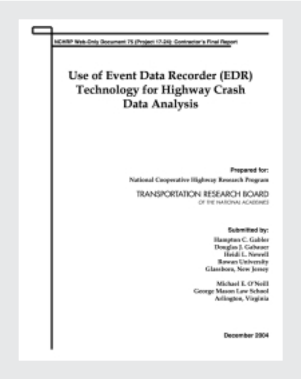
NCHRP Web-Only Document 75 (Project 17-24): Contractor's Final Report

Use of Event Data Recorder (EDR) Technology for Highway Crash Data Analysis

Prepared for:
National Cooperative Highway Research Program
TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

Submitted by:
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George Mason Law School
Arlington, Virginia

December 2004

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Table of Contents

List of Figures

List of Tables

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Abstract

Widespread deployment of Event Data Recorders (EDRs), sometimes called "black boxes", promise a new and unique glimpse of the events that occur during a highway traffic collision. The EDR in a colliding vehicle can provide a comprehensive snapshot of the entire crash event –pre-crash, crash, and post-crash. In 2004, an estimated 40 million passenger vehicles were equipped with EDRs. By carefully collecting and analyzing the details provided by the growing number of EDR-equipped vehicles, state transportation agencies, federal agencies, and the highway safety research community have an unprecedented opportunity to understand the interaction of the vehicle-roadside-driver system as experienced in thousands of U.S. highway accidents each year.

State and federal transportation agencies can expect both immediate and longer term benefits from the collection of EDR data. The initial benefit for state transportation agencies will be the use of EDR data from individual traffic accident investigations as a powerful new form of evidence in legal proceedings, e.g. to defend against lawsuits or to recover costs of repairing collision damage to the highway infrastructure. With a more methodical system of EDR data collection, state and federal transportation agencies can expand this benefit to significantly improve the efficiency of database collection for accident statistic databases. For example, in state accident databases designed to meet the Model Minimum Uniform Crash Criteria (MMUCC) format, one-third (24 of 75) of the recommended data elements could be provided by EDRs. In the longer term, one of the crucial benefits of EDRs will be their influence on highway crash safety research. The ready availability of EDR data in an accident statistics database will enable highway safety researchers to address a number of elusive research questions which directly affect state transportation agencies, e.g. the relevancy of the NCHRP 350 roadside safety feature crash test guidelines.

State and federal transportation agencies can expect to incur both startup and operational costs associated with EDR data collection. Startup costs will include both the purchase of EDR data retrieval units and training for the accident investigators or law enforcement personnel who will be performing the actual EDR downloads. In addition, EDR data collection will add somewhat to the time required for accident investigation. These costs however are expected to be a barrier to EDR data collection only in the near term. As EDR data becomes more widely used in the courts and as EDRs become more widespread in the passenger vehicle fleet, there will be growing legal incentives for the states to collect EDR data.

EDRs are a rapidly evolving and, in many ways, still immature technology. Both the Society of Automotive Engineers and the Institute of Electrical and Electronics Engineers have recently released standards or recommended practices for EDRs. In 2004, the National Highway Traffic Safety Administration (NHTSA) issued a Notice of Proposed Rulemaking (NPRM) for EDRs voluntarily installed in light vehicles. This NCHRP program has developed several recommendations for enhancement of these devices to meet the specific needs of highway crash data analysis. These recommendations include

the adoption of the standardized set of data elements included in the NHTSA NPRM on EDRs, the addition of a specialized list of data elements which would assist roadside crash safety research, as well as a list of other required improvements to EDR performance and data download methods. Finally, the research program has developed a recommended EDR Database format for state and federal transportation agencies which seek to collect and systematically store EDR data.

While the preceding technological issues are challenging, they are solvable. More uncertain are the concerns which have been raised about the legal and public acceptability of the widespread collection of EDR data. Much of the public hesitation to accept EDRs has revolved around the recording of pre-crash data, e.g. vehicle speed, rather than the crashworthiness data, e.g. crash pulse. Pre-crash data can be used to directly evaluate a driver's responsibility for a crash. This report presents the findings of two special studies, conducted as part of this research program, which specifically examine the legal issues surrounding EDRs and the consumer acceptability of EDR data collection.

1. Introduction

1.1 Research Problem Statement:

The research problem statement, as outlined in the Statement of Work for the project, is quoted below:

> There is a critical need to obtain accurate and reliable "real-world" crash data to improve vehicle and highway safety. The use of Event Data Recorder (EDR) information has the ability to profoundly affect roadside safety. EDRs are capable of capturing vehicle dynamics data, such as vehicle speed; lateral and longitudinal acceleration-time histories; principal direction of force on the vehicle; the status of braking, steering, seat belt usage, and air bag deployment; and other valuable crash information. This represents a new source of objective data for the highway and vehicle safety community because it will provide a "real world" connection between controlled test results and actual field performance of vehicles and highway design features.
>
> EDRs have the potential to capture a large number of crash-related and other data elements for a wide range of users with different data needs. The data elements related to improving vehicle safety and driver performance are being used, but little has been done to apply the data elements to roadside safety analysis. Research can identify data elements relevant to roadside safety and improve methods to retrieve, store, and access these data.

1.2 Objectives and Scope

The objectives of this research program were to (1) recommend a minimum set of EDR data elements for roadside safety analysis and (2) recommend procedures for the retrieval, storage, and use of EDR data from vehicle crashes to include legal and public acceptability of EDR use.

To accomplish these objectives, the study was delineated into the following seven (7) tasks:

1. Conduct literature review and meet with an EDR data collection agency

2. Identify existing and potential EDR data elements that could be used to improve vehicle and roadside safety.

3. Identify and prioritize EDR Data needs.

4. Investigate current methods for initial retrieval and storage methods for EDR data.

5. Prepare an interim report documenting the findings of Tasks 2 through 4.

6. Recommend procedures for improved retrieval, storage, and use of EDR crash data to include legal and public acceptability of EDR use.

7. Submit a final report that documents the entire research effort.

1.3 Research Approach

This section describes the technical approach for conducting National Cooperative Highway Research Program (NCHRP) Project 17-24 "Use of Event Data Recorder (EDR) Technology for Roadside Crash Data Analysis".

1.3.1 Survey of EDR Literature and Current Practices

This objective of this task was to determine current U.S. and international methods and practices for the collection, retrieval, archival, and analysis of EDR data for roadside and vehicle safety. The research team performed a comprehensive literature survey of existing literature on the use of EDR data for roadside and vehicle safety. The review included examination of existing studies performed by the National Highway Traffic Safety (NHTSA) Event Data Recorder Working Group, the NHTSA Truck and Bus EDR Working Group, and the National Transportation Safety Board (NTSB) Symposia on Data Recorders in Transportation.

The research team next met several times with NHTSA to discuss their growing EDR data collection efforts. NHTSA collects EDR data as part of their in-depth accident investigation research. Topics of discussion included (1) NHTSA EDR data collection, (2) current EDR data storage methods, and (3) methodologies for linking with NHTSA highway accident databases, e.g., National Automotive Sampling System Crashworthiness Data System (NASS / CDS). The research team continued these discussions with NHTSA throughout the term of the project in order to follow the development of the NHTSA EDR data collection practices. The research team summarized the results of the literature and the initial NHTSA meeting in a white paper on current EDR practices.

1.3.2 Determine Existing and Potential Future EDR Data Elements

The objective of this task was to determine existing and potential future EDR data elements. The resulting list of EDR data elements formed a catalog of data element sources from which a minimum set of roadside safety-related data elements could be selected. The team investigated those safety-related data elements that could be provided by EDRs – both by current and potential future devices. This investigation was based upon (a) production EDR systems installed by automakers, (b) aftermarket EDR systems which could be retrofit to a car, (c) availability of data in other electronic control units, e.g. anti-lock braking units, (d) data elements stored in Automated Crash Notification systems, (e) availability of current sensors, (f) data elements proposed in the NHTSA proposed rule on EDRs, and (g) data elements proposed by EDR standards groups. As much of the data on existing EDRs is proprietary, this was a particularly challenging task to accomplish.

Key to the success of this task was the establishment of an Expert Advisory Group of subject experts who could provide insight into safety data needs, existing EDR design practices, and emerging technological directions for EDRs. Of particular importance was the broad representation from the automakers whose systems are the source of all existing and potential EDR data. Our Expert Advisory Group included EDR subject experts from GM, Ford, Daimler-Chrysler, Honda, Nissan, Mitsubishi, and Volkswagen. Many of the findings of this project were obtained through interviews with these industry experts who volunteered their insights into current and future EDR practices.

A second crucial source of information was the research team participation with the professional societies and industry groups which are developing standards or position papers for EDRs. The Principal Investigator joined the Institute of Electrical and Electronics Engineers (IEEE) P1616 Standards Working Group, which has now developed a standard for Motor Vehicle Event Data Recorders (MVEDRs), and the Society of Automotive Engineers (SAE) J1698 Standards group, which has now developed a recommended practice for EDR output formats for cars and light-duty trucks. The research team has also followed the progress of other standards and industry groups, including the International Organization for Standardization (ISO) and the Technology and Maintenance Council of the American Trucking Associations, who are developing EDR related standards and position papers.

