, Emergency Response, Biomechanics Research, Highway Design, Threshold, Crash Causation	Started MY1999 with phase-in through MY2004. After MY2004 will add more data to record in response to NHTSA	Internal Fleet only-for Crash Research-Have not announced external plans	to be determined	to be determined	Started MY2001 with phase-in	to be determined
Activation of EDR Function	Not defined. Focus is on Frontal crash with some interest in Side crashes.	To be determined	Frontal - "Algorithm Enable" started by "Near Deployment" predetermined Delta-V.	Frontal Algorithm Activated - Events will be recorded when a minimum velocity change is achieved.	After any pyrotechnic deployment from a front, side, or rear impact	Frontal "Algorithm Enable" started by "Near Deployment"	trig: G >= 2.0 Hold: Deployment	Wake up of Airbag ECU Algorithm

	Category/Data Item	NHTSA EDR Working Group	Use of data. Why record data?	GM	Ford	DCX	Honda	Toyota	Volkswagen
A	**1. Restraint System Usage (airbags, belts, other) (Internally called Occupant Restraint System Status)**								
A	Airbag Type Deployed (Dual Stage)	yes	Crash Reconstruction, Biomechanics Research	yes	yes	yes	yes	yes	yes
A	Ignition Cycle Counter		Crash Reconstruction	yes	yes	yes	yes	yes, during the warning lamp illumination	yes
A	Seat Belt status for front occupants (with buckle switch inputs)	yes	Crash Reconstruction, Biomechanics Research	yes (driver only)	yes	yes	yes	yes	yes
A	Occupant Sensing Status	yes	Crash Reconstruction, Biomechanics Research	no	yes	yes	yes, if applied	yes. if applied	yes
A	Airbag Disable switch status	yes	Crash Reconstruction	yes	yes	yes	yes, recorded in manual cut-off switch itself	yes, recorded in manual cut-off switch itself	yes
A	Airbag warning lamp status	yes	Crash Reconstruction	yes	yes	yes	yes	yes	yes
A	System Voltage		Crash Reconstruction	no	yes	to be determined	no	no	yes

	Category/Data Item	NHTSA EDR Working Group	Use of data. Why record data?	GM	Ford	DCX	Honda	Toyota	Volkswagen
B	**Vehicle System Status**								
B	**2. VIN & EDR ID**	yes	Crash Reconstruction	no	EDR ID not vehicle VIN	yes	no	no	Yes
B	Vehicle Mileage		Crash Reconstruction	no	No	yes	no	no	?
B	Engine Lamp Status		Crash Reconstruction	no	No	to be determined	no	no	?

	Category/Data Item	NHTSA EDR Working Group	Use of data. Why record data?	GM	Ford	DCX	Honda	Toyota	Volkswagen
C	**3. Driver Controls (Brakes, accelerator, etc.)**								
C	Cruise Control On/Off/Engaged Status	yes	Crash Reconstruction, Crash Causation	no	to be determined	to be determined	no	no	to be determined
C	Engine RPM	yes	Crash Reconstruction, Crash Causation	yes (5 sec before impact)	to be determined	to be determined	no	some cars	yes
C	**Throttle Position**	yes	Crash Reconstruction, Crash Causation	yes (5 sec prior to impact)	to be determined	to be determined	no	some cars	yes
C	**Brake Applied**	yes	Crash Reconstruction, Crash Causation	yes (5 sec prior to impact)	to be determined	to be determined	no	some cars	yes
C	**ABS Activated**	yes	Crash Reconstruction, Crash Causation	no	to be determined	to be determined	no	No	yes
C	**4. Vehicle Speed**	yes	Crash Reconstruction, Crash Causation	yes (5 sec prior to impact)	to be determined	to be determined	no	some cars	due to high impact on privacy issues recording would be owners choice at new car purchase or by dealer programming
C	Adaptive Cruise Control and other driver assistance systems	yes	Crash Reconstruction, Crash Causation	no	to be determined	to be determined	no	No	to be determined
C	ESP (stability control)	yes	Crash Reconstruction (verify ETC), Crash Causation	no	to be determined	to be determined	no	to be determined	to be determined

Category/Data Item		NHTSA EDR Working Group	Use of data. Why record data?	GM	Ford	DCX	Honda	Toyota	Volkswagen
D	**5. Crash Pulse Information**	delta V, deceleration, angular rates	Crash Reconstruction, Emergency Response, Biomechanics Research, Threshold	Calculated (from decel. Pulse) Delta Velocity at 10ms intervals	Actual deceleration pulse at 1ms intervals	no	Partial delta velocity	every 10ms delta V	deceleration; rate and duration depending on direction of pulse and available storage capacity
E	**6. Location, Time, Date-likely available from Telematics system, if equipped**	yes	Highway Design, Crash Reconstruction	no	no	no	no	no	no
E	**7. Automatic Collision Notification (ACN) Data Record sent to Telematics Provider-Time, Date, Location, Number of Occupants**	yes	Emergency Response	no	no	no	no	no	no
E	**8. Environmental Conditions**	yes	Emergency Response, Highway Design	no	no	no	no	no	no

* Numbered (1-8) and bold items are from the top ten data list. See section 4 for further details on WG findings related to data elements.

3.2.2 GM EDR Technology

The NTSB has recommended that automobile manufacturers and NHTSA work cooperatively to gather information on automotive crashes using on-board collision sensing and recording devices[9]. Since 1974, General Motors' (GM) airbag equipped production vehicles have recorded airbag status and crash severity data for impacts that caused a deployment. Many of these systems also recorded data during "near-deployment" events, i.e., impacts that are not severe enough to deploy the airbag(s). GM design engineers have used this information to improve the performance of airbag sensing systems and NHTSA researchers have used it to help understand the field performance of alternative airbag system designs. Beginning with the 1999 model year, the capability to record pre-crash vehicle speed, engine RPM, throttle position, and brake switch on/off status has been added to some GM vehicles.

3.2.2.1 Evolution of GM Event Data Recording

GM introduced the first regular production driver/passenger airbag systems as an option in selected 1974 production vehicles. They incorporated electro mechanical g-level sensors, a diagnostic circuit that continually monitored the readiness of the airbag control circuits, and an instrument panel Readiness and Warning lamp that illuminated if a malfunction was detected. The data-recording feature utilized fuses to indicate when a deployment command was given and stored the approximate time the vehicle had been operated with the warning lamp illuminated. In 199010, a more complex Diagnostic and Energy Reserve Module (DERM) was introduced with the added capability to record closure times for both the arming and discriminating sensors as well as any fault codes present at the time of deployment. In 1992, GM installed sophisticated crash-data recorders on 70 Indy racecars. While impractical for high volume production, these recorders provided new information on human body tolerance to impact that can help improve both passenger vehicle occupant and race car driver safety. As an example, the data demonstrated that well restrained healthy, male race car drivers survive impacts involving a velocity change of more than 60 mph and producing more than 100 g's of vehicle deceleration. Such information will be helpful to biomechanic experts refining their understanding of human injury potential.

Certain 1999 and newer model year GM vehicles have the added capability to record vehicle systems status data 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. Almost all GM vehicles will add that capability over the next few years.

The following table contains an abbreviated summary of the data recording capability provided with various GM production airbag systems.

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9 This section is based on: "Recording Automotive Crash Event Data;" Augustus "Chip" Chidester, NHTSA, John Hinch, NHTSA, Thomas C. Mercer, GM, Keith S. Schultz, GM; 1999

10 SDMs were actually introduced in 1987 on a limited number of production vehicles. In 1990, they were used widely.

Data Stored by Selected GM Airbag Systems			
Parameter	**1990 DERM**	**1994 SDM**	**1999 SDM**
State of Warning Indicator when event occurred (ON/OFF)	X	X	X
Length of time the warning lamp was illuminated	X	X	X
Crash-sensing activation times or sensing criteria met	X	X	X
Time from vehicle impact to deployment	X	X	X
Diagnostic Trouble Codes present at the time of the event	X	X	X
Ignition cycle count at event time	X	X	X
Maximum DV for near-deployment event		X	X
DV vs. time for frontal airbag deployment event		X	X
Time from vehicle impact to time of maximum DV		X	X
State of driver's seat belt switch		X	X
Time between near-deploy and deploy event (if within 5 seconds)		X	X
Passenger's airbag enabled or disabled state			X
Engine speed (5 sec before impact)			X
Vehicle speed (5 sec before impact)			X
Brake status (5 sec before impact)			X
Throttle position (5 sec before impact)			X

3.2.2.2 Technical Description of the Event Data Recording Process

The crash sensing algorithm used in 1999 model year GM vehicles decides whether to deploy the airbags based on calibration values stored in the SDM reflecting that vehicle model's response to a variety of impact conditions. This predictive algorithm must make airbag deployment decisions typically within 15-50 msec (.015-.050 sec) after impact. The SDM's longitudinal accelerometer is low-pass filtered at approximately 400 Hz. to protect against aliasing, before being input to the microcontroller. The typical SDM contains 32k bytes of ROM for program code, 512 bytes of RAM, and 512 bytes of EEPROM. Every 312 microseconds, the algorithm samples the accelerometer using an A/D converter (ADC) and when two successive samples exceed about two Gs of deceleration, the algorithm is activated (algorithm enable). (See Figure 3)

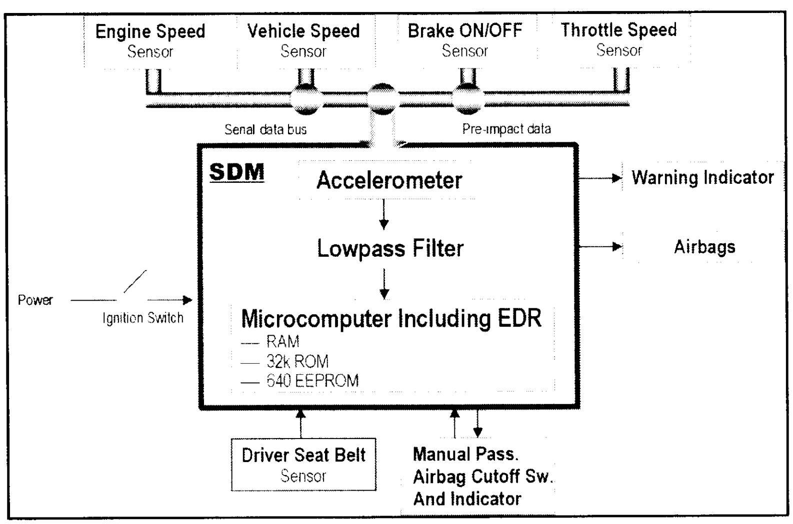


Figure 3. Block Diagram of 1999 SDM.

Because of EEPROM space limitations, the SDM does not record the actual deceleration data. However, the frequency content of the crash pulse that is of interest to crash reconstructionists typically does not exceed 60 Hz and the crash pulse can therefore, be well-represented by low frequency velocity change data (DV). The SDM computes DV by integrating the average of four 312 microseconds acceleration samples and stores them at 10 msec increments in RAM. (See Figure 4)

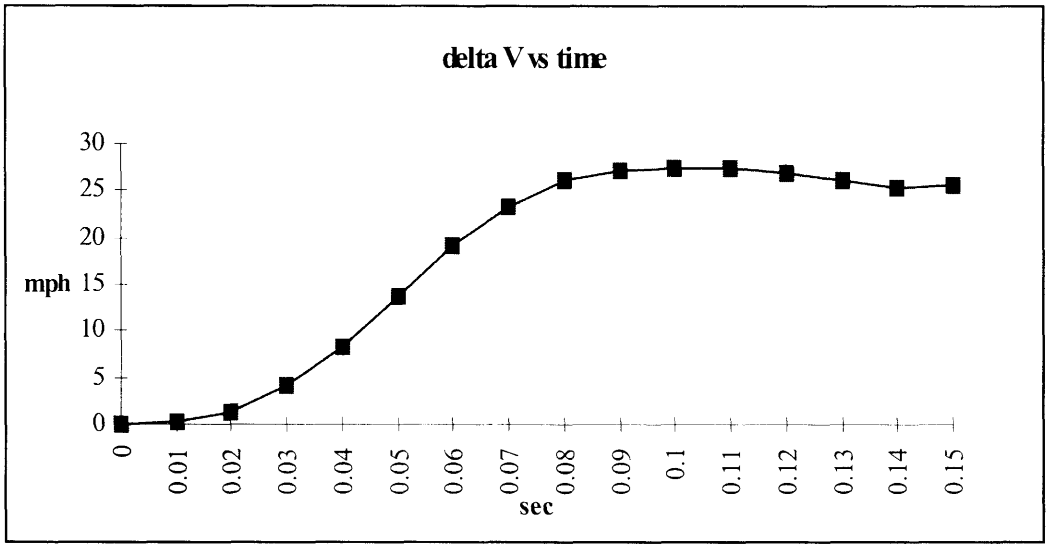


Figure 4. Delta-V Data Collection during Crash.

Several other sensors provide driver seat belt status, vehicle speed, engine RPM, brake on/off status, and throttle position. The driver seat belt switch signal is typically input into the SDM while the remaining sensors are monitored by one or more other electronic modules that broadcast their data onto the serial data bus. If there is an airbag deployment or a near-deployment crash, the last five seconds of data immediately preceding algorithm enable are stored in EEPROM. All stored data can later be recovered using a laptop PC equipped with appropriate software and interface hardware. The SDM block diagram shows how the pre-impact sensor data would appear when downloaded. To understand this requires some knowledge of the serial data bus and the SDM's role. First, the serial data bus operates as a "contention" type of bus. Electronic modules transmit data based on a "send on change" design. For example, when engine speed changes by at least 32 RPM, the engine microcontroller broadcasts the new RPM value on the serial bus.

Once each second, the SDM takes the most recent sensor data values and stores them in a recirculating buffer (RAM), one storage location for each parameter for a total of five seconds. When the airbag sensing system algorithm "enables" shortly after impact, buffer refreshing is suspended. Note that algorithm enable is asynchronous with the transmission of vehicle speed and other data. Hence, the data on the bus can be skewed in time from the crash by as much as one second. (See Figure 5)

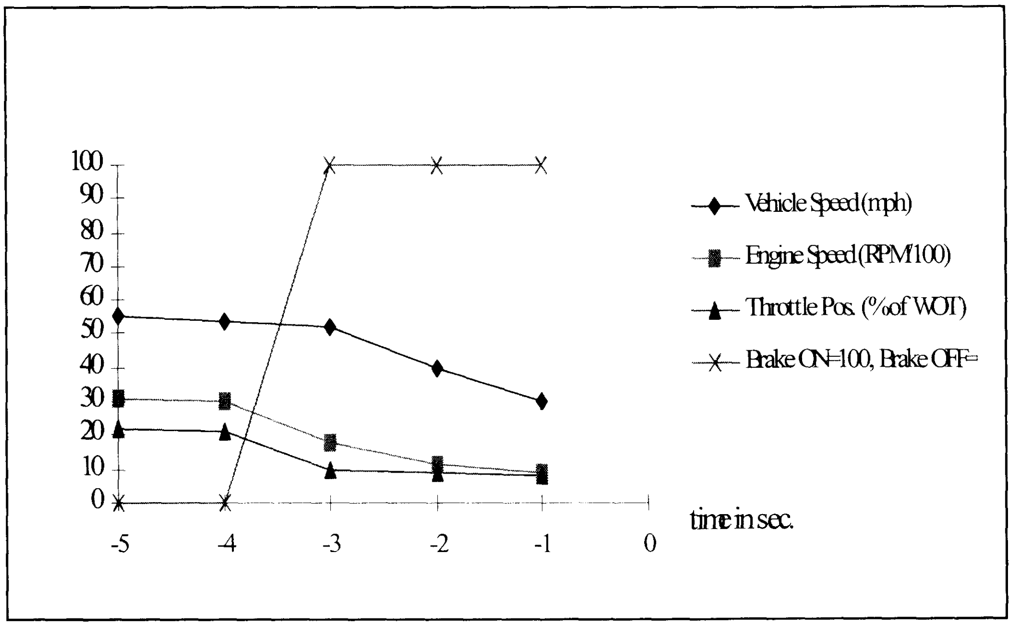


Figure 5. Example of Pre Crash Data Collection.

The modules that broadcast the sensor data (engine RPM, brake status, etc.) also diagnose the sensors for faults and indicate the data's validity to the SDM. The bus is also constructed so failures of the serial link are detected by the SDM. At the time of deployment, the state of the driver's seat belt switch, the manual cutoff passenger airbag switch (if equipped), warning lamp state, and time to deployment are temporarily stored in RAM. The critical parameter values used to make the deployment decision are also captured in RAM. When 150 msec have elapsed from algorithm enable, the data stored in RAM are transferred to the EEPROM. It requires about 0.7 sec to permanently record all information. Once a deployment record is written the data are frozen in EEPROM and cannot be erased, altered, or cleared by service or crash investigation personnel.

The recording of near-deployment data includes the pre-impact vehicle speed, engine RPM, etc. The criteria used to determine whether a near-deployment event is stored in EEPROM is based on the maximum DV observed during the event. If this maximum DV is larger than the previously recorded DV, the new near-deployment event is stored along with the corresponding pre-impact data. The near-deployment record is cleared after 250 ignition cycles. This is equivalent to an average of about 60 days of driving. Each time the algorithm is enabled and no deployment is commanded, the SDM compares the maximum DV previously stored with the maximum DV of this new event to decide whether to update the near-deployment event data.

3.2.3 Ford Motor Company

As of the time of this working group report, Ford did not have a technical description of their EDR system. Some Ford vehicles, especially those with advanced occupant restraint systems, are equipped with an EDR, which is an integral part of the airbag control system. The system records longitudinal and lateral acceleration, along with some data related to the driver and airbag deployment. Figure 6 depicts the longitudinal acceleration of a typical output chart from a Ford EDR.

Preliminary DRAFT

EDR Report – Summary Page [mock data]

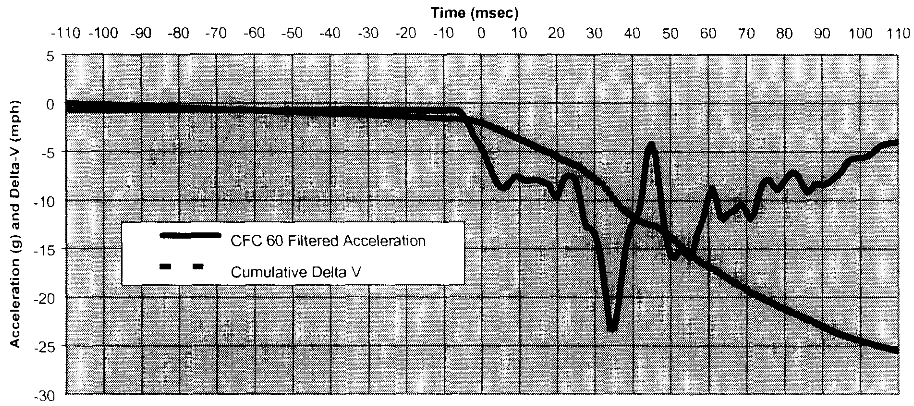
Investigator entered data:

Case No.	#1	Photos	No	Investigator	PG	Model Year	2000
VIN	195778			Invest. Date	4Jun99	Vehicle. Make/ Model	LM Sable 4dr

EDR Control module data:

		Data Validity Check	Valid	Deploy Attempt Made	YES
Read-Out Date	09-Jun-99	Time From Algorithm Wake-Up (0 msec) To Deploy Attempt (msec)			15
EDR Serial N	4107929028	Passenger Airbag Switch Position (On/ Off) During The Event			NA
Model-Version	ECS 2a				
Stored VIN	NA	Pretensioner		Side Air Bags Deployed	NA
Diagnostic Codes Active When Recorded Event Occurred:			None		

Longitudinal Crash Pulse Data



Cumulative Delta-V (mph) **Data Points**

Time (msec)	-100	-90	-80	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100	110
Delta-V (mph)	-0.2	-0.3	-0.5	-0.6	-0.8	-0.9	-1.1	-1.3	-1.4	-1.6	-2.0	-3.7	-5.5	-7.7	-12	-14	-17	-19	-21	-23	-24	-25

Notes: + Read-Out Date based on PC/ tool's internal calendar.
+ Features and data parameters that are 'Not Available' are noted as 'NA'
+ CFC 60 is Butterworth 4-Pole Phaseless Digital Filter, SAE J211/ Part 1 MAR95, Appendix C.
+ Total and maximum Delta-V results are not available from truncated/ incomplete crash pulses.
+ Algorithm Wake-up (0 msec) is not the first moment of vehicle contact or impact.

Figure 6. Mock up of Ford EDR Output.

3.3 Aftermarket Systems

3.3.1 Safety Intelligence Systems

Safety Intelligence Systems (SIS), formerly Loss Management Services, Inc. (LMS), has developed a state-of-the-art EDR as part of an end-to-end system solution for securely collecting, transmitting, storing, managing and reporting vehicular crash data. This EDR, called the MAC (Mobile Accident Camera) BOX system (See Figure 7), captures on-board diagnostic data and compressed digital video imagery of the events leading up to, during, and immediately following a vehicular crash. This provides an accurate, reliable, and unbiased "driver's eye view" of the entire incident. The MACBOX is a modular, all-digital, self-contained, and non-intrusive data center with flexibility for multiple applications. This technology is currently being refined through an ongoing collaboration with the Georgia Institute of Technology, partially funded by NHTSA.

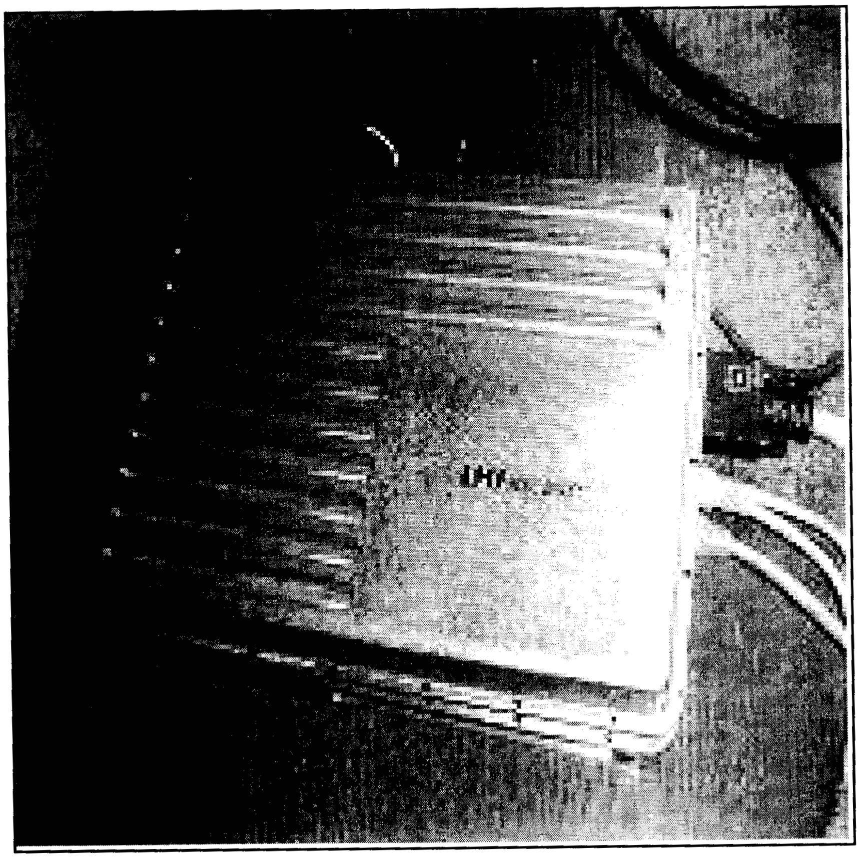


Figure 7. Safety Intelligence Systems EDR Unit.

Once collected, the crash data is encrypted (128-bit) and transmitted over a digital wireless network to a secure data vault. Safety Intelligence Systems has the U.S. and European exclusive patent on the wireless transmission of encrypted vehicular crash data, including video. Safety Intelligence Systems' solution will also include the ability to simultaneously notify the appropriate public safety answering points (PSAPs) and emergency medical services (EMS), as well as provide the necessary critical details of the crash and the likelihood of severe injury. The overall concept is shown in Figure 8.

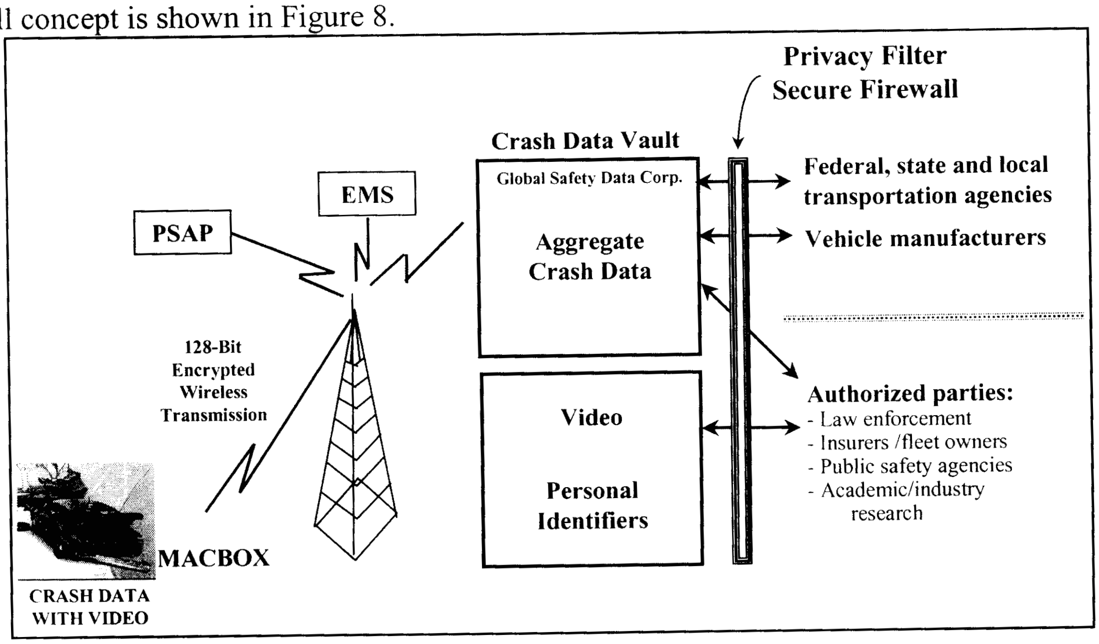


Figure 8. Safety Intelligence Systems Data Transmission, Collection, and Storage Concept.

To ensure all crash data is maintained in a private, secure and central location, Safety Intelligence System has formed a strategic partnership and joint venture with Insurance Services Office, Inc. (ISO), the trusted database of the property & casualty insurance industry and associated government agencies for over 100 years. This alliance created a separate entity, Global Safety Data Corporation, for the sole and exclusive purpose of providing a secure, private data vault to store and manage all vehicular crash data. This data vault will include the necessary privacy filters and security firewalls required to ensure that only authorized users have access to the crash data. The comprehensive Safety Intelligence Systems data vault complements the current data-gathering and analysis activities of existing federal and private databases.

Functional components of the system include the MACBOX with global positioning system (GPS) and digital video, wireless encryption and transmission systems, and a comprehensive, secure data vault to:

- Determine when and where a crash has occurred
- Capture, store, and lock crash data, including video images, after a crash
- Transmit encrypted crash data, including video images, to wireless networks
- Decode and download data to trusted, secure crash data vault

For additional details regarding products and services offered by Safety Intelligence Systems, please contact:

Safety Intelligence Systems, Inc; 790 Atlantic Drive, S-0355
Atlanta, GA 30332-0355
404-385-2551; rmartinez@safetyintelligence.com

3.3.2 VDO North America

The VDO UDS System registers the vehicle's speed, records transverse and longitudinal acceleration, and changes in direction at the rate of 500 times per second. In addition to recognizing the length of operation for ignition, brakes, indicators, and lights, the system can also record special functions such as the use of sirens and flashing lights on emergency vehicles. The UDS system is shown in Figure 9.

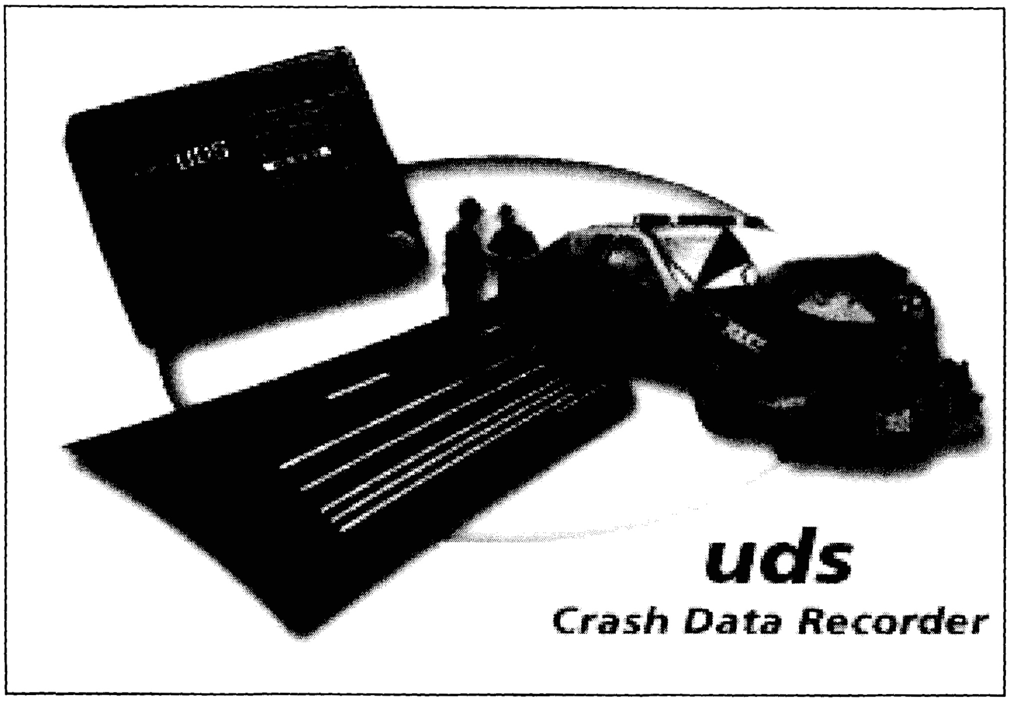


Figure 9. VDO UDS EDR System.

When the UDS is in operation, the data recording is continuous. In the event of a collision, the system automatically and permanently stores 45 seconds of data: 30 seconds before and 15 seconds after the crash. When a collision is recognized, the device emits a signal that can also be used in other applications such as signaling the vehicle's logistics system or incorporating in emergency signal management. See Figure 10 for UDS system layout.

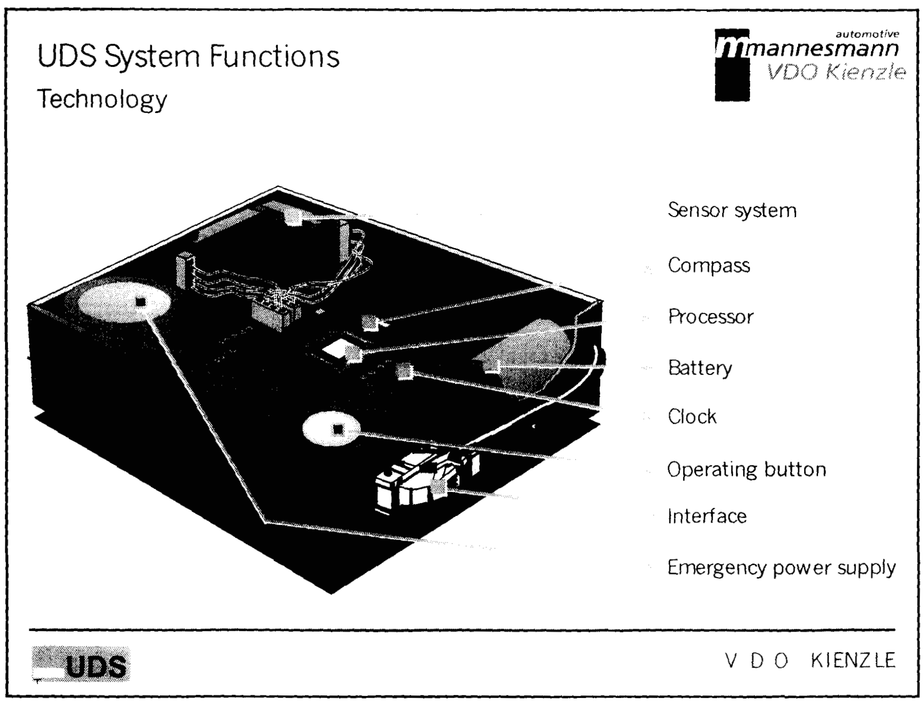


Figure 10. UDS System showing major Components.