1.3.3 Identify and Prioritize EDR Data Needs

This task developed a catalog of EDR data needs which support vehicle and roadside safety research and design. The approach was to match the data needs of the vehicle and roadside safety community with available or potential EDR data elements. From this analysis, this task developed a recommended minimum EDR data set to support highway crash data analysis.

The research team pursued several avenues to methodically identify additional data elements that could be captured using EDR technology. Candidate data elements fell into two categories: (1) data elements, currently being collected manually, which could be collected by EDRs, and (2) data elements which were not collected previously because the data collection capabilities of EDRs were not previously available. The catalog was developed by:

- **Analysis of Existing Accident Databases.** One important use of EDR data will be replace or improve data collection for the accident databases. The research team methodically examined existing eleven crash databases and recommended database formats for candidate EDR data element needs. The databases included U.S. national accident databases, state accident databases, specialized roadside safety databases, and specialized commercial truck accident databases. The research team also examined recommended databases formats or extensions including the Minimum Model Uniform Crash Criteria (MMUCC), NCHRP 350 data requirements, and NCHRP 22-15 recommended data extensions to NASS/CDS.

- **Literature Review of Roadside Safety Data Needs**. The research team conducted an extensive review of the roadside technical literature to identify recommended improvements to data elements presently collected, and to identify data elements not presently captured that could be of significant value to the roadside safety community.

- **Develop a Catalog of Potential EDR Data Elements.** Not all data elements needed for roadside safety analysis can be captured in an EDR. Fundamentally, an EDR is a vehicle-mounted device and can record only what can be measured from the vehicle. However, the performance of roadside features can sometimes be inferred from the performance of the vehicle. After analysis of the data elements in each database and the technical literature, a comparison was made with the listing of current and potential EDR capabilities to ascertain potential data elements. The extraction process resulted in a catalog of elements representing the intersection of feasible EDR data elements and matching data element needs. The data elements from each of these data sources were merged into a data catalog of recommended EDR Data Elements for highway crash data analysis.

- **Prioritize Candidate Data Elements that could be collected from EDRs.** Because there may be insufficient memory in an EDR to store all data elements of interest, the candidate data elements were prioritized by their importance to roadside safety analyses. This program prioritized the candidate data elements through consultation with subject experts in roadside safety from the state transportation agencies, federal agencies, research universities, automakers, and other organizations. Of particular importance was a priority ranking exercise conducted in collaboration with the American Association of State Highway and Transportation Officials (AASHTO) Technical Committee on Roadside Safety. The results of this task were documented in a white paper which was presented to the Project Panel for review.

1.3.4 Current Methods for Retrieval, Storage, and Subsequent Use of EDR Data

This objective of task was to discuss current methods for initial retrieval and storage of, as well as subsequent use of, EDR crash data for roadside safety analysis. There are currently no standards for retrieval or long-term storage of EDR data. Through interviews with the automakers, NHTSA, field accident investigators, and retrieval equipment manufacturers, the research team investigated current EDR data retrieval methods and issues, the lack of automated methods for exporting EDR data to accident databases, and the need for standardized methods of long-term EDR data storage.

1.3.5 Interim Report

This task prepared an interim report which summarized the project findings on candidate EDR data elements and recommended methods for retrieving / storing EDR data.

1.3.6 Recommendations for Improved Retrieval, Storage, and Use of EDR Data

Based upon the findings of earlier tasks, this task produced a statement of recommended practices for the retrieval, storage, and use of EDR crash data. The recommendations consider resource requirements, and cost-effectiveness. This task identified possible obstacles to implementing the recommended procedures. The task conducted two special studies on the legal and public acceptability of EDR use.

1.3.7 Final Report

This task documented the findings and recommendations of the research project. The report was focused to encourage the vehicle manufacturers and highway safety research agencies to begin implementation of the project conclusions.

2. Existing and Potential EDR Data Elements

The objective of this section is to present existing and potential EDR data elements which could support vehicle and roadside safety research and design.

2.1 Approach

The approach of the analysis was to construct a catalog of EDR data elements by evaluating the current and expected future capabilities of EDR technology. Only data elements that were judged to be both technically and economically feasible were included in the catalog. Our assessment was based upon:

a) Production EDR Systems. Examination of data elements currently being recorded in production vehicle EDR systems such as those EDRs in General Motors (GM) and Ford passenger vehicles.

b) Aftermarket EDR Systems. Determination of data elements stored in aftermarket EDR systems, e.g. the Siemens-VDO system, the Safety Intelligence Systems device, the Drive Cam system, and the Independent Witness device.

c) Availability of Data in Other Electronic Control Units. The feasibility of accessing data in Electronic Control Units, other than the EDR, was explored. Other Electronic Control Units, whose non-volatile memory can be downloaded, include the engine fuel management (EFI) module, antilock braking (ABS) module, automatic traction control (ATC) module, and cruise control (CC) module.

d) Automated Crash Notification Systems. Data elements that are not currently being collected by EDR systems but could be collected or transmitted by Automated Crash Notification systems were identified.

e) Government Regulatory Requirements. NHTSA has issued a Notice of Proposed Rulemaking (NPRM) on Event Data Recorders. The proposed rule defines a comprehensive list of potential EDR data elements and a minimum subset of data elements to be recorded in all EDRs.

f) Standards Groups. Several industry and professional societies are developing or have developed EDR-related standards. The data elements, specified or under consideration by these groups, were explored as sources of potential EDR data elements. In December 2003, the Society of Automotive Engineers issued SAE J1698, a recommended practice for a Vehicle Event Data Interface (VEDI), which applies to passenger cars and light trucks. In September 2004, the IEEE Standards Association (IEEE-SA) approved the IEEE 1616 standard, Motor Event Data Recorders (MVEDR) which applies to all types of highway vehicles including passenger cars, light trucks, heavy trucks, and buses. ISO is developing a standard for crash pulse recorders. The Technology and Maintenance Council of the American Trucking Associations has developed a recommended practice for Event Data Recorders for heavy trucks.

g) Data elements for which EDR collection is technically feasible. Determination of data elements stored in research EDR Systems, e.g. the Folksam Crash Pulse Recorder, the Rowan University Crash Data Recorder system, and the Volvo research EDR. Research EDR systems may include sensors, e.g. driver video cameras or cell phone monitors, which are not currently on production vehicles, but may be included in future vehicle models.

2.2 Automaker EDR Data Elements

Automakers are installing Event Data Recorders in growing numbers of passenger cars, vans and light-duty trucks. Current EDRs provide an ideal baseline for developing a list of existing and potential EDR data elements. Because the automakers have installed millions of these devices, we may presume that the data elements stored in current EDRs are both technically and economically feasible.

Both GM and Ford have publicly released their EDR formats. Most automakers however view this information as proprietary. For the discussion which follows, determination of EDR contents has been based upon examination of the literature, EDR data retrieved from real-world accidents, and interviews with EDR experts in the automotive industry. In many cases, industry EDR experts have agreed to discuss their corporate EDR design only with the understanding that their company will not be identified.

2.2.1 General Motors

GM EDRs have the capability to store a description of both the crash and the pre-crash phase of a traffic collision [Correia et al, 2001]. The GM EDR is referred to as the Sensing and Diagnostic Module (SDM). Crash event parameters include longitudinal change in velocity vs. time during the impact, airbag trigger times, and seat belt status. Later versions of the GM EDR also store precrash data including a record of vehicle speed, engine throttle position, engine revolutions per minute, and brake status for five seconds preceding the impact. Since their introduction in the early 1990’s, GM has continuously improved their EDR design. This has been both a boon and a challenge to researchers who seek to compare the crash performance of vehicles equipped with different generations of the GM EDR.

Pre-Crash Data

As shown in Figure 2-1, newer versions of the GM EDR can store up to five seconds of pre-crash data. Data elements include vehicle speed, engine throttle position, engine revolutions per minute, and brake status versus time for the five seconds preceding the time the airbag control module believes that a crash has begun, sometimes referred to as the time of algorithm enable. These data elements provide a record of the actions taken by the driver just prior to the crash.

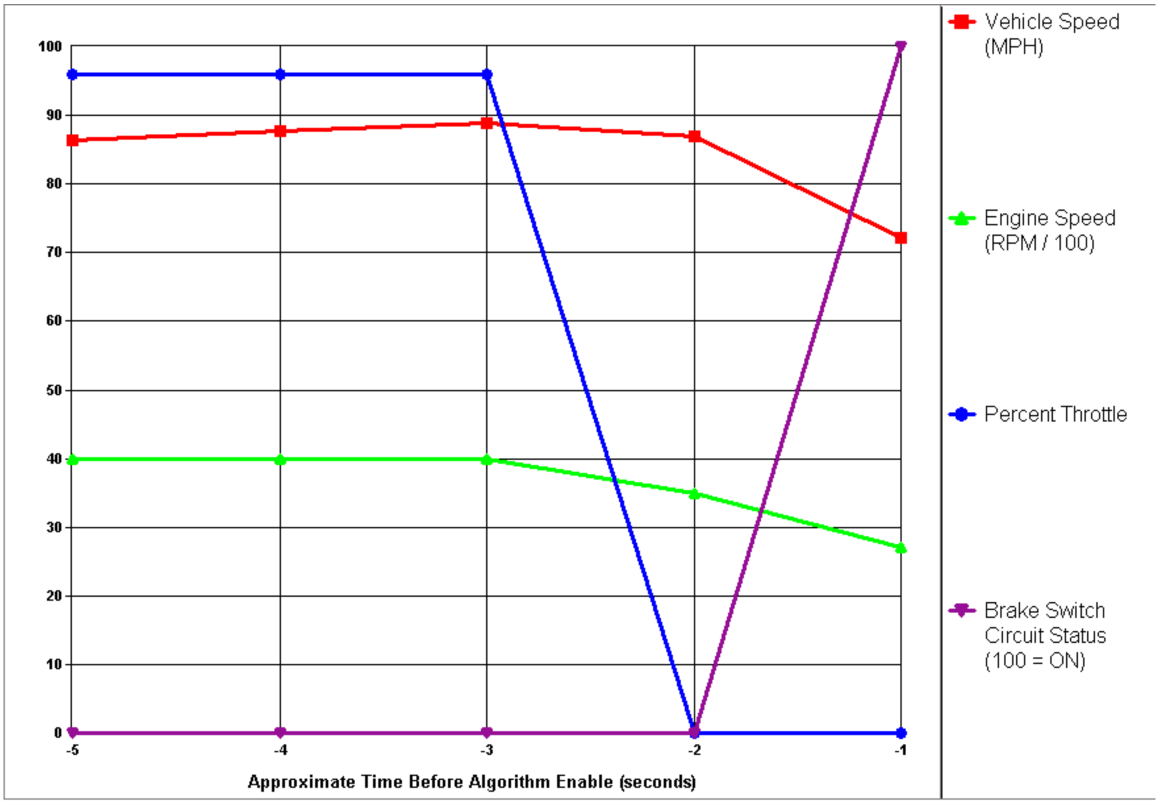

Figure 2-1. Example of GM EDR pre-crash information

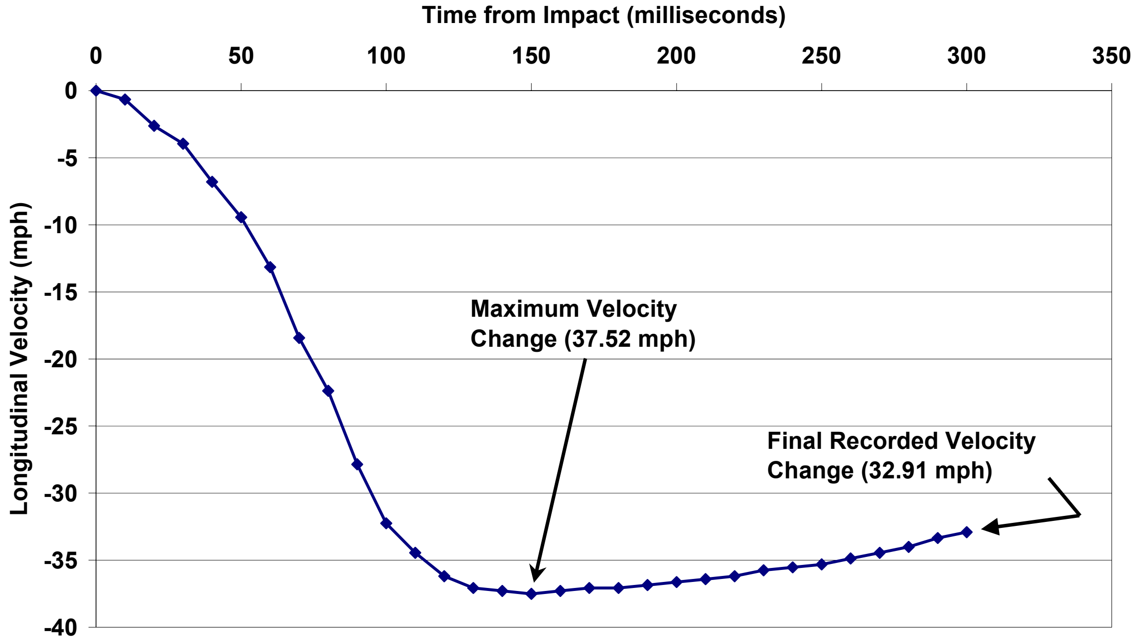

Figure 2-2. GM EDR record of Longitudinal Velocity vs. Time

Data Elements Recorded during the Crash

Arguably, the most valuable data element stored in the GM EDR is the longitudinal change in velocity versus time history of the vehicle during the crash. Change in velocity is sometimes referred to as delta-V. In GM EDRs, the longitudinal delta-V is recorded every ten milliseconds for up to 300 milliseconds in older EDR designs and up to 150 milliseconds in newer EDR designs. Lateral delta-V is not recorded. Figure 2-2 shows the longitudinal delta-V vs. time recorded by an EDR in a 1999 GM Pontiac Grand Am involved in a frontal collision with another vehicle.

Storing Multiple Crash Events

Many crashes are composed of several impact events. GM EDRs can store up to two (2) events associated with a crash. GM EDRs can store three different types of events: a non-deployment event, a deployment event, and a deployment-level event. A non-deployment event is defined as a crash of too low a severity to warrant deploying the airbag. A deployment event is an impact in which the airbag was deployed. A deployment-level event is an impact of sufficient severity that the airbag would have been deployed if a previous event had not already deployed the airbag.

Tabulation of GM Data Elements

Table 2-1 lists the data elements stored by GM Event Data Recorders. The parameters have been grouped into five categories: (1) General parameters which include airbag diagnostic information, (2) Restraint Performance during the crash, (3) Pre-Crash

Information, (4) Crash Pulse Parameters, and (5) Event Counters. Note that not all GM EDRs have all of these parameters. The design of GM EDRs has evolved through several generations as GM has added new features to the device. For example, pre-crash information was first stored in some model year 1999 cars and light trucks. More recent additions include the "Event completely recorded" flag, and the "≥ 1 Events not recorded" field. These data elements were added in response to concerns that some events may be only partially recorded, or missed in multi-event collisions.

Table 2-1. GM EDR Data Elements

Parameter Type	Parameter	Data Type	Values
General	Prior Deployment?	Coded	Yes / No
	Airbag Warning Lamp Status	Coded	On / Off
	Ignition Cycles @ Event	Integer	
	Ignition Cycles @ Investigation	Integer	
	Brake Switch State @ Algorithm Enable	Coded	Applied / Not Applied
	Brake Switch State Validity Status	Coded	Valid / Invalid
Restraints	Seat Belt Status, Driver	Coded	Buckled / Unbuckled
	Frontal Airbag Suppressed, Passenger	Coded	Yes / No
	Frontal Airbag, Driver, Time from Algorithm Enable to 1st Stage Deployment (ms)	Floating Point	
	Frontal Airbag, Driver, Time from Algorithm Enable to 2nd Stage Deployment (ms)	Floating Point	
	Frontal Airbag, Passenger, Time from Algorithm Enable to 1st Stage Deployment (ms)	Floating Point	
	Frontal Airbag, Passenger, Time from Algorithm Enable to 2nd Stage Deployment (ms)	Floating Point	
Event Counters	Time between Non-deployment and Deployment event (sec)	Floating Point	
	Frontal Airbag Deployment Level Event Counter	Integer	
	Event Recording Complete	Coded	Yes / No
	Multiple Events	Coded	Yes / No
	>= 1 Events not recorded	Coded	Yes / No
	Time between Non-deployment and Deployment-Level event (sec)	Floating Point	
Pre-Crash Data	Vehicle speed vs. time	Integer Array	
	Engine Throttle (%) vs. time	Integer Array	
	Engine speed (rpm) vs. time	Integer Array	
	Brake Status vs. time	Coded Array	On/Off
Crash Pulse	Longitudinal Delta-V vs. time (mph)	Floating Point Array	
	Max Longitudinal Delta-V (mph)	Floating Point	
	Time of Algorithm Enable To Max Delta-V (ms)	Floating Point	

2.2.2 Ford Motor Company

The Ford EDR is called the Restraint Control Module (RCM). The emphasis of the Ford EDR is on monitoring the performance of occupant restraint systems including multi-stage frontal airbag deployment, pretensioners, and side impact airbags. As shown in Table 2-2, Ford EDRs provide extensive restraint performance.