Data storage can be manually activated in situations where the driver is not directly involved in a crash but wishes to record actions during or after the incident to counter any unjustified assertions of blame and questions of compensation. Manual storage can be triggered by switching on the hazard warnings or depressing a start button on the unit (24V version only). An external start unit is available if the UDS is not mounted in close proximity to the driver. Up to three separate 45-second events can be recorded.

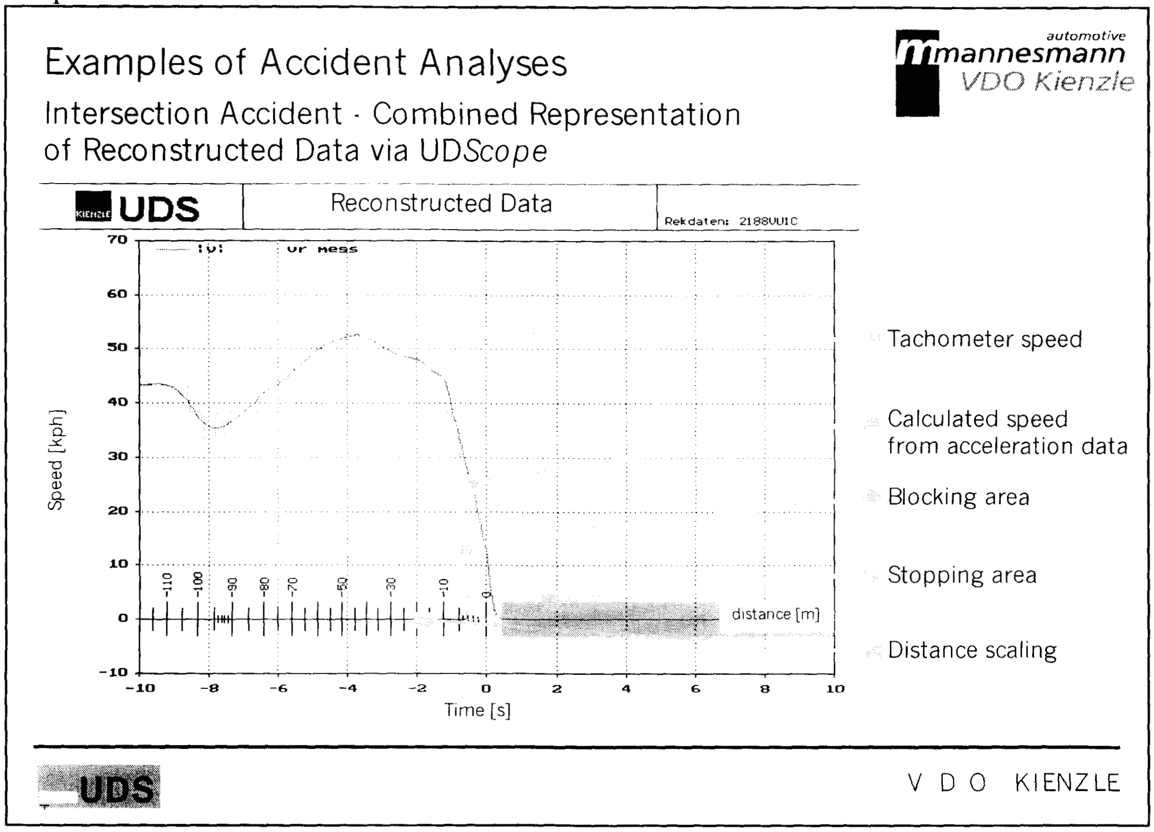


Figure 11. Sample Output from UDS EDR System.

UDS has three distinct operating modes: driving, parking, and sleep. When not in the "driving mode," the system goes into a "parking mode" a few seconds after the ignition has been turned off. It remains fully functional for a 24 hour period, after which, it automatically deactivates and goes into a "sleep mode" to protect the battery. The system becomes fully operational when the driver switches on the ignition. The unit signals the driver with an audible "beep" or dash-mounted lamp.

For additional details regarding this device, contact:
VDO North America; Fleet Systems; 188 Brooke Rd., Winchester, VA 22603(888) 373-4515; http://www.vdona.com/fleet/fleetudsframes.html

3.3.3 Drive Cam

DriveCam is designed to help fleet vehicle operators, researchers, and consumers improve safety and security by increasing the sophistication and effectiveness of identifying, diagnosing, apprehending, and reporting crash and road incidents. (see Figure 12)

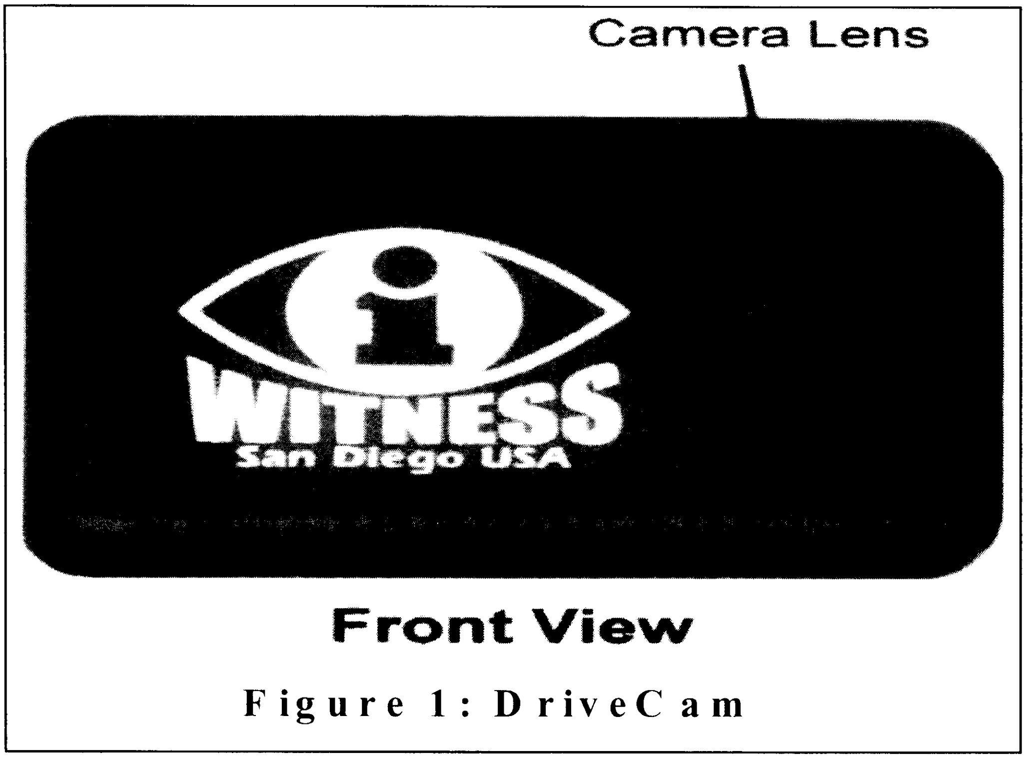


Figure 12. Drive Cam EDR Unit.

DriveCam was designed with the nontechnical person in mind. DriveCam puts the viewers in the driver's seat at the time of the crash or road rage event by recording everything the driver could see, hear, and feel in video, audio, and g-forces. The device is miniature (the size of a pager), inexpensive, very simple to install (less than 10 seconds), simple to operate, view and evaluate the data, tamper proof, and durable.

DriveCam continuously records exactly what the driver sees (in video), hears (in audio), and feels (in G-forces) in real time. When DriveCam is triggered, it records 10 seconds prior to, including, and 10 seconds after a crash. Being digital, the system has no moving parts, is maintenance free, and can be used repeatedly.

DriveCam has a very sensitive video camera that adjusts well in both daylight and at night. In addition, an internal lithium battery continues to provide power during recording if the main vehicle power is cut during the crash.

A green indicator light shows that the system is "armed" and operating correctly. After DriveCam has been triggered, the indicator light will turn red and begin blinking. Once DriveCam has recorded the event the light remains red. Manual triggering can be used to capture road rage, crashes involving other motorists, or car jacking by pressing the "panic button."

Installation is as simple as pressing DriveCam onto the windshield close to the rear view mirror. The plastic suction cups on DriveCam keep it firmly mounted. In fact, the complete unit can be installed or moved from car to car as easily as a radar-detector. For power, it plugs into the cigarette lighter power socket. Alternatively, the unit may also be wired directly into the vehicle's power.

The video, sound, and G-forces relating to the crash can then be replayed on a standard television or camcorder, which then can be recorded on videotape or a computer hard drive. Pressing the play, rewind, or forward buttons on DriveCam operates it like a VCR. An on screen display shows in real time the G-Force measurements experienced with audio and video in real time. (See Figure 13)

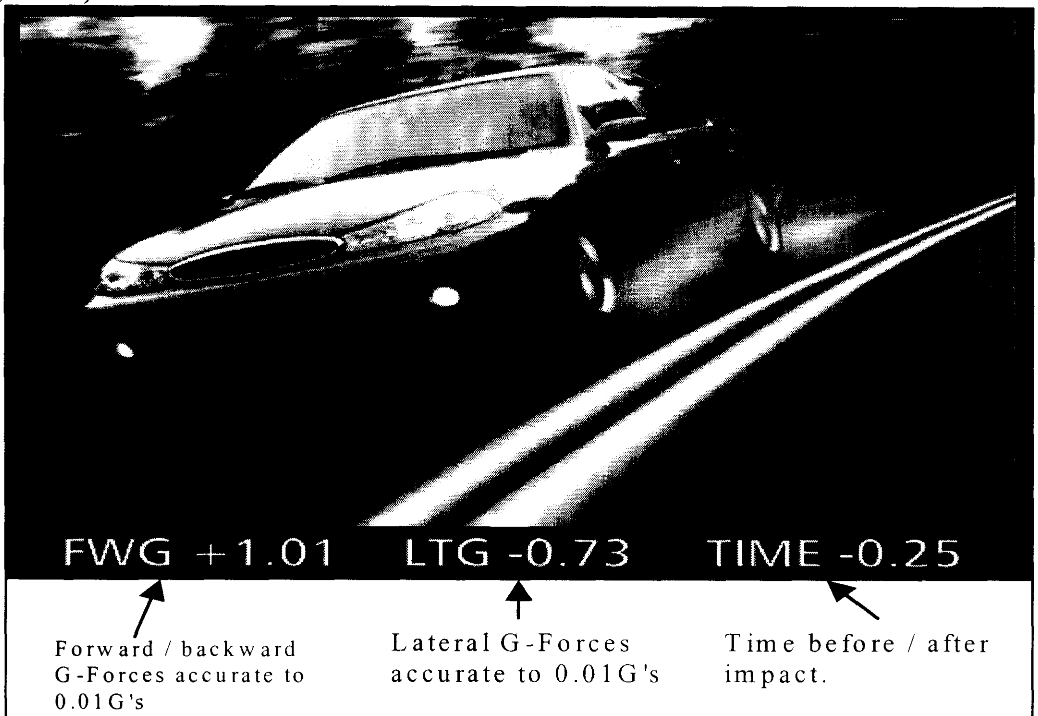


Figure 3: Onscreen Playback View of DriveCam Video EDR

Figure 13. Drive Cam EDR Output.

There are many benefits that EDR data will provide in the short and long term. These include: Researching collision data, providing more objective data for litigation, lower insurance premiums, promote and encourage conscientious driving, data to improve vehicle design internally and externally. DriveCam is currently developing a program that will be able to read EDR information from the several EDR software programs already in use and put them into a common readable format. This will greatly simplify databasing of crashes with a standard file format that will allow researchers around the world to download crash files over the Internet and view them with a familiar program. This software program is called Hindsight 20/20.

For more information:
DriveCam Video Systems; 9550-A Ridgehaven Court; San Diego CA 92123
Phone: 858-430-4000; Fax: 858-430-4001
www.drivecam.com

3.3.4 Independent Witness Incorporated

Independent Witness Incorporated (IWI) is a company dedicated to reducing the growing number of fraudulent and exaggerated insurance claims associated with low-impact collisions. IWI's proprietary technology monitors events that cause property damage to company vehicles, from rental cars to long haul semi-trucks and trailers. IWI's solution consists of two components: The Witness and the Accident Severity and Injury Potential Database (ASIP).

The Witness is a EDR specifically designed for cars, trucks, vans, buses, and trailers. The Witness monitors the vehicles motion and in the event of an impact it records the date, time, direction, impact severity (G-forces) and acceleration profiles. IWI has adopted SAE-J211 guidelines for collecting data. The data are stored in the Witness and can be accessed immediately for verification at the scene of a crash with a laptop computer or removed and downloaded at a desk. Upon extraction of the recorded data, the information is downloaded to IWI for cross-referencing in IWI's ASIP database. Once IWI's website is accessed, a full report can be immediately printed outlining the crash severity and injury potential details. (See Figure 14)

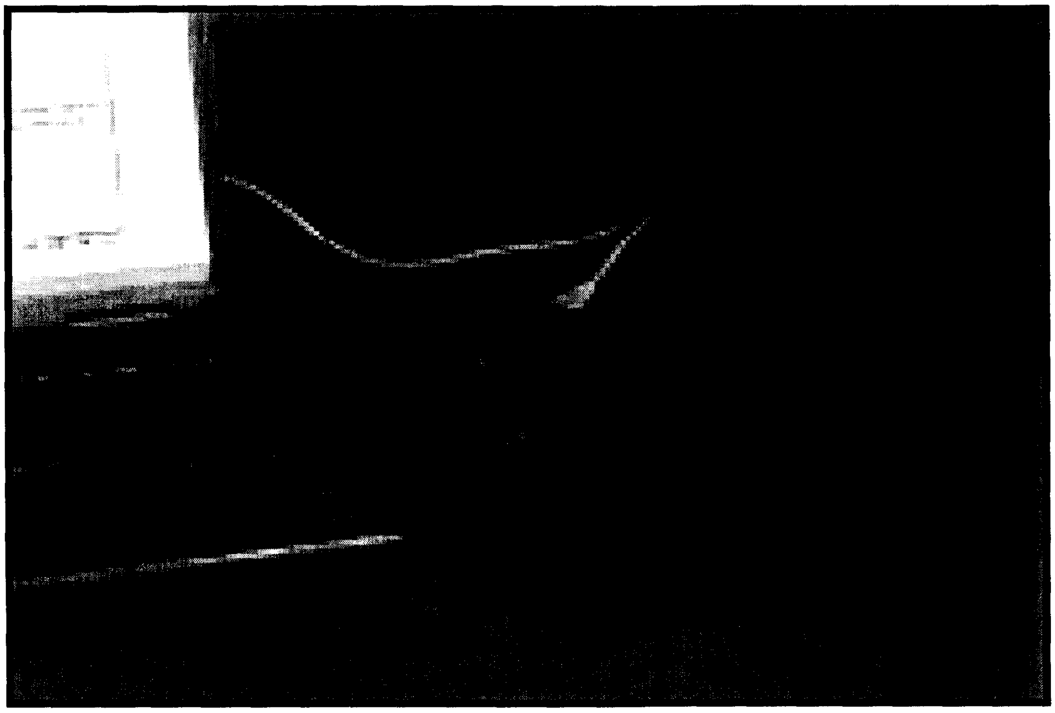


Figure 14. Independent Witness Incorporated 's EDR system

The ASIP database tracks EDR data from crashes recorded by the Witnesses installed in automobiles and trucks across the country. The information captured by The Witness is correlated with the injury claims, medical treatment, recovery time, pre-existing conditions, and other qualifiers (age, sex, occupation, hobbies, income, prior claims, etc.), creating a database capable of "objectively" predicting the probability of injury based on the forces involved in the crash. The database, based on real world data, will be used by claims adjusters, risk managers, and worker's compensation analysts to accurately and fairly assess the subjective injuries that result from a given crash. The ASIP will also correlate crash force with injury potential.

Contact information:
Independent Witness Incorporated; 1515 West 2200 South, Suite E; Salt Lake City, UT 84119(801) 983-0024; www.iwiwitness.com

3.3.5 Rowan University EDR/ACN System

Rowan University has developed and successfully demonstrated the Automated New Jersey Emergency Locator (ANJEL). Developed under the sponsorship of the New Jersey Department of Transportation, the system detects a crash, determines the location of the crash, and communicates the crash pulse and crash site location to an Emergency Response Base Station.

System Architecture. The system is composed of two major subsystems: (1) the Mobile Unit which is installed in the occupant compartment of the vehicle, and (2) the Base Station which is responsible for receiving distress calls from the Mobile Units and reporting their location to emergency response dispatch personnel. The Mobile unit, shown right, contains a two-axis silicon accelerometer, an embedded 8-channel GPS system, an embedded single chip microprocessor with an on-chip 10-bit ADC, and an embedded wireless modem. One axis of the twin silicon accelerometers is aligned to capture frontal-rear crashes while the second axis is aligned to detect side impacts. During operation, the onboard microprocessor continuously monitors the two accelerometers at a sampling frequency of 1 kHz. Upon detecting a collision, the microprocessor polls the GPS subsystem to determine the final resting position of the car. The microprocessor then uses its wireless modem to transmit both crash site location and the crash pulse to the Base Station. Ideally, the entire process, including linkup, will be completed within 30 seconds after the crash occurred – giving EMS personnel a crucial edge in rapidly reaching the crash victim. (See Figure 15)

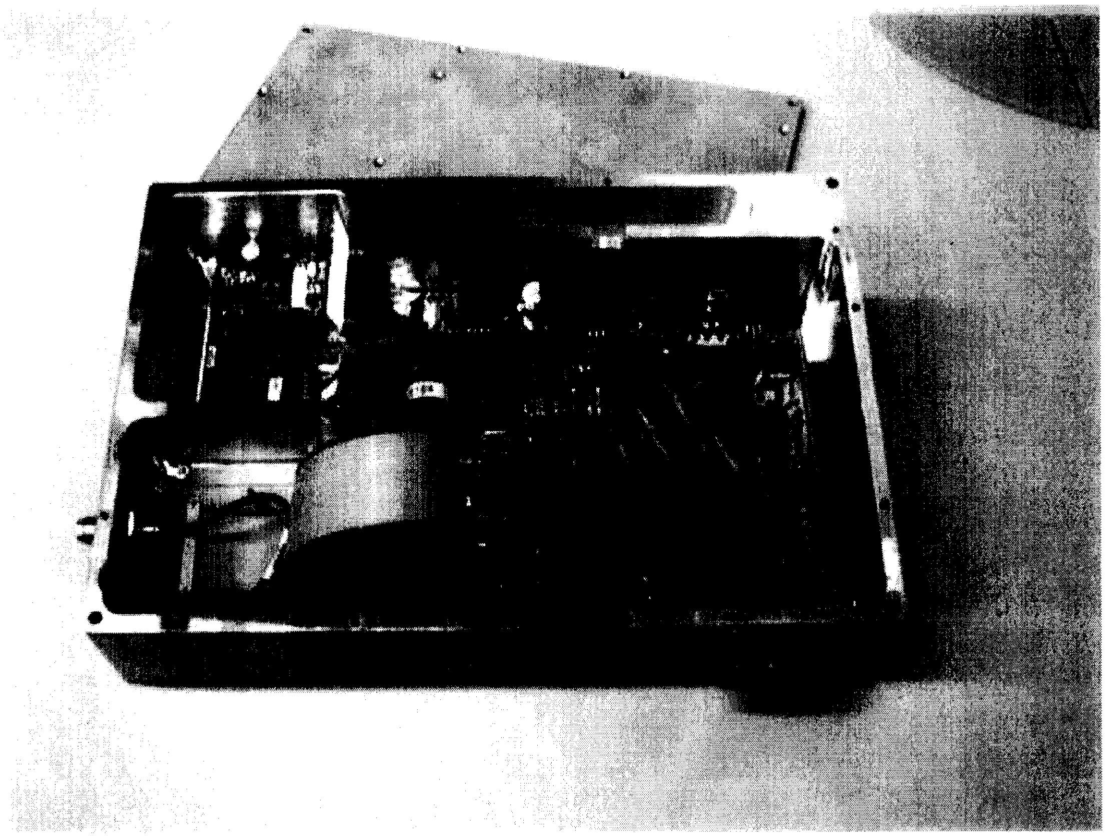


Figure 15. Rowan EDR

Crash Data Recording. A proprietary crash algorithm, a software module in the microprocessor, was developed to detect a crash while avoiding false alarms. Based upon analysis of NHTSA crash tests, coupled with crash test modeling, the algorithm is able to distinguish between actual crashes and low-severity crashes or non-crashes such as panic braking or backing into a shopping cart. The crash pulse along both axes is transmitted to the Base Station along with GPS coordinates. It should be noted that while inclusion of the crash pulse requires transmission of a longer message, the crash pulse can provide trauma teams with crucial early warning of the nature of the crash event. The crash pulse contains, for example, sufficient information to infer whether the car struck a tree or another car. Likewise, inclusion of crash severity for each axis also allows the Base Station to distinguish between frontal and potentially more serious side impacts.

Wireless Web Communication. The system uses Cellular Digital Packet Data (CDPD), sometimes referred to as a Wireless IP connection, to transmit data between the Mobile Unit and the Base Station. CDPD is a cutting edge wireless communications protocol that allows direct connection of remote devices to the Internet. The use of CDPD wireless web protocol avoids the dial-up delay and phone line contention issues inherent in circuit-switched ACN systems.

Power. Power for this system is provided by the car 12-volt electrical system. Note that this is the only interconnection between the Mobile Unit and the car. Power from the car battery is conditioned as necessary before input to the Mobile Unit electronics. In the event of power loss, backup power is provided by a small onboard battery.

Performance Testing. The Rowan research team has successfully demonstrated operation of ANJEL in on-road tracking tests and drop tower impact tests up to 10 Gs – with additional tests planned up to 30 G. The impact tests are designed to evaluate the survivability of the electronics to impact as well as testing the ability of the system to detect and report collisions of this magnitude.

For additional information, contact:
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Phone: 856-256-5346; Fax: 856-256-5241; Web: http://engineering.rowan.edu/~gabler

4.0 Data Elements

4.1 Overview

The working group developed a "top ten" list of data elements for storing in an EDR. This list was based on the input of many EDR users, not just the EDR manufacturer. The following provides the list along with some of the rationale for selecting each.

1. **Longitudinal and Lateral Acceleration and Principal Direction of Force (PDF)** - These data are used to define the crash pulse. They can be used to improve vehicle design and understand the interaction between the vehicle and what it's impacting. PDF can be derived from the two accelerometer signals and can be used to better assess the crash environment.

2. **Location of Crash** - This data is desired by the highway community to help understand the relationship between the roadside design and the vehicle crash outcome.

3. **Seat belt status by seating location** - These data will aid in understanding injury outcome, and generally improve the knowledge of seat belt performance.

4. **Number of occupants and location** - Because seat belts are often not worn, it is difficult to reconstruct where an occupant was seated prior to a crash, which may be instrumental to injury outcome. For ACN application, this could be used to improve emergency response.

5. **Pre-crash data** - Pre-crash data, such as steering wheel angle, brake use, vehicle speed, etc., will assist researchers to determine how drivers act just prior to a crash. This knowledge will can help manufacturers and the government establish intervention programs to eliminate crashes.

6. **Time of Crash** - The time of the crash is often unknown.

7. **Rollover sensor** - Many crashes involve rollover, and improved knowledge regarding how the vehicle rolled over (such as tripped vs. untripped) would be valuable in developing countermeasures.

8. **Yaw data** - Vehicle control is often related to the vehicle's yaw angle. Data relating crash outcome to yaw angle could be important in preventing single vehicle and other crashes.

9. **ABS, Traction control, Stability control information** - This information would help determine if these control devices were active during a crash. There is no method, other than EDR technology, to determine from a post crash investigation if these systems were active.

10. **Air Bag data, such as deactivation status, deployment time, stage of deployment, etc.** - These data can not be determined after a crash, and since they are critical safety systems, knowledge of their operation during a crash in critical, and EDR technology is the only method to obtain these data.

4.2 Data Element Lists

The WG developed a detailed list of data parameters which could be considered for recording in an EDR.

Data Element List	
#	Description
1	2 vs. 4 Wheel Drive
2	Active Suspension Measurements
3	Advanced Systems
4	Air Bag(s) Deploy Time (Time from Start of Crash to Start of Air Bag Inflation)
5	Air Bag(s) Status
6	Air Bag(s) Lamp Status
7	Air Bag(s) On/Off Switch Position (Suppression System Status)
8	Auto Distance Control
9	Auto Collision System
10	Automatic Collision Notification
11	Battery System Voltage
12	Belt Status - Each Passenger
13	Brake Effort - Service
14	Brake Pressure
15	Brake Status - ABS
16	Brake Stop Lamp Status
17	Clutch Status
18	Collision Avoidance, Braking, Steering, Etc.
19	Crash Pulse - Longitudinal
20	Crash Pulse - Lateral
21	Cruise Control Active
22	Child Safety Seat Presence Indicator
23	Delta-V - Longitudinal
24	Delta-V – Lateral
25	Digital Imaging
26	Door Ajar Switch On
27	Door Lock State
28	Electronic Compass Heading
29	Electric Steering Functional
30	Engine Throttle Status
31	Engine RPM
32	Environment - Ice
33	Environment - Wet
34	Environment - Inside Temperature
35	Environment - Outside Temperature
36	Environment - Lumination
37	Environment - Other
38	Exhaust Brake Status
39	Fuel Level
40	Ignition Cycle Counter
41	Lamp Status (Headlight and Tail Lamps On/Off)
42	Lateral Acceleration Just Prior to Crash Longitudinal Acceleration Just Prior to Crash
43	Location - GPS Data

44	Number of Occupants
45	Occupant Weight Sensor - Front Passenger
46	Pre-Tensioners
47	Phone Status
48	Principal Direction of Force
49	Roll Angle
50	Roll Rate
51	Rollover (# 1/4 turns)
52	Seat Position - Driver
53	Service Engine Soon Lamp On
54	Service Vehicle Soon Lamp On
55	Stability Control
56	Steering Wheel Angle
57	Steering Wheel Tilt Position
58	Steering Wheel Rate
59	Stop Lamps Status - School Bus
60	Trailer Status
61	Throttle Position
62	Throttle-by-Wire
63	Time/Date
64	Tire Pressure Warning Lamp On
65	Traction Control
66	Traction Coefficient (Estimated from ABS Computer)
67	Transmission Selection (PRNDL Position)
68	Turn Signal Operation
69	Vehicle Mileage
70	Vehicle Speed
71	VIN
72	Wheel Speeds
73	Windshield Wiper Status
74	Yaw Rate

During the process of reviewing the data elements and top ten list, the working group developed the following categories of data elements:

Data Element Categories
Restraint system usage (air bag, belts, other)
Crash Pulse (delta v, deceleration, angular rates)
Vehicle/EDR ID
Speed
Driver Controls (Brakes, accel. etc)
Location
ACN (time, date, location, number occupants)
Environmental Conditions

4.3 EDR Parameters Important to Highway Safety Research

4.3.1 Federal Highway Data Element List

- Vehicle Speed
- Brake Switch Status

- Throttle Opening (Percent)
- Steering Wheel Input
- Location of Crash (GPS Data)
- Longitudinal Velocity Change vs. Time
- Longitudinal Acceleration vs. Time
- Occupant and Driver Belt Status
- Occupant Seating Positions
- Time of Day

4.3.2 Transportation Research Board Data List

- Speed & Speed Profile
- Steering Inputs
- Braking Inputs
- Throttle Settings/Accelerator Inputs
- Location (GPS)
- Time
- Pavement Friction
- Wheel Rotation
- Seat Belt Usage
- Yaw/Pitch/Roll Measures
- Impact Velocity
- Occupant/Load Distribution
- Suspension Pulse History
- Crush Zone History
- Driver Condition
- Vehicle Id/Equipment Status

4.4 Haddon Matrix

NHTSA's first Administrator developed a 3x3 matrix which combined the crash and other related characteristics which affect the crash, namely the human, vehicle, and environment. This matrix can be used to demonstrate the effectiveness of an EDR in understanding a crash. The current understanding of a crash, without EDRs, is shown as follows:

	Human	**Vehicle**	**Environment**
Pre-Crash			
Crash			
Post-Crash	Injury	Crash	Environment after crash

As can be seen, all information related to the "pre-crash" and "crash" phases of a crash need to be determined by the crash investigator. Investigators utilize specific tools (from measuring crash scene evidence to crash reconstruction computer code) and rely on their experience as a professional investigator to determine these data. For vehicle crashes where the vehicle is equipped with a futuristic EDR, the Haddon Matrix would look as follows:

	Human	Vehicle	Environment
Pre-Crash	Belts Steering Braking	Speed ABS Other Controls	Conditions at the time of the Crash
Crash	Air Bag Data Pre-Tensioners	Actual Crash Pulse Actual Delta -V Vehicle Dynamics Air Bag Deployment time	Location
Post-Crash	Injury	Crash	Environment after crash

4.5 Potential Method for Classifying EDRs

A method for classifying EDRs was proposed that would categorize EDRs into two major types: Type II and I. Type I EDRs would use a minimal, but essential set of data elements. For example, Type I elements could include: time, location, direction of impact, velocity, occupants, seat belt usage, and crash pulse characteristics. Type II EDRs would evolve with emerging technologies and may include appropriate data elements that target specific vehicle types. In particular, the data gathered by Type II EDRs might provide additional information on crash, behavioral, demographic, vehicle safety, and roadway characteristics that would assist highway safety research and development efforts.

5.0 Data Retrieval

5.1 Overview

There are several issues associated with data retrieval (the process of extracting information from the EDR). The WG felt one of the main issues is that most OEMs have not offered tools to the public for retrieving EDR data. Recently, GM developed, through the Vetronix Corporation, a tool which would allow the public to download EDR data directly from many newer GM vehicles. Ford indicated to the WG that it did not have such a publicly available tool, but does have an engineering tool which they use to retrieve data from the airbag sensor. Ford envisions a common public tool for the future.

Today, hard wire connections are the most typical way to retrieve data from a vehicle. Wireless uplinks may be a common application for collecting EDR data in the near future. These systems may be stand-alone links or become part of an ACN system, which automatically relays the crash data stored in the EDR to a storage facility. SIS' MACBOX offers such a transmission and downloading procedure, where data are encrypted and transferred via a digital wireless network.

Aftermarket companies have included data retrieval as part of the overall design of their systems. Some systems are more complicated than others, but all have methodologies available to their customers to allow downloading data.

Truck EDR retrieval systems are being discussed by The Maintenance Council (TMC), part of the American Truck Associations (ATA). They have a recommended practice for interfacing the PCs with the vehicle's engine computer. Several truck engine manufacturers are currently offering various options of EDRs.

Downloading EDR data may require that the users be certified. The working group felt training would be beneficial, and noted that Vetronix Corp., was offering training for its CDR system. The WG also discussed fraud, but did not have any data to report that were related to this issue.

The WG discussed the benefits related to retrieval, the use of flight data recorders in the airline industry, and the need for SAE, or another professional organization, to assist the EDR industry in the area of data definitions and EDR standards.