Table 2-2. Ford EDR Data Elements

Parameter Type	Parameter	Data Type	Data Values
General	Data Validity Check	Coded	Valid / Invalid
	EDR Model Version	Integer	
	Diagnostic Codes Active When Event Occurred	Integer	
Restraints	Side Airbag, Driver, Time from Safing Sensor Decision to Deployment [ms]	Integer	
	Side Airbag, Passenger, Time from Safing Sensor Decision to Deployment [ms]	Integer	
	Seat Belt Buckled, Driver	Coded	Yes / No
	Seat Belt Buckled, Passenger	Coded	Yes / No
	Seat Track in Forward Pos, Driver	Coded	Yes / No
	Occupant Classification, Passenger	Coded	Adult / Child
	Algorithm Runtime [ms]	Integer	
	Number of Invalid Recording Times	Integer	
	Pretensioner, Driver, Time from Algorithm Wakeup to Deployment [ms]	Integer	
	Frontal Airbag, Driver, Time from Algorithm Wakeup to 1st Stage Deployment [ms]	Integer	
	Frontal Airbag, Driver, Time from Algorithm Wakeup to 2nd Stage Deployment [ms]	Integer	
	Pretensioner, Passenger, Time from Algorithm Wakeup to Deployment [ms]	Integer	
	Frontal Airbag, Pass., Time from Algorithm Wakeup to 1st Stage Deployment [ms]	Integer	
	Frontal Airbag, Pass., Time from Algorithm Wakeup to 2nd Stage Deployment [ms]	Integer	
Pre-Crash	Longitudinal acceleration	Floating Point Array	
	Acceleration time stamp	Floating Point Array	
Crash Pulse	Longitudinal acceleration	Floating Point Array	
	Lateral acceleration	Floating Point Array	
	Acceleration time stamp	Floating Point Array	

Two versions of the Ford RCM can be downloaded by the Vetronix CDR system. As shown in Figure 2-3 and Figure 2-4, the RCM in Ford Taurus and Mercury Sable cars equipped with side airbags can store both a longitudinal and a lateral crash pulse. The crash pulse is stored as acceleration versus time at one sample every 2 milliseconds. Up to 40 acceleration measurements along each axis can be stored for a total duration of 78 milliseconds.

A second version of the Ford RCM stores only a longitudinal crash pulse, but is able to record up to 142 acceleration points. Vehicles with this RCM design include the Ford Windstar, the Ford Crown Victoria, the Mercury Grand Marquis, and the Lincoln Towncar. Data measured before algorithm wakeup is recorded every millisecond. Data measured after algorithm wakeup is recorded every 0.8 milliseconds. The RCM can reallocate the 142 acceleration points between the precrash and crash phases based on the crash pulse. For example, in one NASS/CDS case analyzed by the research team, the RCM recorded 68 milliseconds of pre-crash data, but only recorded 58.4 milliseconds of crash data. In another NASS/CDS case, the RCM recorded only 21 milliseconds of pre-crash data, but captured 96 milliseconds of crash data. Theoretically, 142 acceleration points would allow a crash pulse of up 112.8 milliseconds in duration to be recorded.

Both RCM designs feature considerably finer resolution than the GM storage rate of one sample every ten milliseconds. However, because a faster sampling rate consumes more of the airbag module's limited memory, the Ford EDR does not record for as long as the GM EDR. As the typical crash duration is well over 100 milliseconds, these Ford EDRs may not, in fact, be capable of storing the entire event. Ford EDRs can only store a single event.

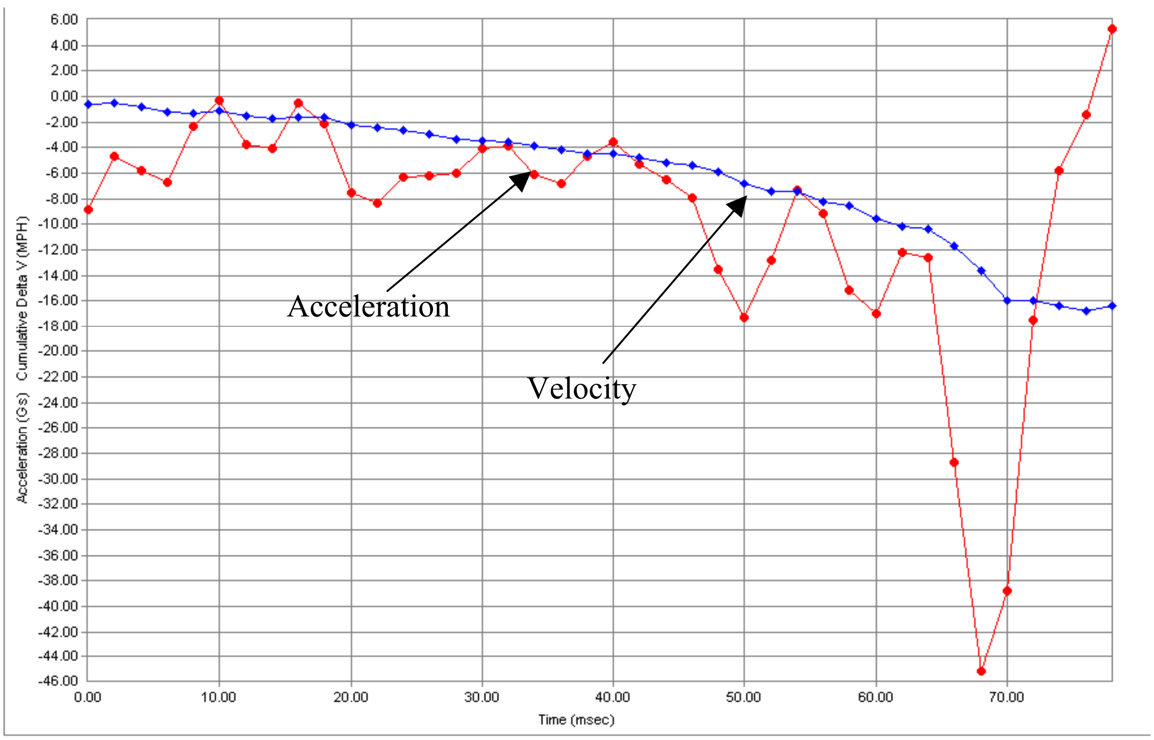

Figure 2-3. Ford Longitudinal Crash Pulse – acceleration and velocity vs. time

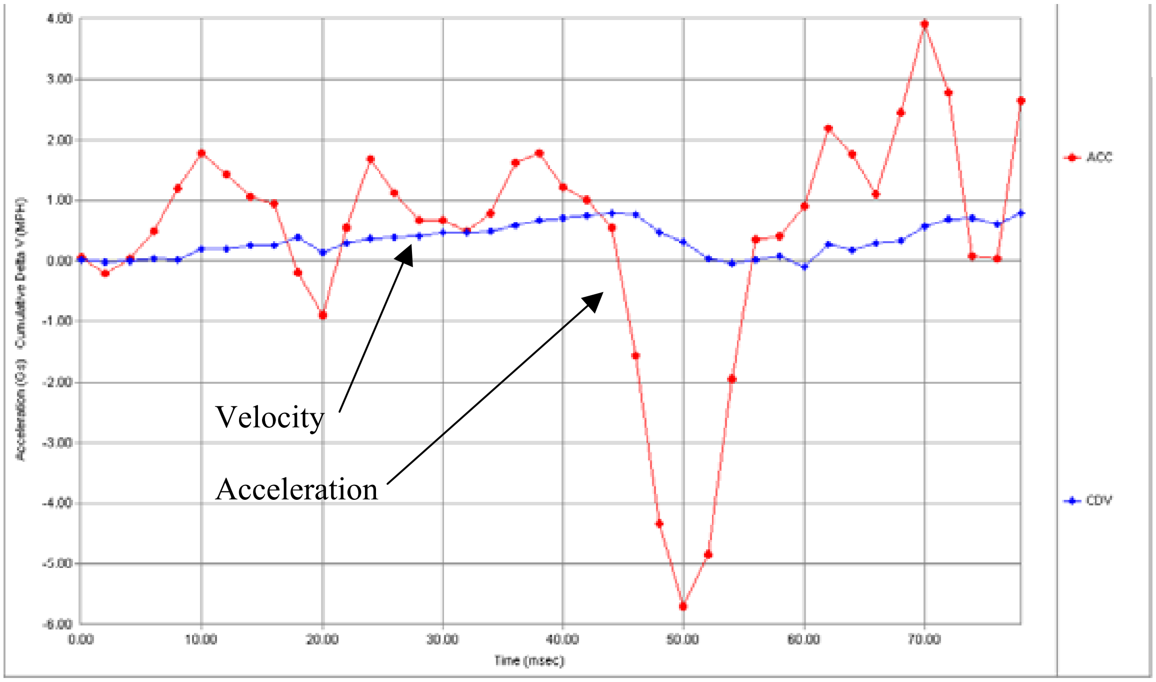

Figure 2-4. Ford Lateral Crash Pulse – acceleration and velocity vs. time

<u>Electronic Throttle Control Data Elements</u>
In addition to the data stored in the RCM, additional data elements are stored in the Power Control Module (PCM) in some late model Ford vehicle models with Electronic Throttle Control (ETC) [Ballard, 2004]. In vehicles with ETC, the accelerator pedal is not directly linked to the throttle by a cable. Instead, the accelerator pedal has sensors which provide driver inputs to the Powertrain Control Module (PCM) which controls the throttle. ETC is available on the 2004 Ford Explorer, Ford F-150, Ford Thunderbird, and Lincoln LS.