5.2 Review of Issues Related to Data Retrieval

The working group developed a series of issues related to data retrieval. These included:

Issues Related to Data Retrieval	
Central data source must be robust	• Submersion, fire, or other disruptive possibilities
	• Must survive the crash.
Power source	• May not be any power in vehicle for retrieval
	• Crash damage may effect operation of computer data BUS
Wired EDRs vs. wireless EDR installations	
Reliability	
Size of the data collection equipment	
Information collected in various modules	

Protection of the data from fraud	
Access	• Plug into a central BUS • Connection to individual EDR (many of these are on the market and all have different interface technology. Also, crash damage may require connection directly to the individual EDR box)
Recording singular events vs. multiple events.	
Memory	• Manufacturers record data for different lengths of time. • Memory map could be standardized, additionally, other items could be standardized, including: what is recorded, format for recording, connector for retrieval, download tool for retrieval
Validity and accuracy of translation - WG felt that the technician downloading the data should always provide the "raw" data from the download, for example "hex dump."	
Standardization of interface protocol.	
Interpretation of data collected related to damage of vehicle.	

5.3 Vetronix Data Retrieval System

In March of 2000, Vetronix Corporation began selling its Crash Data Retrieval (CDR) system. The CDR system (See Figure 16) is the first and only tool available to the public that allows users to download data from the event data recorders installed on passenger and light-duty vehicles.

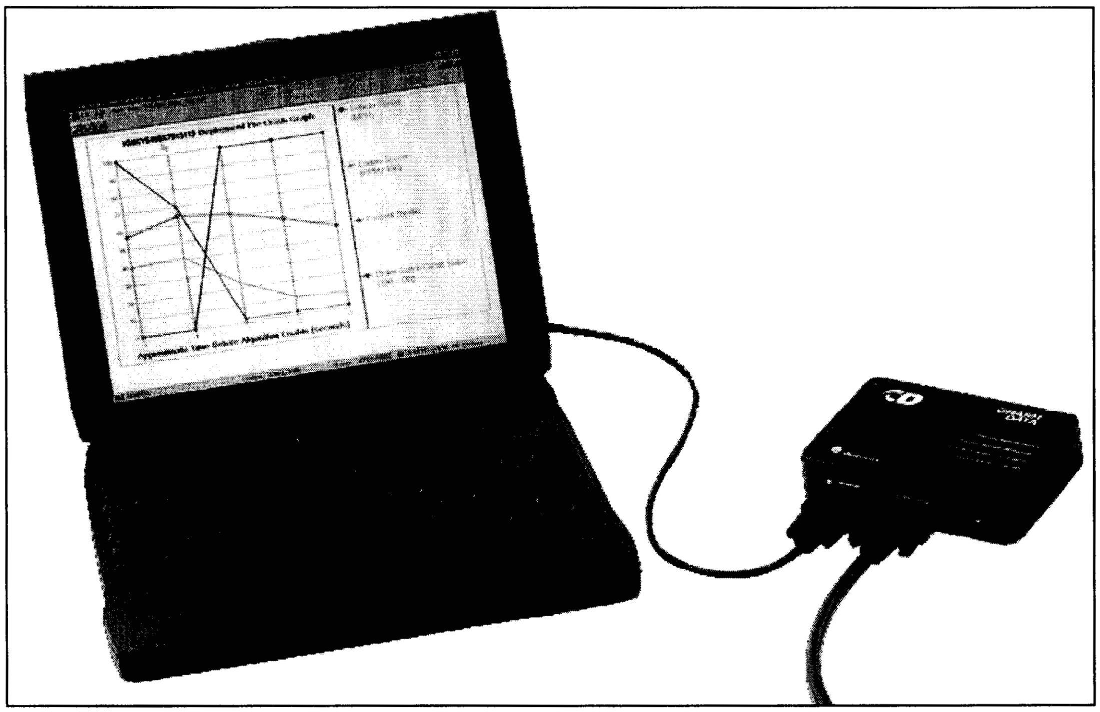

Figure 16. Vetronix EDR Data Retrieval System.

Currently, Vetronix has agreements with GM and Ford to write software that allows users to download hexadecimal data from their EDRs. The Windows® based CDR software then converts this data into easy-to-read graphs and tables.

Vetronix has designed its hardware in anticipation that other vehicle manufacturers will come on board. To support a new vehicle manufacturer, only a software and cable update is necessary.

The CDR system allows users to connect directly to the vehicle's diagnostic link connector (DLC), typically located below the steering wheel, or directly to the EDR in cases where the vehicle's electrical system has been damaged during a crash.

The CDR system is currently used by over thirty different law enforcement agencies (in the U.S. and Canada), NHTSA, GM, Ford, IIHS, insurance companies, and private crash reconstructionists.

Beginning in fall 2001, federal grant money is available through NHTSA for law enforcement agencies to purchase the Vetronix CDR system. For more information, the appropriate regional NHTSA office (www.nhtsa.dot.gov) should be contacted.

The CDR system costs $2,495. For further information regarding this tool, contact:

Vetronix Corporation
2030 Alameda Padre Serra; Santa Barbara, CA 93103
(800) 321-4889; (805) 966-2000; (805) 965-3497 Fax
www.vetronix.com

5.4 Other Data Retrieval Tools

Aftermarket manufacturers of EDR technology include retrieval methodology as part of their product. Typically, the retrieval system is included as part of the system, or the output is in an industry accepted standard, such as standard formatted video output. The following presents some examples of these aftermarket strategies for data retrieval:

SIS: With the SIS MACBOX, encrypted crash data are transmitted over a digital wireless network, then decoded and downloaded to a secure data storage facility. Manual downloading directly from the vehicle, by appropriate entities with authority to view the data, could also be done if a transmission failure occurs.

DriveCam: The video, sound, and G-forces relating to the crash are played on a standard television or camcorder and can be recorded on videotape or a computer hard drive. Pressing the play, rewind, or forward buttons on DriveCam operates it like a VCR. An on screen display shows in real time the G-Force measurements experienced with audio and video in real time.

IWI: The data are stored in the Witness and can be accessed immediately for verification at the scene of an collision with a laptop computer, using IWI interface products. Upon extraction of the recorded data, the information is downloaded to IWI via the Internet. Once IWI's website is accessed, a full report can be immediately printed outlining the crash severity and injury potential details.

5.5 Data Retrieval at NHTSA

NHTSA began collecting crash data from EDRs in the mid 1990s. The early efforts involved cooperation between the NHTSA and the automobile manufacturers. Data was typically collected by NHTSA's Special Crash Investigation (SCI) program to support crash investigation activities. Two methods were employed -- the boxes were removed by the agency and sent to the manufacturer for downloading or the manufacturer sent a representative to the crashed vehicle to directly read the data. The process still continues today for some manufacturers.

During the late 1990s General Motors licensed to Vetronix the right to manufacture and sell EDR download tools which could interface with GM motor vehicles. In 2000, NHTSA equipped the crash investigation teams with these tools: including the SCI teams, the Crash Injury Research and Engineering Network (CIREN) crash investigation teams, and the NASS Crashworthiness Data System crash investigation teams. The teams were trained on proper use of these tools, and have begun collection of EDR data on a routine basis. To date, the NHTSA crash investigation teams have investigated nearly 100 crashes where an EDR was read.

6.0 Data Collection and Storage

6.1 Overview

Data collection and storage is the least developed area related to EDRs. Most organizations have developed collection and storage systems/databases to suit the need for their own programs. Until recently, there was no national effort to collect and store EDR crash data. About a year ago, NHTSA modified its national data bases, SCI, CIREN, and NASS-CDS, so they could capture EDR data retrieved in a crash investigation.

The working group also discussed evidence and traceability issues related to collection and storage. Manufacturers stated that they needed to know where the data originates.

The group considered how different users affect collection and storage. That is, federal collection would make the data public (with in the constraints of the current privacy laws) while insurance companies may want to keep data they collect private.

6.2 Data Collection and Storage Activities

Several aftermarket and OEM companies have been collecting EDR data. Aftermarket companies tend to collect data for their clients, while OEM companies collect EDR data for internal engineering analyses required to improve occupant safety. NHTSA, FHWA, FMCSA, and some states collect data for use in setting public policy, regulating commercial vehicle operations, and also makes the data public through its public sharing process.

Some aftermarket companies are providing collection and storage as part of the service for their clients. IWI collects and stores data from many customers into a common data base.

7.0 Permanent Record

7.1 Overview

Currently, there are many companies storing data for their corporate purposes, but typically these data are confidential and cannot be accessed by the public. NHTSA recently starting using its NASS-CDS, SCI, and CIREN databases as the first publicly accessible permanent records where EDR data are stored. Because of the time lag to get cases in the NHTSA databases, they're only a few cases public, but more will become public in the near future.

Since the use of EDR data is still in its early stages of development, it will be some time before large databases populated with EDR data exist. Generally, the database needs to have a function beyond that of storing EDR data, hence, the early EDR databases will be added onto other currently-existing databases, such as NASS-CDS. Specialty databases, created for the sole collection of EDR data will gain popularity as EDR data collection become more automated.

The working group believes there is a need for a central repository for EDR data. The Federal role is limited, since NHTSA only collects data on crashes related to its internal crash data collection programs. Additional efforts will be required to explore the possibility of a National EDR database.

7.2 Examples of EDR Data

NHTSA: As discussed above, NHTSA collects crash data in three major vehicle crash programs: **NASS-CDS** – a national statistically sampled data base, currently collecting data on about 4,000 crashes each year at 24 locations around the U.S.; **CIREN** – a system of crash investigations conducted at hospitals, collecting about 400 cases per year; and **SCI** – a collection of targeted crash investigations looking at emerging safety issues. While a few SCI cases had been collected in previous years, it was not until 2000 that these groups started collecting and entering EDR data into their associated databases. Each database has been modified to contain a field which indicates if the case has an associated EDR file. This data element is part of the searchable electronic file associated with the database. Since the data collected by various EDR manufacturers is not uniform, NHTSA has chosen not to attempt to store the output in the electronic file. Rather, NHTSA has implemented a policy which enters a electronic image of the EDR output into the file. This allows the researcher to review the various data elements (for example: DV for GM vehicles vs. acceleration profiles for Ford vehicles).

SIS: SIS, the developers of the MACBOX, in a strategic partnership with Insurance Services Office, Inc., have created a separate entity, Global Safety Data Corporation, for the sole and exclusive purpose of providing a secure, private data vault to store and manage all the EDR data. This data vault will include the necessary privacy filters and security firewalls required to ensure that only authorized users have access to the crash data.

IWI: IWI maintains a database (Accident Severity and Injury Potential {ASIP}) which tracks EDR data from the crashes recorded by their EDR systems installed in vehicles in various parts of the country. The information is correlated with the injury claims, medical treatment, recovery time, pre-existing conditions, and other qualifiers (age, sex, occupation, hobbies, income, prior claims, etc.), creating a database capable of "objectively" predicting the probability of injury based on the forces involved in the collision. The database, based on real world data, will be used by claims adjusters, risk managers, and worker's compensation analysts to accurately and fairly assess the subjective injuries that result from a given crash. The ASIP will also correlate crash force with injury potential.

DriveCam: DriveCam is currently developing a program that will be able to read EDR information from the several EDR software programs already in use and put them into a common readable format. This will greatly simplify databasing of crashes with a standard file format that will allow researchers around the world to download crash files over the Internet and view them with a one familiar program. This software program is called Hindsight 20/20.

States: States may have a role in developing permanent databases for EDR data. State agencies, such as police and crash investigators, will soon begin to use EDR data as part of their crash investigation process. As they do, these data could become available at the state level for storage. These data could be transferred to the federal government along with other state data currently shared between the states and NHTSA, hence becoming part of the NHTSA permanent record associated with the Fatality Analysis Reporting System (FARS) and electronic state data files. Currently state data are reported using electronic formats, so the EDR data would need to be converted from the paper output, currently generated, to an electronic format compatible with the state files.

8.0 Privacy and Legal Issues

8.1 Overview

The issues of ownership of information collected by an EDR and the effect on the privacy rights of individuals involved in the recorded events will need to be further explored with the development of the technology. The following discussions may have application to many types of transportation recordings, but the focus of this working group was the privacy and legal issues associated with recording data for a very short time period (for example, less than a minute during a crash), and with the capture of the data on the vehicle, not automatic transmission of the data to a PSAP or other service provider. Since these topics cannot always be disconnected, some overlaps in the discussions occur.

The fundamental issue is the need for information collected from an EDR to increase safety yet protects the privacy of individuals affected by the information collected from an EDR.

In April 2000, the NTSB sponsored an international symposium regarding legal and privacy issues related to transportation recorders. While considering mostly aviation, pipeline, sea, rail, and commercial highway vehicles with very little emphasis on noncommercial highway vehicles (such as automobiles), "Transportation Safety and the Law," offered expert opinions from leaders in the area of recorders. With a theme of improving transportation safety and the use of available information in the 21st Century, the symposium addressed such items as: 1) How can the generation of data and information enhance transportation safety? 2) What are the implications of government investigations and private litigation for information development? 3) What is the proper governmental approach to encourage the availability of data for legitimate uses? The proceedings from the symposium can be viewed in their entirety at: http://www.ntsb.gov/events/2000/symp_legal/default.htm

8.2 Federal Law

8.2.1 Privacy Act

The Privacy Act of 1974, 5 U.S.C. §552a (the Act) provides that no federal agency shall disclose any of its records which are contained in a system of records by any means of communication to any person, or to another agency, except pursuant to a written request by, or with the prior written consent of, the individual to whom the record pertains, unless disclosure of the record would be pursuant to one of the exceptions outlined in section (b) of the Act.

The purpose of the Act is to balance the government's need to maintain information about individuals with the right of individuals to be protected against unwarranted invasions of their privacy stemming from federal agencies' collection, maintenance, use, and disclosure of personal information about them. The Act focuses on four basic policy objectives:

- To restrict disclosure of personally identifiable records maintained by agencies.
- To grant individuals increased rights of access to agency records maintained on themselves.
- To grant individuals the right to seek amendment of agency records maintained on themselves upon a showing that the records are not accurate, relevant, timely or complete.
- To establish a code of "fair information practices" which requires agencies to comply with statutory norms for collection, maintenance, and dissemination of records.

8.2.2 Other Statutory Authority for NHTSA Data Collection

NHTSA is authorized by Congress (15 U.S.C. §1395, 1401 and 23 U.S.C. §403) to collect statistical data on motor vehicle traffic crashes to aid in the development, implementation and evaluation of motor vehicle and highway safety countermeasures. This also prohibits the disclosure of personal information that the agency would receive as a result of crash investigations.

Exemption 6 of the Freedom of Information Act, 5 U.S.C. §552(b)(6) prohibits disclosure of personal information received by the agency that, if disclosed, would constitute a clearly unwarranted invasion of personal privacy.

8.2.3 Federal Court Decisions

Since the EDR technology is in the developmental stages, there is no case law available in this area of law. The most recent case that relates to EDR technology involves the Diagnostic and Energy Reserve Module (DERM), which was described by an engineer with General Motors as "like an airplane 'black box.'" In this case, the Plaintiff sued General Motors alleging that the airbag deployed after rather than during a low-speed collision, resulting in injury to plaintiff. Although this case was decided on procedural grounds, the engineer for General Motors submitted an affidavit stating that he had downloaded data from the DERM and concluded that the DERM data from the vehicle suggests that the supplemental restraint system functioned as designed by deploying during the plaintiff's crash. *See*, Harris v. General Motors Corporation, 201 F.3d 800, 804 (6^{th} Cir. 2000).

There are other cases that mention "black boxes," but these cases describe the role of the "black box" as evidence in the case. *See*, In re Korean Airlines Disaster of September 1, 1983, 156 F.R.D. 18 (D.C. Cir. 1994)(where the release and analysis of the flight data recorder were evaluated and determined to be newly discovered evidence); Sundstrom v. McDonnell Douglas Corp., 816 F.Supp. 587 (N.D. Cal. 1993)(wrongful death suit where the seat data recorder in USAF planes was alleged to be a defective design, manufacture and assembly); In re Air Crash Disaster at Sioux City, Iowa, on July 19, 1999, 131 F.R.D. 127 (N.D. I11. 1990)(the court held a flight simulator was not needed where sufficient evidence was available using the flight data recorder and the cockpit voice recorder).

8.3 Who Owns the Data

This section presents the views of several of the WG participants.