As shown in Table 2-3, the PCM with ETC stores pre-crash information. The ETC data is recorded in non-volatile memory in the event of an airbag deployment. The system will record a minimum of 20 seconds before and 5 seconds after the airbag deployment. Measurements are recorded once every 200 milliseconds [Ruth, 2004]. Currently, there is no publicly available system available to read the Power Control Module.

Table 2-3. Data Elements in Ford Power Control Modules with Electronic Throttle Control

Data Element Description
Vehicle Speed
Accelerator Pedal (%)
Brake Pedal (%)
Brake Switch Status
Throttle Position (%)
Engine Speed (RPM)
Transmission Status

2.2.3 Other Automakers

With the exception of Ford and GM, the automakers contacted by the research team would only discuss their EDRs with the understanding that any information provided was confidential. Compared with the Ford and GM EDRs, the EDRs of many, but not all, other automakers, provide only limited information pertaining to a crash. In fact, most automakers were uncomfortable with the term EDR, and preferred the designation "airbag control module with memory". Typical of the parameters stored by these more limited EDRs or airbag control modules were airbag diagnostic codes and driver seat belt status.

Several automakers told us that they were evaluating or developing more advanced EDRs. When, and if, installed in production vehicles, these more advanced devices will likely be introduced at the same time as the advanced occupant protection systems required under the recent modification to Federal Motor Vehicle Safety Standard (FMVSS) 208 requiring Advanced Airbags.

2.2.4 Estimated Number of EDRs in Production Vehicles

In 2004, an estimated 40 million registered passenger vehicles and light trucks manufactured by GM and Ford contained an EDR. This estimate is based on the following assumptions: a) annual sales of 4.5 million GM light vehicles and of 3.5 million Ford light vehicles, b) EDRs installed in all GM vehicles manufactured from 1996-2004 and 90% of Ford vehicles manufactured from 2001-2004, and c) an annual scrappage rate of 7% per year. Our estimate is a lower bound on the EDR population in the U.S. NHTSA (2004) estimates that 65 to 90 percent of all model year 2004 passenger cars and light trucks have some recording capability and that more than half record parameters such as crash pulse.

2.2.5 List of Existing Data Elements Recorded by OEMs in Production Vehicles

Table 2-4 is a compilation of all the publicly disclosed data elements stored in a production passenger vehicle. As discussed in the previous sections, only General Motors and Ford have publicly released their production vehicle EDR formats. This does not however diminish the significance of this table. The goal of this analysis was to determine the current state of the art in production EDRs – not to develop an exhaustive automaker-by-automaker list of EDR data elements.
As the majority of the remaining automakers currently provide only a subset of the data stored by GM or Ford, Table 2-4 provides a realistic snapshot of the current state of the art in OEM EDRs.

Table 2-4. Data Elements Currently Recorded by OEMs

Parameter Type	Data Element / Description	GM	Ford	Notes
Crash Pulse	Longitudinal acceleration (crash)		x	
	Lateral acceleration (crash)		x	
	Acceleration time stamp		x	
	Longitudinal Delta-V vs. time	x		
	Lateral Delta-V vs. time	x		
	Time To Max Delta-V	x		1
	Max Delta-V	x		
Pre-Crash	Longitudinal acceleration (pre-crash)		x	
	Lateral acceleration (pre-crash)		x	
	Accelerator Pedal (%)		x	
	Brake Pedal Status (on / off)	x	x	
	Brake Pedal (%)		x	
	Engine Speed (rpm)	x	x	
	Engine Throttle (%)	x	x	
	Transmission (PRNDL)		x	
	Vehicle speed	x	x	
Restraints	Pretensioner, Driver, Time to Deployment (ms)		x	1
	Pretensioner, Pass, Time to Deployment (ms)		x	1
	Frontal Airbag, Driver, Time to 1st Stage Deployment (ms)	x	x	1
	Frontal Airbag, Driver, Time to 2nd Stage Deployment (ms)	x	x	1
	Frontal Airbag, Passenger, Time to 1st Stage Deployment (ms)	x	x	1
	Frontal Airbag, Passenger, Time to 2nd Stage Deployment (ms)	x	x	1
	Seat Belt Status, Driver (buckled / unbuckled)	x	x	
	Seat Belt Status, Passenger (buckled / unbuckled)		x	
	Frontal Air Bag Suppression Switch, Passenger	x		
	Seat Track in Forward Position, Driver		x	
	Occupant Classification, Passenger (Adult, non-adult)		x	
	Side Airbag, Driver, Time to Deployment (ms)		x	1

Parameter Type	Data Element / Description	GM	Ford	Notes
	Side Airbag, Passenger, Time to Deployment (ms)		x	1
Event	Event Recording Complete	x	x	2
	Event Counter	x		3
	Time between Events	x		1, 4
General	Frontal Airbag Warning Lamp Status	x		
	Diagnostic Codes Active When Event Occurred		x	
	EDR Model Version		x	
	Prior Deployment Flag	x		
	Ignition Cycles @ Event	x		
	Ignition Cycles @ Investigation	x		

Note:

1. The definition of time zero varies from OEM to OEM and may include time of algorithm enable, time of algorithm wakeup, or time of safing sensor decision.

2. The "Event Recording Complete" data element encompasses all OEM data elements which monitor EDR recording status including the GM "Event Recording Complete" field and the Ford "Number of Invalid Recording Times" and "Data Validity Check" fields.

3. The "Event Counter" data element encompasses all OEM EDR data elements which count the number of non-deployment, deployment, or deployment-level events. This would include ">= 1 Events not recorded", "Frontal Deployment Level Event Counter", and the "Multiple Events" fields.

4. The "Time between Events" data element encompasses the GM fields "Time between non-deployment and deployment events" and Time between deployment and deployment-level events"

As summarized in Table 2-5, the recording or memory capacity of each EDR design varies considerably from OEM to OEM. Crash pulse duration ranges from a maximum of 150 milliseconds for GM to a low of 78 milliseconds for some Ford vehicle models. The GM SDM records up to 5 seconds before impact but does not record post-crash information. The Ford PCM records a minimum of 20 seconds of pre-crash and 5 seconds of post-crash data. The GM EDR, unlike the Ford EDR, is able to store more than a single event.

Table 2-5. Recording Capacity of OEM EDRs

Recording Capacity	GM	Ford
Crash Pulse Duration (milliseconds)	150	78
Pre-Crash Duration (seconds)	5	20
Post-Crash Duration (seconds)	-	5
Number of Events - maximum	2	1

2.3 Diagnostic Parameters Accessible from the OBD-II Port

Service diagnostic information available through the On Board Diagnostics II (OBD-II) ports of vehicles provides a source of potential EDR data elements. The OBD-II connector has been EPA-mandated equipment on all U.S. passenger cars and light trucks manufactured since model year 1996. Specifications for the OBD-II connector are standardized under SAE J1962 [SAE, 2002]. On the majority of vehicles, the OBD-II connector can be found under the driver instrument panel.

Although the original intent of the OBD-II connector was to allow access to engine and emissions diagnostic data, the OBD-II connector is increasingly used as an access point to the other on-vehicle computers including the EDR or airbag control module. As shown in Figure 2-5, the OBD II port provides diagnostic access to many of the vehicle onboard computers and the sensors monitored by these computers. Examples include the engine fuel management (EFI) module, antilock braking (ABS) module, automatic traction control (ATC) module, and cruise control (CC) module. If a sensor was being monitored by some onboard computer, we assumed that the data parameter was either currently being recorded or could potentially be recorded in an EDR at some point in the future.

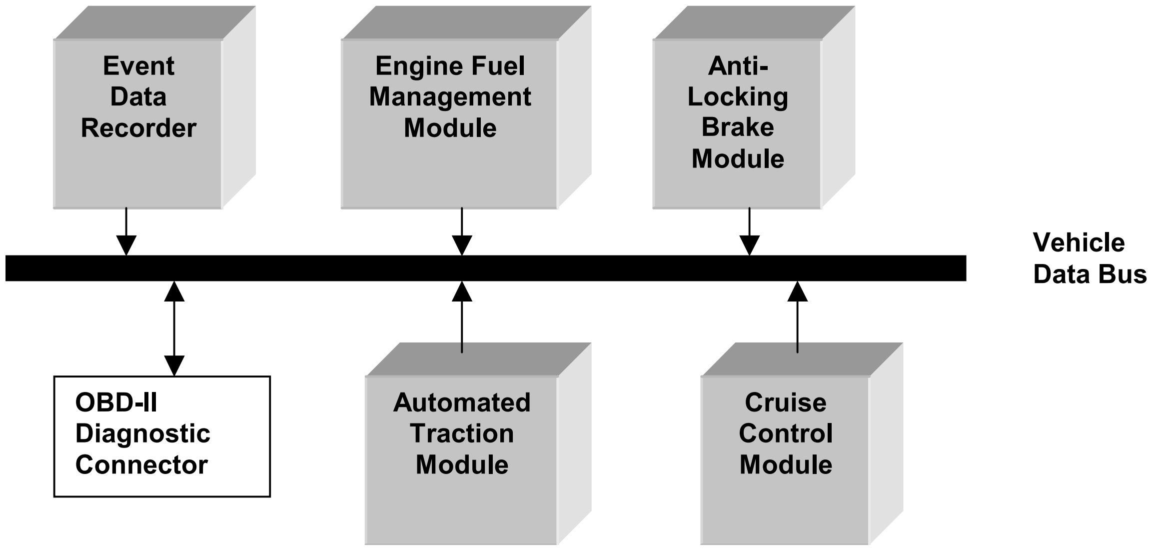

Figure 2-5. OBD-II connector provides access to onboard vehicle computers

Although a comprehensive list of the diagnostic parameters for each vehicle model is not publicly available, we theorized that we could infer which parameters were accessible by plugging a service diagnostic scan tool into a vehicle of interest. To test the feasibility of the OBD-II parameters as a source of potential data elements, the research team used a MD2009B Basic Determinator Scan Tool by Matco Tools to examine a 1997 Chevy Silverado 1500 pickup truck. A tabulation of the elements for this vehicle is provided in Table 2-6.

Table 2-6. Example of Data Elements Available from the OBD-II Connector

1997 Chevy Silverado 1500 Ex Cab 2WD 6' bed 5.7 L V8		
Data Element	**Element Definition**	**Information obtained from OBD-II**
Acc Pedal Position	% Of Wide Open Throttle	Yes (0-100%)
PRNDL	Transmission gear selection position	Yes - can be derived from trans info
RPM	Revolutions per Minute (RPM)	Yes
Speed	Given in mph or km/hr	Yes (mph)
Airbag Lamp Status	Readiness Indicator on / off	Yes (on/off)
Airbag Status	System Suppression Status on / off	Yes (on/off)
CC	Cruise Control on / off	Yes (on/off)
TS	Turn signal status left / right, on / off	Yes (on/off)
HAZ	Hazard Lamp Status on / off	Yes (on/off)
Drivers Seat Belt	Drivers Seat Belt Status	buckled / unbuckled

2.4 Heavy Truck EDR Data Elements

The Technology and Maintenance Council (TMC) of the American Trucking Associations has proposed a recommended practice for Event Data Recorders in commercial trucks. RP 1214 (T) "Guidelines for Event Data Collection, Storage and Retrieval" describes a recommended set of data elements, presented in Table 2-7, which would be useful in reconstructing a heavy truck accident.

Table 2-7. Proposed Commercial Truck EDR Data Parameters

Data Parameter	Description
Brake – engine	Engaged / Disengaged
Brake pedal switch	On / Off
Cruise Control	On, Off, speed set (mph)
Engine speed	Revolutions per minute
Engine throttle status	% applied
Odometer Reading	Miles
Time-Date	Day, Month, Year
Vehicle Speed	Miles per hour

Under the proposed recommended practice, these parameters are to be sampled at a minimum rate of once per second beginning when the engine is started. All information is to be stored in non-volatile memory for a minimum of 30 seconds before an event and 15 seconds after an event is triggered. This implies that each of these parameters would actually be stored as an array of data elements versus time. Event recording is triggered when truck deceleration is rapid. The deceleration trigger threshold is not specified by the standard, but is stated to fall between 0 and 10 mph/second. The guidelines specify that a minimum of two events shall be recorded.

Unlike the EDR formats used in cars and light trucks, the heavy truck EDR format does not include either crash pulse or occupant restraint parameters. In fact, RP 1214 recommends that the heavy truck parameters should be stored in an engine control unit (ECU) in contrast to the automaker approach of storing EDR data in the airbag control module. Although not specified under RP 1214, crash pulse and occupant restraint performance may be available by downloading the airbag control module on those trucks having this occupant protection feature.

Retrieval of the data collected under RP 1214 (T) will follow the protocols established under TMC RP 1212 "PC to User Interface Recommendations for Electronic Engines" and the proposed TMC RP 1213(T) "Component User Interface Guidelines". The proposed practice specifies that the data should be password-protected, and retrievable or reset only by the vehicle owner.

2.5 EDR Standards Groups

2.5.1 The Need for an EDR Standard

Current EDR designs were developed independently by each automaker to meet their own vehicle-specific needs. In current EDRs, there is no common format for EDR data. Both the data elements and the definition of these data elements vary from EDR to EDR. Both GM and Ford, for example, record vehicle impact response vs. time – i.e., a crash pulse. GM however stores the crash response as a velocity-time history recorded every 10 milliseconds while Ford stores the crash response as an acceleration-time history recorded every 0.8 millisecond, e.g. stored in the Ford Windstar RCM. Even for a given automaker, there may not be standardized format. The GM SDM, for example, has evolved through several generations. This lack of standardization has been an impediment to national-level studies of vehicle and roadside crash safety.

2.5.2 Status of Standards Activities

Until recently, there has been no industry-standard or recommended practice governing EDR format, method of retrieval, or procedure for archival. There are currently three professional organizations actively developing standards for highway vehicle event data recorders – (1) the IEEE P1616 Standards Working Group on Motor Vehicle Event Data Recorders, (2) the Society of Automotive Engineers (SAE) J1698 Standards Working Group on Vehicle Event Data Interfaces, and (3) the ISO/TC22/SC12/WG7 group on Traffic Accident Analysis Methodology. The status of each of the standards groups are summarized below:

- IEEE 1616. In September 2004, the IEEE Standards Association (IEEE-SA) approved the IEEE 1616 standard, Motor Event Data Recorders (MVEDR). The IEEE 1616 standard defines a minimum standard for onboard crash recorders for all types of highway vehicles including passenger cars, light trucks, heavy trucks, and buses. The IEEE P1616 working group began meeting in January 2002, and concentrated on the standardization of both candidate EDR data elements and the EDR output connector. The resulting 1616 standard includes a data dictionary of 86 data elements. The standard does not specify a minimum set of data elements, but instead provides a standardized definition for individual data elements. The IEEE 1616 group is following up this effort with development of a new standard, IEEE P1616a, “Standard for Motor Vehicle Event Data Recorders (MVEDRs) – Amendment 1: Brake and Electronic Control Unit (ECU) electronic Fault Code Data Elements.

- SAE J1698. In December 2003, the Society of Automotive Engineers (SAE) issued SAE J1698-1, a recommended practice for a Vehicle Event Data Interface (VEDI). SAE established the J1698 working group in early 2003 to develop a Vehicle Event

Data Interface (VEDI) recommended practice. The objective of the VEDI was to develop common data formats and definitions for data elements which could be stored in an Event Data Recorder. The J1698 recommended practice applies only to passenger cars and light trucks. The VEDI committee has very active participation from the automakers which suggests strong industry support for this standard.

- ISO/TC22/SC12/WG7. The objective of the ISO group, which has been meeting for several years, is to standardize the measurement of impact severity. This group is composed primarily of European participants with observers from other regions including North America. The ISO group has concentrated primarily on the development of standards for crash pulse.

2.5.3 SAE J1698 Data Elements

Table 2-8 presents a list of SAE J1698 elements (SAE, 2003). It should be noted that at the time this report was written, the J1698 committee was working on an extension to the original standard. The list of data elements is therefore subject to change. Automakers are not required to implement any of these elements. However, automakers choosing to store any of the proposed elements would use J1698 as a recommended format for storing these elements. No minimum data subset of these parameters is mandated by this recommended practice.

The J1698 effort builds on the successful installation of EDRs in current production vehicles. A comparison of Table 2-8 with the data elements from both the GM and Ford EDRs shows the strong influence of these two EDR designs upon the VEDI. Of particular interest to this project, however, are the set of proposed data elements which are not currently in EDRs, e.g., yaw rate. The strong automotive industry participation in this standard indicates that the industry considers these elements to be technically feasible for incorporation into future EDRs.

The parameters are categorized according to their sampling frequency. Three sampling frequencies have been proposed: High, Low, and Static. Parameters collected with a high sampling frequency are those data elements, e.g. crash pulse, associated with the crash event. Parameters collected with a low sampling frequency are those data elements, e.g. throttle position, collected during the pre-crash phase of an event. Static parameters, e.g. VIN or door lock status, are parameters which are not expected to change during the event. Note that parameters denoted as either High or Low Sampling Rate are actually stored as an array of data elements versus time.