8.3.1 Position of the National Highway Traffic Safety Administration

It is NHTSA's position that the owner of the subject vehicle owns the data from the EDR. In order to gain access to the data NHTSA must obtain a release for the data from the owner of the vehicle. In crash investigations conducted by NHTSA, the agency assures the owner that all of NHTSA's personal identifiable information will be held confidential pursuant to the Privacy Act (5 U.S.C. § 552a) and other statutory authorities which limit disclosure of personal information. Any information derived from the crash investigation, including an EDR, that would lead to personal identifiable information may not be disclosed pursuant to the Privacy Act.

8.3.2 Position of the Federal Highway Administration

According to the Federal Highway Administration's Office of Chief Counsel, vehicles are sold to consumers without any vestigial interests retained by the manufacturers. If the EDR is treated in this way, however, the vehicle owner would presumably own the data as well. This would hamper the ability of public authorities to access the data by requiring permission from the owner. In addition to the obvious practical difficulties of obtaining permission at the crash scene, the owner would also presumably retain the ability to withhold the data if he felt this would serve his self interest.

A further level of complexity occurs when a supplier, rather than the motor vehicle manufacturer, retains ownership of the data. In Europe, for example, the suppliers essentially control access to the data by utilizing proprietary protocols that prevent anyone else from accessing the data, though they do report the results of the data extraction.

The problems related to ownership might be resolved by some sort of retention of ownership by manufacturer, by a contractual retention of rights to access the data (perhaps similar to an easement in real property), by a provision in state motor vehicle licensing laws, or by some other federal regulation that permits public authorities to access the data regardless of ownership.

8.3.3 Position of Insurance Companies

Many insurance companies have not explored the legal obligation concerning the EDR. For example, one insurance company advised NHTSA it has looked into the technology, but has not looked into any ownership issues. Another insurance company advised that it has not explored the issue of ownership extensively, but concluded summarily that if the insurance company gains ownership of the vehicle, it then owns the EDR data.

The complications develop when ownership of the vehicle does not get transferred to the insurance company. The insurance industry believes an argument can be made that the existing standard policy language may allow the insurance company access to data from the EDR. For example, the standard Insurance Services Office, Inc. formatted Personal Auto Insurance Policy Agreement states that the owner "authorize[s] us to obtain . . . other pertinent records." The phrase "other pertinent records" may include the data from the EDR.

8.3.4 Position of Volkswagen

Federal and in many instances state law, with certain exceptions, prohibit the disclosure of any document to any person or another agency except with the written consent of the person to whom the record pertains. The purposes of these statutes are to protect the individual against infringing upon his or her rights to privacy as agencies embark upon data collections for multiple purposes. Certain private businesses are similarly regulated by federal and/or state law, i.e., the credit reporting industry.

The extent to which a vehicle owner has a right to privacy regarding EDR data depends in Volkswagen's view on whether or not the data identifies the individual person or event, or whether or not the individual person is deemed to have given his or her consent to the use of the data in the manner proposed.

It is Volkswagen's position that irrespective of how any particular data relating to the crash is proposed to be used, if it permits identification of the individual person tied to the accident, that person should be advised of its proposed collection and use regardless of whether or not the law requires it.

8.3.5 Position of General Motors

The risk of private citizens reacting negatively to the "monitoring" function of the EDR can be diffused through honest and open communications to customers through owners' manuals by telling them such information is recorded. The acceptance of recording this data is more likely if the "monitored" data is used to improve the product or improving the general cause of public safety.

8.3.6 Position of Safety Intelligence Systems, Corp, Lindenhurst, New York

Vehicular EDRs must be developed to improve transportation safety by utilizing all 21st century information technology available. The goal is to improve highway safety while protecting the privacy of the individuals affected by the information collected. Crash data assembly has the potential for great public safety benefit but the data must be separated from personal identifiers.

Administrative structures presently exist to collect aggregate crash data without personal information being revealed. Examples include government agencies (highway safety research), auto manufacturers (improving design and safety) and insurance companies (maintaining underwriting records). In some research studies utilizing EDRs in vehicles, the confidentiality of the owners and operators is protected by having numbers assigned to the individual test vehicles rather than the owners' name. Accordingly, the cumulative data assembled can be studied without identifying the names of the owners and operators involved.

With regard to EDR data, there must be a secure and private data vault to store and manage all aggregate vehicular crash data. This data vault must include the necessary privacy filters and security firewalls required to ensure that only authorized users have access to the crash data. This data vault would complement the current data gathering and analysis activities of existing federal and private databases. The cumulative data stored in the security vault could then be made available to the public, government agencies, auto manufacturers, insurance companies, and other authorized entities as needed.

8.3.7 Position of Susan Walker, Esq., Kanouse & Walker, Florida

A possible legal model for the legal implementation of EDR technology would retain all rights with the owner of the motor vehicle. The decisions as to whether to install aftermarket EDR technology and use the data would be vested with the owner of the vehicle.

She envisions the data would be collected in hardware located in the motor vehicle and then be wirelessly transmitted in an encrypted and encoded format to a central data repository. The transmission of the data would occur on a regular basis and contemporaneously with an event. No data would remain in the vehicle after an event. The central repository would be an independent agency which has yet been determined.

The data generated would be identified by the VIN, which is given to all vehicles. The personal identity of the owner would remain confidential, unless permission was given by the owner of the information to use such data.

The central repository would be free to use the cumulative form of any data, which could be available to the public, car manufacturers, insurance companies and others. The personal information would be treated as "privileged" information, a concept similar to the patient/doctor privilege. The privilege may be "waived" by its owner, and when the privilege is waived the information may be released.

In civil court proceedings (which include individuals seeking monetary damages), the privilege could be absolute or qualified. In criminal court proceedings, (which involves the state seeking criminal sanctions against an individual), the data would be protected and the individual would be afforded the constitutional protections of the Fifth Amendment right against self-incrimination, so too, the Fourth Amendment rights of the individual against unreasonable search and seizure would be afforded as to the collection of data.

The delicate balance between the need to save lives by obtaining and prudently using critical data and the need to respect the expectations of privacy, constitutional safeguards, and due process, must be preserved. The model envisions that personal choices be preserved for the owner of the vehicle.

8.3.8 Position of Thomas Michael Kowalick, Click, Inc, North Carolina

Mr. Kowalick advised that all data collected and stored should make use of data security technology and audit procedures appropriate to the sensitivity of the information. EDR technology data storage should include protocols that call for the purging of individual identifier information respectful of the individual's interest in privacy. Information collected should be relevant to the purpose and a mission statement associated with the EDR disclosure statement.

Privacy is an important issue regarding the success or failure of implementing the EDR. Individual motorists and occupants have an explicit right to privacy. Although this right to privacy is not explicitly granted in the Constitution, it has been recognized that individual privacy is a basic prerequisite for the functioning of a democratic society. Indeed an individual's sense of freedom and identity depends a great deal on governmental respect for privacy. Therefore all efforts associated with introducing future EDR technologies must recognize and respect the individual's interests in privacy and information use. Thus, it is imperative to respect the individual's expectation of privacy and the opportunity to express choice. This requires disclosure and the opportunity for individuals to express choice, especially in regards to aftermarket products.

Disclosure must be constant and consistent. Any data collected via EDR technologies should comply with state and federal laws governing privacy and information use. All data collected and stored should make use of data security technology and audit procedures appropriate to the sensitivity of the information. EDR technology data storage should include protocols that call for the purging of individual identifier information respectful of the individual's interest in privacy.

9.0 Customers and Uses of EDR Data

9.1 Overview

Based on the data collected by the WG, the customers appear in two major categories: Non-Real time and Real time. Non-real time users comprise all the current users of EDR data. Non-Real tine users typically included government, police, researchers, insurance companies, and other crash reconstruction experts. These customers normally begin their work after the crash EMS and crash cleanup personnel have completed their work, and the collection of the data is not time-critical, that is, they can wait for a few hours, to days or months to collect the data, as long as the data is preserved in the EDR memory. Real time customers of crash data tend to be those which could use the data at the crash scene to improve injury and death outcomes. This use is the most time-sensitive and could be read by the EMS personnel at the crash site or augmented with an ACN system to transmit the data. The WG did not find any current examples of real-time EDR data users.

The WG developed an overview of all the customers for EDR data, of which most fell into the Non-real time user category. Customers were divided into 5 major categories:

R&D (including: OEM, Governments, Academics)
Incident Management (including: Law Enforcement, Medical, Insurance Companies, On-scene crash investigators)
Fault Assignment (including: Authorities {police, court}, OEM & Government, Insurance Companies through claims, Negotiated settlements, Courts, Juries, Judges)
Driver (including: Personal Data, Vehicle Performance)
Owner (including: Fleet, Personal, Self-Insured)

The following presents the customer overview, along with some observations:

Manufacturers	Vehicle manufacturers indicated they were typically installing EDRs to collect data to improve the design of motor vehicles and diagnose vehicle systems.
Government	The government users fell into several levels of government -- the federal level, state level, and other local users. The WG observed that the federal role included uses of EDR data to carry out its mission: to save lives, reduce injuries, and property loss. This could include collecting data to assist in a better safety management system for the highway and traffic systems. The federal government could also utilize these data to assess safety problems and solutions for issuing new and revised vehicle safety performance standards. At the state level, crash data could be used to assist states in managing road systems and designing better roadside safety hardware, such as guardrails and crash cushions. These groups are very interested in collecting crash location information that would vastly improve their ability to improve roadside safety. At the local level, EDR data could be used to assist medical EMS control, especially if EDR data could be automatically dispatched from the crashed vehicle to the PSAP center as well as other affected parties. EDR data would help the local authorities assign the "right" response teams early in the event. The WG felt it was the governments' role to lay a foundation to cooperatively use these data.
Law Enforcement	These users would benefit greatly from obtaining quick and impartial information regarding the crash. They are often charged with determining the facts associated with a crash, and these data would give them

	additional tools to validate field collision data, determine crash causation, and fraud.
Insurance Companies	Insurance companies often analyze a collision claim for validity prior to paying the claim. EDR data will allow these customers of EDR data to obtain more accurate data related to the crash.
Plaintiffs, Defense Attorneys, Judges, Juries, Courts, and Prosecutors	This group of users often obtain costly experts in the field of crash reconstruction to assist them in proving their position. The use of EDR data will put more "science" on the table during these actions and could lead to shorter actions or no action altogether. Juries would get objective information, too. Courts could require vehicles be equipped with recording devices.
Human Factors Research	Human factor researchers are continuously looking for more data to understand the human's involvement associated with crash causation. Pre-crash EDR data could be used by these researchers to understand driver performance and conduct further analysis of this complicated issue in an in situ environment.
State Insurance Commissioners	Insurance officials could use EDR data to support decisions regarding insurance rates, such as, approving discounts for owners who pre-agree to release EDR data should a crash occur.
Parent Groups	These customers, such as MADD and other parent groups, could use EDR data to support trends in crashes.
Fleets & Drivers	These devices could be used by drivers/fleet owners in many ways, including: improving driver safety, educating drivers about technology on vehicles, auto-downloading data for driver use, providing information vehicle safety characteristics (data element related), and providing information regarding the general performance of vehicle. Another primary use of EDR data by the driver/owner could be the use of the data to demonstrate their proper vehicle operation during a collision.
Medical Injury Guideline Data Usage	Hospital officials, EMS providers, and other EMS decision makers could use EDR data to improve field triage decisions. These data could be used to trigger a series of events which would ensure that the "right" help got to the crash and ER staff to look for non-visible injuries. While more related to ACN, these new methodologies could save lives.
Vehicle Owner	The vehicle owner could review EDR data to determine if the vehicle had been in a previous crash. These data would indicate the severity of the crash, which may relate to the level of repairs the vehicle had undergone during its life.
Transportation Researchers & Academics	Transportation researchers could use EDR data to conduct research related to vehicles, highway, medical treatments, etc.

9.2 Potential Uses of EDRs

There were many discussions related to using EDR data. They are generally summarized in the table above, but some more specific ideas were presented to the WG, and are detailed as follows:

DriveCam: During the process of developing their EDR technology, the DriveCam staff developed a list of "current problems" faced by drivers, and a set of solutions which an EDR could offer. While these were developed directly for the DriveCam EDR technology which included video capturing, they are applicable to EDR application in general and are included as part of the EDR WG report.

Current Problems	EDR Solutions
Reliable, valid collaboration of eyewitness testimony and elimination conflicting testimonies. Witness might not exist or have inaccurate or incomplete of crash.	Accurate account of everything the driver sees, hears, and feels 10 seconds before, during, and 10 seconds after the crash.
Improvement in driver accountability.	Drivers in all vehicles are encouraged to drive more responsibly, since they can be held accountable when incidents occur.
Road rage, Car-jackers, and Hit-and-Run crime solving.	Provides visual record of the incident and opportunity for follow up with the authorities.
Improved police reports and crash reconstruction techniques.	It serves as a video, audio, and g-force notebook to enhance police and insurance companies' crash reports.
There is difficulty in assessing the extent of injuries at the scene of an crash.	Emergency personnel may also review the recording at the scene with any portable TV to identify the intensity of a crash, which will help catch serious injuries that may have been overlooked.
Staged crashes, insurance fraud, exaggerated claims can be difficult and costly to prove.	DriveCam is designed to reduce or eliminate auto insurance fraud by providing an easily understood and irrefutable video and audio playback of "exactly what happened."
Real time crash video is very rare.	The real time DriveCam can be used as a training tool to study crashes and improve highway safety through driver education.
Causes of crashes may involve multiple factors such as road or vehicle design, but may go undetected with traditional investigation techniques	G-Force readings can be carefully studied to determine exact tire traction, speed, and vehicle handling. Weaknesses can be identified and rectified.

Highway Department Uses: The Transportation Research Board staff reviewed the possible uses for EDR data as related to the highway environment. Generally, traffic and highway engineers are looking for data which will assist in the improvement of the roadside crash environment, especially run-off-road crashes which result in rollover. The following list describes their current needs.

- Verify speed & angle of impacts
- Assess side-slope effects on roll propensity
- Effectiveness of "softer" roadside devices
- Adequacy of severity indices
- Driver behavior in run-off-road events
- Off-road soil-tire interactions
- Effects of curbs
- Clear zone distance requirements
- Correlations to crash test results
- Potentials for supplementing police reports about the performance of roadway safety and traffic control features
- Validation of simulations
- Crash reconstruction
- Incident linkages to intelligent transportation systems and traffic management centers

10.0 Demonstration of EDR Technology

10.1 Overview

The working group wanted to provide some examples of EDR technology being used in today's crash investigation environment. The WG developed a potential set of systems for use to demonstrate EDR technology (See below).

Several demonstrations are presented here to give real-world examples of how EDRs are being used to help make motor vehicles safer, conduct research, and detect vehicle defects. These were selected for illustrative purposes, and the WG does not infer any findings from these particular examples, except that EDRs are being used.

Generally, the various EDR systems provide consistent crash information.

10.2 Potential Sources for Demonstration of EDR Systems

The working group developed a list of possible sources to demonstrate EDR applications. The following presents the sources, listed by major categories.

Major Category	Potential EDR Demonstration Sources
OEM	Light vehicles (passenger cars, SUVs, vans, pickups) Buses Heavy trucks
NHTSA	Special Crash Investigation Crash Injury Research and Engineering Network National Automotive Sampling System-Crashworthiness Data System Crash test evaluation program Crash avoidance research
NTSB	Various transportation modes, with concentration on surface transportation
Race Car	SAE Papers describing EDR uses in these vehicles
VDO North America	European systems and their impact on safety
ATA's TMC	Working Group activities related to EDRs
Military	The use of EDRs in military vehicle testing and operation
Vetronix Corporation	Recent activities related to development of a commercially marketed tool for downloading and presenting EDR data
TRB	Recent activities in A2A04 committee on roadside safety
Litigation	Civil and criminal justice system
Forensic Accident	Recent investigation where EDR data was used

10.3 Analysis of EDRs in NHTSA's NCAP and 208 Tests

NHTSA routinely conducts tests of new vehicles as part of our New Car Assessment Program (NCAP) and compliance test programs (FMVSS 208). During the 1998 model year (MY) test program, several GM vehicles were tested. After the tests were conducted, the air bag SDMs were removed from these vehicles and the EDR data stored during the crash were read to determine the Delta-V shape and total Delta-V for each vehicle tested. These data were then compared to the data collected by NHTSA's contractors during the conduct of the crash tests. The contractors' data collection generally consisted of accelerometers located near the seat tracks. Typically there were four accelerometers for each test. The individual traces were inspected for general agreement, and any outliers were dropped from the analysis. The remaining data were averaged at each time step and integrated to determine the Delta-V vs. time characteristic.

There was a total of 21 1998 model year vehicle EDRs read during this effort, consisting of 15 cars, 2 vans, 2 SUVs, and 2 pickups. The test types consisted of 3 FMVSS 208 tests, 13 Frontal NCAP tests, and 5 Side NCAP tests.

Generally, there was good agreement between the contractors' instrumentation and the Delta-V trace from the SDM, although the EDR data from the SDM was slightly lower in magnitude than the integrated accelerometer data. One of the reasons the EDR data may be less than the accelerometer based data is the SDM does not start acquiring data until 2 g's of crash deceleration has been detected. Also, some of the SDM traces were incomplete. A typical trace comparison is shown in Figure 17.

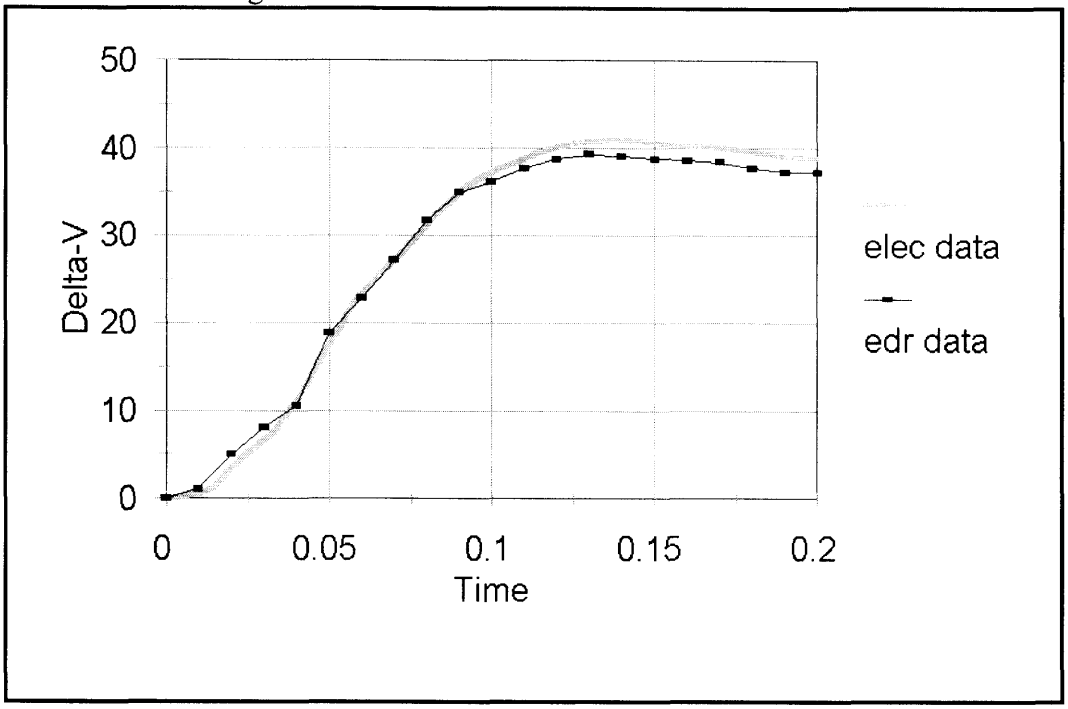

Figure 17. Comparison of EDR data and Crash Test Instrumentation Output.

10.4 IWI EDR Testing

The agency has an interest in monitoring the technology of aftermarket EDRs as well as that provided by vehicle manufacturers. Several companies are known to make aftermarket EDRs which have the capability of recording crash acceleration, velocity change, and other information. A series of one or more comparative crash tests of after market EDRs was planned. The purpose of the tests was to compare the data recorded by the EDRs to that collected by the routine data acquisition used for such crash tests. An invitation was extended to makers of aftermarket EDRs. The first company to respond with delivery of an EDR unit was Independent Witness, Inc. (IWI). The EDR unit manufactured by IWI is interesting in that they follow SAE guidelines for acquiring and processing crash acceleration data as prescribed in SAE J-211.

The IWI units were received in January 2001. The IWI units were utilized on three separate tests at the Vehicle Research and Test Center. The first was a FMVSS 208 compliance sled test of a Subaru Legacy. The second and third tests were crash tests of a moving deformable barrier (MDB) and a moving vehicle. As an example, the test involving the MDB and a 1997 Dodge Caravan (test # TRC 010129) will be examined. The test vehicle impacted the MDB front-to-front, with a closing velocity of 70 mph, resulting in a deceleration in line with the longitudinal axis of the vehicle. The IWI EDR is capable of recording three orthogonal axes of acceleration and rotational motion. In this case, the motion was essentially confined to a single direction, so only the axis aligned with the vehicle longitudinal axis will be examined.

Figure contains an overlay of the IWI and instrumentation data signals filtered to channel class 180. The solid line is from the VRTC cg accelerometer, and the dashed line is from the IWI EDR box. Since there is no link in time between the two instruments, the traces have been "adjusted by eye" to align with each other. It is noted that the IWI trace is the same general shape and similar in magnitude to the VRTC instrument. Whereas the VRTC accelerometer trace records continuously, the IWI did not begin capturing data until approximately .005 seconds, and begins at approximately 18 g of deceleration. This is because the IWI instrument triggers at 2.5 g, and in severe collisions, the time lag causes the early portion of the signal to be lost. It is noted that the IWI signal has more oscillations than the VRTC signal. This may be due to the oscillations of the circuit board inside the EDR to which the IWI accelerometers are attached. The peak deceleration recorded on the VRTC accelerometer is 39 g, compared to 45 g from the IWI EDR.

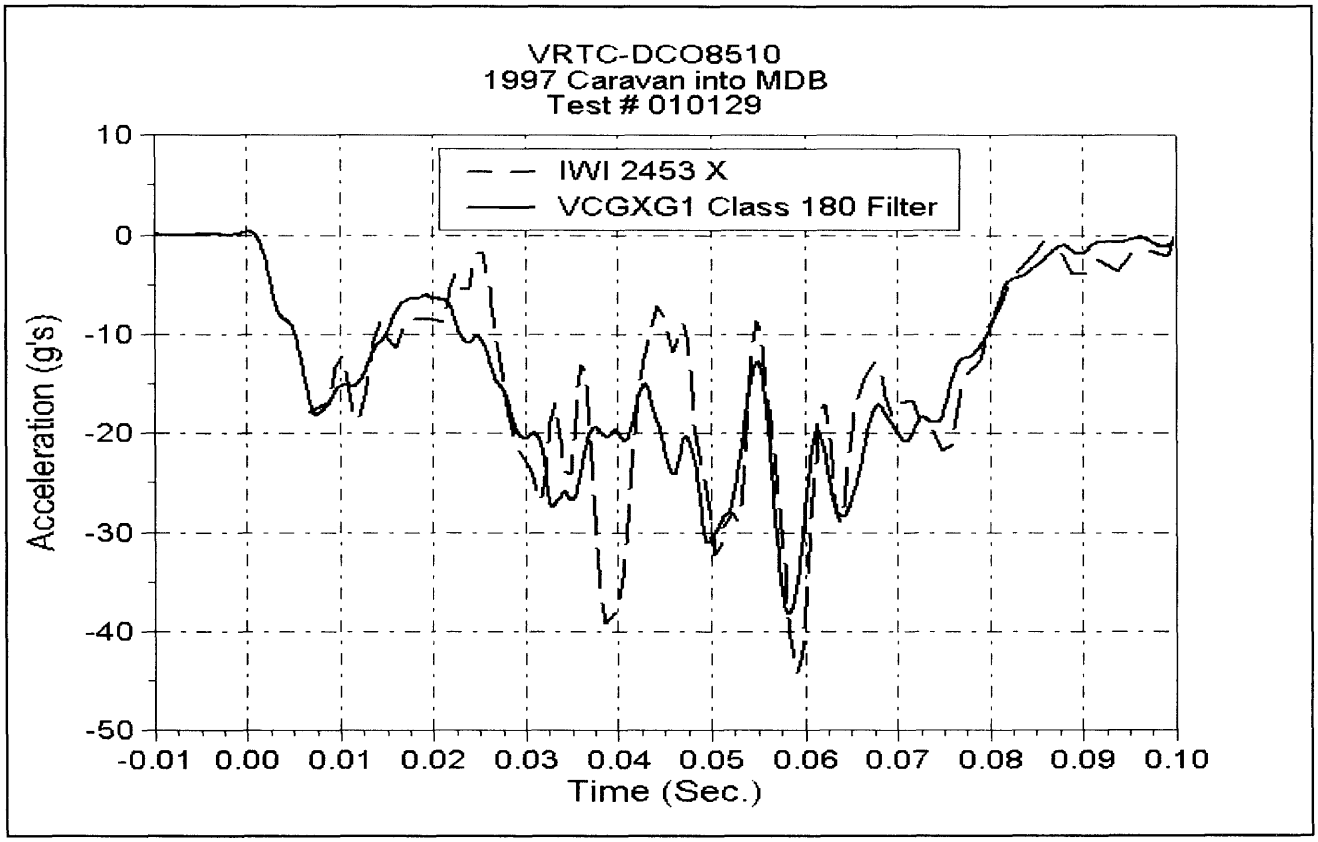

Figure 18. Overlay of the IWI and Test Instrumentation Acceleration Data Signals.

The VRTC signal was integrated to obtain the velocity signal, see Figure 19. The vehicle velocity starts at 35.2 mph and decreases to 2 mph at about 120 ms. The change in velocity is therefore 33.2 mph. The output from the IWI EDR directly lists the magnitude and direction of the delta-velocity. For this test, the IWI EDR computed a delta-v of 30.6 mph at 182 degrees. The difference in delta-v is likely due to that portion of the acceleration missed before the IWI EDR triggers and begins capturing data.

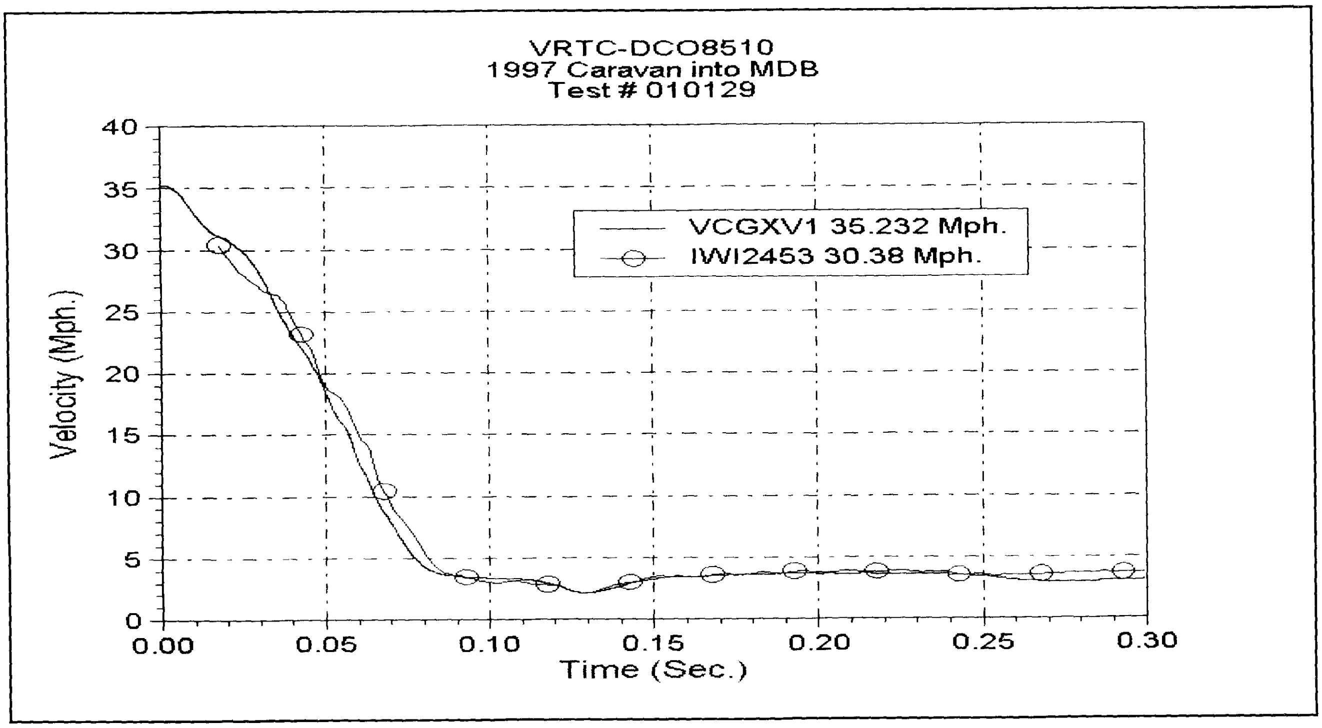

Figure 19. Overlay of the IWI and Test Instrumentation Delta-V Data Signals.

10.5 NHTSA EDR Data Collection Experience

NHTSA began collecting crash data from EDRs in the mid 1990s. The early efforts were cooperative between NHTSA and the automobile manufacturers. Data were typically collected by NHTSA's SCI program to support crash investigation activities. Most of these early cases were low speed air bag related fatalities that could not be accurately reconstructed by the WINSMASH algorithm. Prior to the Vetronix CDR tool, two methods were employed for obtaining the EDR data in the GM vehicles:

1. EDR boxes were removed by the SCI investigators, and sent to GM for downloading
2. GM sent a representative, typically a contractor, to the crashed vehicle to directly read the data.

As previously mentioned, NHTSA has equipped their crash investigation teams (SCI, NASS CDS and CIREN) with Vetronix CDR tools. Ford has provided five proprietary readers to the SCI and NASS. The teams were trained on proper use of these tools and now collect EDR data on a routine basis. To date, the NHTSA crash investigation teams have investigated over 100 crashes where an EDR was read.

Nineteen SCI cases contain EDR data with GM vehicles in which the manufacturer performed the download. In the 2000 data collection year, NHTSA teams began routinely collecting and entering EDR data into their Electronic Data Collection System (EDCS) database. The EDCS is utilized by all three (SCI, NASS CDS and CIREN) data collection systems as their common database. The EDCS was modified to contain a field which indicates if the case has an associated EDR file. This data element is part of the searchable electronic file associated with the database. Since the data collected by various vehicle manufacturers in their EDRs is not uniform, NHTSA is not able to store the output in the electronic file. Currently, NHTSA scans the paper output from the EDR report into the data base. This allows the researcher to review the various data elements (for example: DV for GM vehicles vs. acceleration profiles for Ford vehicles). Future enhancements to the EDCS may include the automation of all the data elements available output from the EDR as variables and attributes.

The SCI and NASS CDS crash investigation teams have attempted 101 downloads; 94 of which, have been successful. The NASS CDS teams have attempted downloading 48 EDRs; 41 of which have been successful. The SCI has successfully downloaded 53 cases (25 GM, 28 Fords) involving an EDR. The following table presents these data as of January 1, 2001.

EDR Download Success by Manufacturer, Crash Program, and Downloading Agency

Program	GM		FORD		Total	
	Attempted	Completed	Attempted	Completed	Attempted	Completed
SCI	7[18]*	7[18]	28	28	53	53
NASS CDS	41[1]	34[1]	6	5	48	41
Total	48[19]	41[19]	34	33	101	94

* The numbers in the brackets are counts of the EDRs downloaded by GM.

The GM cases the NASS CDS teams were unable to read were either due to the lack of correct cables or to Vetronix software problems. Vetronix has sent out new cables and an upgraded software package that has corrected the download problems. The NASS CDS and SCI have noted a printing problem with the latest Vetronix software version.

The NASS CDS and SCI have successfully downloaded data from 33 Ford vehicles. In the only case not downloaded, the vehicle's electrical system was damaged during the crash, and the NASS CDS researcher was unable to remove the RCM.