Table 2-8. SAE J1698 Data Elements (Excerpted with permission from SAE J1698 © 2003 SAE International)

Sampling Rate	Parameter
High	Change in Velocity (delta-V) – Longitudinal
	Change in Velocity (delta-V) – Lateral
	Acceleration (G) – Longitudinal

	Acceleration (G) – Lateral
	Acceleration Time Stamp
Low	Vehicle Traveling Speed
	Engine Revolutions (RPM)
	Throttle Position – Engine Throttle Position
	Throttle Position –Throttle Pedal Position
	Steering Angle
	Driver Controls – Brake Pedal
	Driver Controls – Turn Signal
	Engine Torque Ratio
	Yaw Rate
	Status – Gear Position
	Status – Anti-lock brake
	Status – Traction Control
	Status – Stability Control System
Static	Vehicle Identification Number
	Seating Position
	Seatbelt Buckle Switch Status
	Foremost Seat Track Position Switch Status
	SRS Deployment Status
	SRS Deployment Time
	Maximum Recorded Delta-V
	Time to Maximum Recorded Delta-V
	Indicator Status – VEDI, SRS, PAD, TPMS, ENG, DOOR, IOD
	Vehicle Mileage
	Ignition Cycle – at Event
	Ignition Cycle – at Download
	Hours in Operation
	Latitude
	Longitude
	Accident Date
	Accident Time
	Temperature – Ambient Air
	Temperature – Cabin air
	Cruise Control System Status
	Driver Controls – Parking Brake Switch
	Driver Controls – Headlight Switch
	Driver Controls – Front Wiper Switch
	Driver Controls – Gear Selection Status
	Driver Controls – Passenger Airbag Disabling Switch
	Event Data Recording Complete

<u>Where</u>
VEDI = Vehicle Event Data Interface
SRS = Supplemental Restraint System (airbag)
PAD = Passenger Airbag Disabled
TPMS = Tire Pressure Monitoring System
ENG = Service Engine Indicator
DOOR = Door Ajar Indicator
IOD = Battery-Off Device Indicator

2.6 Government Regulatory Requirements

On June 14, 2004, the U.S. National Highway Traffic Administration (NHTSA) published a Notice of Proposed Rulemaking on Event Data Recorders (NHTSA, 2004). The Notice of Proposed Rulemaking (NPRM) is a proposal to:

(1) Require that EDRs voluntarily installed in light vehicles record a minimum set of specified data elements useful for accident investigation, analysis of occupant restraint systems, and automatic crash notification systems

(2) Specify required formats for EDR data elements

(3) Specify requirements for EDR crash survivability

(4) Require vehicle manufacturers to publicly release information to allow accident investigators to retrieve data from the EDR

(5) Require vehicle manufacturers to include a standardized statement in the vehicle owner's manual informing the owner that the vehicle is equipped with an EDR and briefly explaining the purpose of an EDR.

It is important to note that the proposed rule will only apply to EDRs voluntarily installed in passenger cars and light trucks by vehicle manufacturers. The proposed rule does not require the installation of EDRs in any motor vehicles. At the time of this report, NHTSA had taken no final action on the NPRM.

NHTSA Actions preceding the NPRM

Preceding the publication of the NPRM, NHTSA issued a Request for Public Comments on Event Data Recorders on October 11, 2002 (NHTSA, 2002b). The Request for Comments was motivated, to some degree, by the findings of two NHTSA EDR working groups (NHTSA, 2001 and NHTSA, 2002a), and a petition by Ricardo Martinez, former NHTSA administrator, which requested that NHTSA mandate the installation of EDRs in motor vehicles. The Request for Comments asked for comments on a range of EDR-related topics including the proper role of NHTSA in regulation of EDRs, expected safety benefits, technical issues, and privacy issues. NHTSA received comments from vehicle manufacturers, vehicle users, the medical community, insurance organizations, safety advocate organizations, safety research groups, crash investigators, academia, and government agencies [NHTSA, 2004].

Of particular importance to this study was the belief by a wide spectrum of the commenters, ranging from the vehicle manufacturers to the safety advocate groups, that EDRs will improve safety by providing the key information necessary for crash analysis, a better understanding of injury mechanisms, and data for the improvement of both vehicle and highway design. Two of the commenters, Consumers Union and the

Insurance Institute for Highway Safety, submitted lists of proposed data elements. These data elements included crash pulse, safety belt usage, airbag deployment status, vehicle identification number, and pre-crash information, e.g. brake application, engine speed, and throttle position. Many commenters pointed out the desirability of standardization of EDR data.

Required EDR Data Elements

NHTSA has developed a minimum set of required EDR data elements based upon the data needs of accident investigation, analysis of occupant restraint systems, and automatic crash notification systems. The minimum set includes both pre-crash and crash parameters. The NPRM further specifies minimum recording duration and minimum sampling frequency. Up to three (3) events are to be stored under the proposed rule.

The list of required data elements is further divided into two subsets. Vehicles are required to record all elements in the first subset, shown in Table 2-9, if a vehicle stores any one or more of the data elements listed in the 'Data Element Triggers' column of this table. To maximize technical and economic feasibility, this first subset includes only data elements currently being recorded in production passenger car or light truck EDRs. Vehicles with instrumentation beyond that specified in Table 2-9 are required to store any element in Table 2-10 which the vehicle is equipped to measure. This strategy of requiring that more advanced instrumentation be recorded only if equipped, should make compliance with the proposed rule more economically feasible for vehicle manufacturers.

Table 2-9. Data Elements Required for all Vehicles Equipped with an EDR

Data Element	Recording Time / Interval (relative to time of impact) in seconds	Data Sample Rate (Samples per Second)	Data Element Triggers application of Regulation
Longitudinal Acceleration	t=-0.1 to 0.5 sec	500	Y
Maximum Delta-V	Computed after each event	NA	Y
Speed, Vehicle indicated	t=-8.0 to 0.0 sec	2	Y
Engine RPM	t=-8.0 to 0.0 sec	2	Y
Engine Throttle (% full)	t=-8.0 to 0.0 sec	2	Y
Service Brake (on/off)	t=-8.0 to 0.0 sec	2	Y
Ignition Cycle at Crash	t=-1.0 sec	NA	Y
Ignition Cycle at Download	At time of download	NA	Y
Safety Belt Status (buckled, not buckled)	t=-1.0 sec	NA	Y
Frontal air bag warning lamp (on/off)	t=-1.0 sec	NA	Y
Frontal air bag deployment level – driver	For each Event	NA	Y
Frontal air bag deployment level – right front passenger	For each Event	NA	Y
Frontal air bag, time to deploy (in case of	For each Event	NA	Y

Data Element	Recording Time / Interval (relative to time of impact) in seconds	Data Sample Rate (Samples per Second)	Data Element Triggers application of Regulation
single stage air bag) or time to deploy first stage (in case of multi-stage air bag) - driver			
Frontal air bag, time to deploy (in case of single stage air bag) or time to deploy first stage (in case of multi-stage air bag) – right front passenger	For each Event	NA	Y
Number of Events (1,2,3)	After each event	NA	-
Time from Event 1 to 2	As needed	NA	-
Time from Event 1 to 3	As needed	NA	-
Complete File Recorded (yes/no)	Following other data	NA	-

Table 2-10. Data Elements Required for Vehicles Under Specified Conditions

Data Element	Condition for Requirement	Recording Time / Interval (relative to time of impact) in seconds	Data Sample Rate (Samples per Second)
Lateral Acceleration	If vehicle equipped to measure vehicle's lateral (y) acceleration	t=-0.1 to 0.5 sec	500
Normal Acceleration	If vehicle equipped to measure vehicle's normal (z) acceleration	t=-0.1 to 0.5 sec	500
Vehicle Roll Angle	If vehicle equipped to measure or compute vehicle roll angle	t=-0.1 to 6.0 sec	10
ABS activity (engaged / non-engaged)	If vehicle equipped with ABS	t=-8.0 to 0.0 sec	2
Stability control (on / off / engaged)	If vehicle equipped with stability control, ESP, or other yaw control system	t=-8.0 to 0.0 sec	2
Steering Input (steering wheel angle)	If vehicle equipped to measure steering wheel angle	t=-8.0 to 0.0 sec	2
Safety belt status – right front passenger (buckled, not buckled)	If vehicle equipped to measure safety belt buckle latch status for the right front seat passenger	t = -1.0	N.A.
Frontal air bag suppression switch status – right front	If vehicle equipped with a manual switch to suppress the frontal	t = -1.0	N.A.

Data Element	Condition for Requirement	Recording Time / Interval (relative to time of impact) in seconds	Data Sample Rate (Samples per Second)
passenger	air bag for the right front passenger		
Frontal air bag deployment, time to nth stage deployment – driver (Repeat for each of the n stages)	If vehicle equipped with a driver's frontal air bag with a multi-stage inflator	Event	N.A.
Frontal air bag deployment, time to nth stage deployment – right front passenger (Repeat for each of the n stages)	If vehicle equipped with a right front passenger's frontal air bag with a multi-stage inflator	Event	N.A.
Frontal air bag deployment, nth stage disposal - driver (yes/no, whether the nth stage deployment was for occupant restraint or disposal) (Repeat for each of the n stages)	If vehicle equipped with a driver's frontal air bag with a multi-stage inflator that can be ignited for the sole purpose of disposing the propellant	Event	N.A.
Frontal air bag deployment, nth stage disposal – right front passenger (yes/no, whether the nth stage deployment was for occupant restraint or disposal) (Repeat for each of the n stages)	If vehicle equipped with a right front passenger's frontal air bag with a multi-stage inflator that can be ignited for the sole purpose of disposing the propellant	Event	N.A.
Side air bag deployment, time to deploy, driver	If vehicle is equipped with a side air bag for the driver	Event	N.A.
Side air bag deployment, time to deploy, right front passenger	If vehicle is equipped with a side air bag for the right front passenger	Event	N.A.
Side curtain/tube deployment, time to deploy, driver	If vehicle is equipped with a side curtain or tube air bag for the driver	Event	N.A.
Side curtain/tube deployment, time to deploy, right front passenger	If vehicle is equipped with a side curtain or tube air bag for the right front passenger	Event	N.A.
Pretensioner deployment, time to fire, driver	If vehicle is equipped with a pretensioner for the driver	Event	N.A.
Pretensioner deployment, time to	If vehicle is equipped with a pretensioner for	Event	N.A.