10.6 EDRs in Conducting Crash Investigations

The following discussion was provided by Robert C. McElroy, Ph.D.; Forensic Accident Investigations, Inc.; Boca Raton, FL - (561) 995-6781; November 2000. Accurate data protects the public and the transportation system. Improvements in vehicles, highways, operator performance, and infrastructure require analytical assessment methods for optimal benefits. Accountability for each element in the total fabric of transportation requires data which can be analyzed by researchers, in order that incremental improvements be implemented. Each segment of the entire transportation system is a consumer of the data. Scientific data are necessary to explain and address crashes and their effect on a particular segment of the transportation system. EDRs are a logical way to enhance transportation safety and improve the transportation system.

The following presents an example of a crash which may have been related to a brake line failure.

This vehicle was involved in a collision in 2000 in the city of North Miami, Florida. As reported by the driver, he indicated that he was approaching slower traffic. In attempting to slow for traffic he pressed the brake but the car did not stop as expected. Inspection of the vehicle revealed that a flexible brake line connecting the master cylinder to the Antilock Brake System (ABS) hydraulic controller was leaking brake fluid when the brake pedal was pressed. A technician removed both brake lines connecting the master cylinder to the ABS module.

EDR Data: This vehicle was equipped with an OEM EDR which stores pre-collision vehicle data including speed, brake application, and throttle position. Technical post crash vehicle inspection was coupled with EDR data to significantly reduce investigation time.

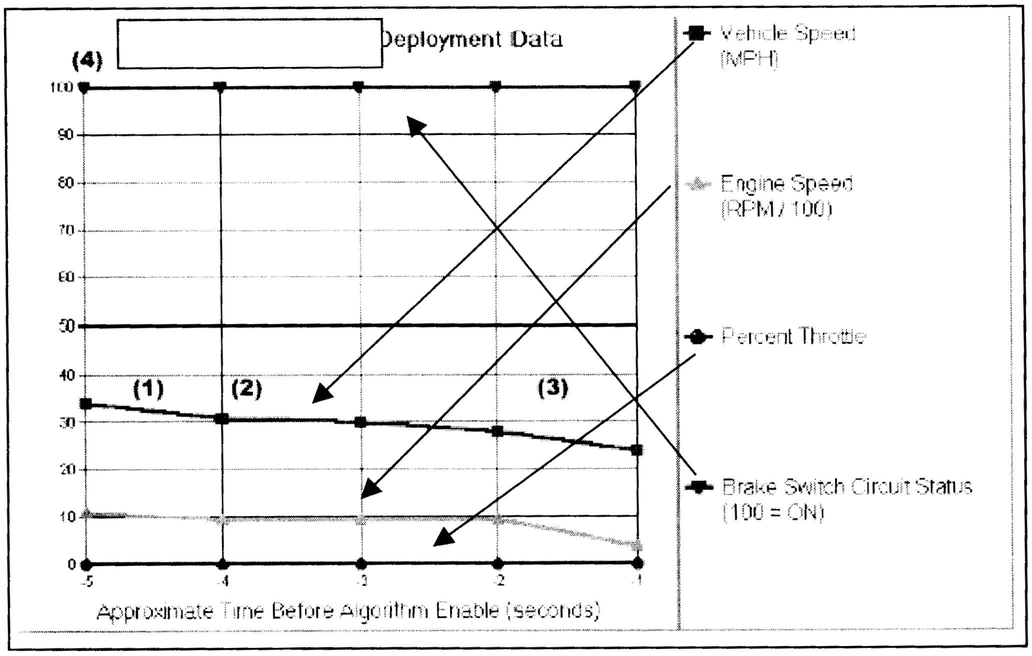

Figure 20. EDR Graphical Output.

As shown graphically in Figure 20 and in text format in Figure 21, initial speed is 34 mph when brakes are applied at least 5 seconds before algorithm enable (impact registration).
(1) Vehicle decelerates.
(2) Vehicle no longer decelerates as rapidly, indicating possible relationship to brake line failure.
(3) Impact occurs on right side of graph.
(4) Brake is applied during entire time.

1G2JB5245Y7108472 System Status At Deployment	
SIR Warning Lamp Status	OFF
Passenger Front Air Bag Suppression Switch Circuit Status	ON
Ignition Cycles At Deployment	2356

(4)

PRE-CRASH DATA			Electronic Data Validity Check Status = VALID	
Seconds Before AE	Vehicle Speed (MPH)	Engine Speed (RPM)	Percent Throttle	Brake Switch Circuit Status
-5	34	1088	0	ON
-4	31	960	0	ON
-3	30	960	0	ON
-2	28	960	0	ON
-1	24	384	0	ON

Figure 21. EDR Text Output.

10.7 EDRs in Conducting Defect Investigations

In a report prepared for NTSB's "International Symposium on Transportation Recorders" in 1999, an example of using an EDR to assist the manufacturer and the government in determining the cause of the inadvertent airbag deployment safety problem was presented. Downloading the event data from a sample of the inadvertent deployment vehicles showed no fault codes present and that the SDM algorithm had commanded the airbags to deploy. The typical DV increased smoothly until it leveled off at approximately 70-120 ms and was usually at least 12 mph in magnitude. This confirmed the design goal of deploying the airbags only if the change in longitudinal vehicle velocity is expected to exceed that observed in 9-14 mph fixed barrier impacts. However, the history recorded for the inadvertent deployments was typically a short duration event (20 ms or less) with a total velocity change of less than 7 mph. This variation from the typical deployment event history suggested an unusual sensor deceleration environment. After extensive laboratory tests and computer simulation work, the environment was found to be similar to that produced by small rocks or debris striking the underside of the vehicle with high impulsive energy. Ultimately a sensor calibration change was made to desensitize the SDM's response to these relatively rare events. This investigation was aided considerably by the EDR data.

10.8 EDRs in Determining Crash Severity

NHTSA's primary metric for representing crash severity is the vehicle's change in velocity (DV). Currently, NHTSA uses the WINSMASH computer algorithm estimate DV for a crash. This algorithm relies primarily on stiffness parameters derived from 35 mph full-width rigid barrier impact tests, which tend to be short in duration. Real world crashes (many of which are longer in duration compared to the 35 mph barrier tests) and less idealized crashes involving yielding fixed and narrow objects, under-rides, or multiple impacts are beyond the capabilities of WINSMASH. NHTSA can now use the output from EDRs to supplement the DV crash severity estimate currently derived from post-crash vehicle inspections. NHTSA crash investigators attempt to make such estimates for all crashes investigated, but because of limitations, only about 38 percent of the cases have DV information reported.

Figure 22 shows a field crash from NHTSA crash files involving a 1998 Chevrolet Malibu that struck a heavy, parked truck in a severe bumper under-ride impact. Such crashes typically generate long crash pulses. WINSMASH estimated a DV of 23 mph, while the investigator noted this DV estimate appeared to be low. The EDR indicated a DV of approximately 50 mph. This again shows the value of having EDRs.

Figure 22. Field Crash from NHTSA Crash Files where EDR Data Were Used.

11.0 Findings

11.1 Safety

EDRs have the potential to greatly improve highway safety. The degree of benefit is directly related to the number of vehicles operating with an EDR and the current infrastructure's ability to use and assimilate these data.

EDR technology has potential safety applications for all classes of motor vehicles (e.g. light duty vehicles, heavy trucks and buses)

Recorded data from real-world collisions are extremely useful for a variety of purposes including conducting research into various aspects of traffic safety, e.g. evaluating potential countermeasures for collision avoidance, refining occupant protection systems, and monitoring safety systems on the roadway and at roadside.

EDRs may become useful tools in the effort to develop safer cars and reduce traffic-related injuries, by providing reliable data about what happens to a driver, occupants, and a vehicle during pre-crash, crash and post-crash. These data may improve crash investigation, reconstruction, and analysis methodologies.

The use of event data recorders can have considerable preventive effect. Studies of EDRs in Europe and the U.S. have shown that driver and employee awareness of an onboard EDR reduces the number of crashes by 20 to 30 percent, lowers the severity of such crashes, and decreases the associated costs.

11.2 Data Collection

A wide range of crash related and other data elements have been identified which might usefully be captured by future EDR systems.

NHTSA has incorporated EDR data collection in its motor vehicle research databases.

Open access to EDR data (minus personal identifiers) will benefit researchers, crash investigators, and manufacturers in improving safety on our highways.

The stored data are somewhat limited and vary with each manufacturer.

Many late-model vehicles are equipped with OEM installed EDRs. The most comprehensive OEM data set currently available contains longitudinal delta-V recorded in 10 ms increments over a 300 ms time frame, and five one-second snapshots of the throttle position, brake light switch status, engine rpm, and vehicle travel speed prior to the occurrence of a recorded event.

The aftermarket systems vary widely: from devices which record crash pulse data only; to those which record a variety of channels for the precrash, crash, and post crash time interval; to those which capture video and audio as well as acceleration data.

There are few standards for collecting, formatting, specifying data elements, and most other aspects related to EDR data.

SAE J211 appears to be the only recommended practice which applies to EDR data collection. ATAs' TMC is developing recommended practices which apply to EDRs on heavy trucks.

Greater standardization of the data content and method of accessing the stored data might be achieved through organizations such as the SAE or ISO (International Organization for Standardization). Alternatively standardization might be achieved through government regulation.

Currently, data are accessed by a physical connection (cabling) to the EDR unit. Manufacturers are developing wireless connections e.g., using a wireless probe near the crashed vehicle, or by having the on-board device upload the stored data to a central location using a telecommunications link, but such devices are not in widespread production.

There is a need for a system for authenticating and securing event data parameters from all vehicles operating in the highway mode of transportation.

There is a need for training of EDR data collection officials.

11.3 Other Observations

EDRs are being used in many applications.

Research studies addressing the pros and cons of utilizing EDRs in the highway mode have provided objective data and findings useful to understanding the issues involved.

Different EDR systems and information files may be required for cars, vans, SUVs, other lightweight vehicles, heavy trucks, school buses, and motorcoaches.

Data recorders for commercial vehicles might include functionality to act as electronic logbooks for drivers' hours of service.

Recording and power systems need to be rugged to withstand the forces of collision, and to be tamper proof.

Most systems utilize proprietary technology and require the manufacturer to download and analyze the data. There is a need to accelerate commercial (non-OEM) devices to download and present EDR data easily and clearly for all users.

There are unresolved privacy concerns relating to who owns the data, who can access and make use of the information (including leasing, rental, and insurance companies), and who might store individual and anonymous/grouped data on a permanent basis.
In the absence of more specific guidelines data can be obtained with the permission of the vehicle's owner.

Automatic crash notification (ACN) systems integrate the on-board crash sensing and EDR technology with other electronic systems, such as global positioning systems and cellular telephones, to provide early notification of the occurrence, nature, and location of a serious collision.

A proposed method for classifying EDRs would involve categorizing EDRs into two major types: Type I and Type II. Type I EDRs would use a minimal, but essential set of data elements. Type II EDRs would evolve with emerging technologies and may include appropriate data elements that target specific vehicle types.

12.0 Bibliography and References

12.1 Docket and Federal Register Records

Record of the NHTSA Event Data Recorder Working Group
Docket NHTSA-99-5218, Available at:
http://dms.dot.gov

Record of the NHTSA Truck and Bus Event Data Recorder Working Group
Docket NHTSA-00-7699, Available at:
http://dms.dot.gov

Federal Register 63 FR 60270 (Nov. 9, 1998) and 64 FR 29616 (June 2, 1999).

12.2 Symposia Records

Transportation Safety and the Law
April 25-26, 2000
The National Transportation Safety Board hosted this symposium to discuss the conflicts between the growing need for data to improve transportation safety and the industry's concern about the use of those data in regulatory actions, law suits, and criminal prosecutions. The symposium brought together knowledgeable participants from government, industry (all transportation modes) and the legal community to examine the problems regarding the collection of data for crash prevention, including during crash investigations, and the privacy concerns of those being investigated. Ideas were exchanged to help create a context in which safety data can be gathered while the legitimate rights of all concerned are protected. Although no specific recommendations were identified, many suggestions were presented. There was general agreement about the need to collect additional information to advance safety.

The proceedings from the symposium can be viewed in their entirety at:
http://www.ntsb.gov/events/2000/symp_legal/default.htm

International Symposium on Transportation Recorders
May 3 - 5, 1999
The National Transportation Safety Board held a symposium on issues related to the use of recorded information to improve safety in all modes of transportation. Topics included the use of recorded information for crash investigations and routine performance monitoring, the privacy, proprietary, and union issues associated with recorded information, and the future recording requirements and capabilities.

The following 16 papers and 4 posters are applicable to EDRs in general:

Papers:

1. Smiths Industries Flight Data/Cockpit Voice Recorders [.htm] [.pdf], Jeffrey L. Brooks
2. An Autonomous Data Recorder for Field Testing [.htm] [.pdf], Joseph A. Carroll, Michael D. Fennell
3. Reducing Highway Deaths and Disabilities with Automatic Wireless Transmission of Serious Injury Probability Ratings from Crash Recorders to Emergency Medical Services Providers [.htm] [.pdf], Howard Champion, J.S. Augenstein, B. Cushing, K.H. Digges, R. Hunt, R. Larkin, A.C. Malliaris, W.J. Sacco, J.H. Siegel
4. Recording Automotive Crash Event Data [.htm] [.pdf], Augustus Chidester, John Hinch, Thomas C. Mercer, Keith S. Schultz

5. Proactive Use of Recorded Data for Accident Prevention [.htm] [.pdf], Ed Dobranetski, Dave Case
6. On-Board Recorders: The "Black Boxes' of the Trucking Industry [.htm] [.pdf], Les Dole
7. Digital Audio Recorders Life Savers, Educators, and Vindicators [.htm] [.pdf], Matthew Durkin
8. Transportation Event Recorder Data: Balancing Federal Public Policy and Privacy Rights [.htm] [.pdf], Gregory L. Evans
9. Security of Recorded Information [.htm] [.pdf], Lindsay Fenwick
10. Future Video Accident Recorder [.htm] [.pdf], Mike Horne
11. Proactive Use of Highway Recorded Data Via an Event Data Recorder (EDR) to Achieve Nationwide Seat Belt Usage in the 90th Percentile by 2002 [.htm] [.pdf], Thomas Michael Kowalick
12. The Contribution of Onboard Recording Systems to Road Safety and Accident Analysis [.htm] [.pdf], Dr. Gerhard Lehmann, Tony Reynolds
13. Transportation Recorders on Commercial Vehicles [.htm] [.pdf], Paul Menig and Cary Coverdill
14. The Benefits of Vehicle-Mounted Video Recording Systems [.htm] [.pdf], R. Jeffrey Scaman
15. On-Board Recording for Commercial Motor Vehicles and Drivers: Microscopic and Macroscopic Approaches [.htm] [.pdf], Neill L. Thomas, Deborah M. Freund
16. A Vision of Future Crash Survivable Recording Systems [.htm] [.pdf], Michael H. Thompson

Posters: Posters are available in HTML (default) or PPT format. Graphics have been included, whenever possible, in the HTML version, but PPT will have the higher-quality image and requires a PowerPoint viewer.

1. Accident Reconstruction/Simulation with Event Recorders [.htm] [.ppt], Kristin Bolte, Lawrence Jackson, Vernon Roberts, Sarah McComb
2. Seat Belt Event Data Recorder (SB-EDR) [.htm] [.ppt], Thomas Michael Kowalick
3. Mobile Accident Camera [.htm] [.ppt], John J. Mackey, Christopher J. Brogan, Edward Bates, Stephen Ingalls, Jack Howlett
4. The Benefits of Vehicle-Mounted Video Recording Systems [.htm] [.ppt], R. Jeffrey Scaman

The proceedings from the symposium can be viewed in their entirety at: http://www.ntsb.gov/events/symp_rec/symp_rec.htm

12.3 Research Projects

Perceptions of College Students Regarding Utilization of Transportation Recorders in the Highway Mode, Thomas Michael Kowalick, 651 pgs.; http://leyte.sandhills.cc.nc.us/research/recorders.pdf

12.4 Bibliography

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