Data Element	Condition for Requirement	Recording Time / Interval (relative to time of impact) in seconds	Data Sample Rate (Samples per Second)
fire, right front passenger	the right front passenger		
Seat position, driver passenger (Is the seat is in a forward seat position? yes/no)	If the vehicle is equipped to determine whether or not the driver seat is in a forward seat position	t = -1.0	N.A.
Seat position, passenger (Is the seat is in a forward seat position? yes/no)	If the vehicle is equipped to determine whether or not the right front passenger seat is in a forward seat position	t = -1.0	N.A.
Occupant Size Classification, driver (is driver a 5th percentile female? yes/no)	If the vehicle is equipped to determine the size classification of the driver	t = -1.0	N.A.
Occupant Size Classification, right front passenger (is passenger a child? yes/no)	If the vehicle is equipped to determine the size classification of the right front passenger	t = -1.0	N.A.
Occupant Position, driver (is driver out of position? yes/no)	If the vehicle is dynamically determine the position of the driver	t = -1.0	N.A.
Occupant Position, right front passenger(is right front seat passenger out of position? yes/no)	If the vehicle is dynamically determine the position of the right front seat passenger	t = -1.0	N.A.

2.7 Data Elements in Automated Crash Notification Systems

Several automakers market or have marketed an optional Automated Crash Notification system for their vehicles. Examples include the General Motors OnStar system and the Ford Rescu system. The idea behind Automated Crash Notification is to equip cars with a crash sensor which can detect that an accident has taken place, an onboard GPS system to locate the crash site, and a wireless modem which can automatically notify the emergency medical personnel of the severity and precise location of an accident.

Although the focus of this project was not on Automated Crash Notification (ACN) systems, the data elements stored or transmitted by ACN systems are an additional source of potential future data elements for EDRs. One example of an advanced ACN system is the research system developed by Veridian [Kanianthra et al, 2001]. The Veridian system transmits an emergency message containing the following data elements:

Table 2-11. Veridian Automated Collision Notification System Data Elements

Parameter	Description
Crash Date	
Crash Time	
Seat Belt Used	Yes / No
Crash Location – Latitude	
Crash Location – Longitude	
Crash Delta-V	
Crash Type	Frontal, Side, or Rear
Rollover	Yes / No
Vehicle final resting position	Normal / Left Side / Right Side / Roof
Principal Direction of Force	
Probable Number of Occupants	
Make of Car	
Model of Car	
Model Year of Car	

Note: Using the onboard clock, another important aspect of the crash event, the date and time of accident notification, could also be recorded.

2.8 Data Elements from Aftermarket Event Data Recorders

Aftermarket EDRs are designed for retrofit to highway vehicles which either do not have an EDR or required extended monitoring capabilities. Commercial applications include monitoring of fleets, e.g. taxicabs or limousines. Aftermarket EDRs provide an important source of potential data elements for studying roadside crash safety. Table 2-12 lists the data elements recorded in a number of aftermarket EDRs. Data elements stored in these systems are technically feasible, and of interest to crash safety researchers. However, as these devices are not inexpensive, the cost-to-benefit ratio of some of these data parameters, e.g. video, may not favor widespread implementation.

Comparison of the aftermarket and OEM EDR capabilities indicates that most of the aftermarket EDR data elements have been implemented in OEM devices. Important exceptions are onboard video cameras, microphones, and vehicle driving direction. In addition, some aftermarket devices include application-specific features such as lap counters for racing and emergency vehicle data parameters, e.g. siren activation.

Several of the aftermarket devices have greater capability than OEM EDRs in sampling frequency, recording duration, and the number of events which can be stored. For example, the Siemens-VDO device can store 30 seconds of pre-crash and 15 seconds of post-crash information. By comparison, the GM EDR can only store 5 seconds of pre-crash data and does not store post-crash information. The Siemens-VDO device can store up to 12 events while the GM device can only store 2 events and the Ford device can only store a single event. The Instrumented Sensor Technology device records one sample every 0.5 milliseconds. By contrast, the GM EDR a delta-V measurement once every 10 milliseconds and the Ford EDR records only one sample every 0.8 milliseconds.

Table 2-12. Aftermarket Manufacturer EDR Data Elements and Features

Manufacturer / Model	Data Recorded	Limits & Sampling Rates
Delphi ADR 2	• Wheel Speed • Throttle Position • Steering Angle • Lap Indicator • X-Axis Acceleration • Y-Axis Acceleration • Z-Axis Acceleration • Yaw Rate • Real Time Clock • 7 General purpose analog inputs • 3 General Purpose Timer inputs	• Pre – crash • Crash • Post Crash info • Sampling Rate: 1000 Hz
I-Witness DriveCam I	• B & W video camera • Microphone • X-Axis Acceleration	• 10 sec pre-crash • 10 sec post-crash • Sampling Rate: 60 Hz

Manufacturer / Model	Data Recorded	Limits & Sampling Rates
	• Y-Axis Acceleration • Z-Axis Acceleration • Real time clock	
Siemens-VDO	• Engine ignition information – time started & how long • Headlights on/off • Turn signals on/off • Brakes on/off • X-Axis Acceleration • Y-Axis Acceleration • Vehicle Speed • Vehicle Direction • Distance Traveled • Optional emergency vehicle functions (e.g. siren)	• 30 sec pre-crash • 15 sec post-crash • Up to 12 different events stored
Independent Witness Incorporated - Witness Black Box	• Date • Time • Vehicle Direction • Acceleration	
Instrumented Sensor Technology – IST Model EDR-3	• X-Axis Acceleration • Y-Axis Acceleration • Z-Axis Acceleration	• 0.5 sec pre-crash • 1.5 sec post-crash • Sampling Rate: 2000 Hz

2.9 Longer-term, Technically Feasible, Data Elements

Several research studies are underway which are using or developing new sensor technologies which may appear in future EDRs. Examples of these advanced sensors include cell phone monitors and real time video of both the driver and the driver's view. Although these sensors are technically feasible, their economic feasibility for installation as standard equipment has not yet been established. Nevertheless it is important to be aware of these technologies as potential longer-term additions to future EDR designs. Table 2-13 presents the data elements either being monitored or stored in these research EDRs.

Table 2-13. Research EDR Data Elements and Features

Manufacturer / Model	Data Recorded	Limits & Sampling Rates
Folksam research – Crash Pulse Recorder – Kullgren et al (1995)	• X-Axis Acceleration	• Sampling Rate: 1000 Hz
Rowan University – Crash Data Recorder (CDR)	• X-axis acceleration • Y-axis acceleration	• Sampling Rate: 1000 Hz
Safety Intelligence Systems MACBOX	• Vehicle Speed • Driver Belt Status • Vehicle Acceleration in 3-axes • Driver's Eye View video • Cell phone on/off • Distance to car in front • Location (GPS)	• Pre – crash • Crash • Post Crash info
NHTSA MicroDAS (Barickman and Goodman, 1999)	• Location (GPS) • Throttle Position • Lateral Lane Position • Distance to car in front • Vehicle Speed • Brake Application • Vehicle Acceleration in 3 axes • Yaw Rate • Roll Rate • Pitch Rate • Steering wheel angle • Turn-signal on/off • Driver Video • Other Researcher-defined	• Up to 32 analog inputs • 24 digital I/O channels • 22 hours of compressed video

Volvo Research EDR

Volvo has developed an advanced EDR for research purposes. This EDR, which is comprised of the Digital Accident Research Recorder (DARR) and the Pre-Crash Recorder (PCR), records both crash and pre-crash data as well as controls the safety systems. Table 2-14 lists the data elements that are stored in either the DARR (Andersson et al, 1997) or the PCR (Engstrom, 2001).

The DARR is integrated with the airbag sensor unit and is installed in production Volvo passenger cars. The DARR records approximately 100 milliseconds of data when the airbag deploys. Only longitudinal crash pulse is stored. The PCR was installed in a Volvo S-80 for evaluation purposes. Although this is a research system – not a production system, the Volvo system nevertheless provides a glimpse of what EDR data elements are considered important and technically feasible by a major automaker.

Table 2-14. Volvo's EDR system, Comprised of the DARR and the PCR

Parameter Type	Parameter	DARR	PCR
Pre-Crash	Steering Wheel Angle		x
	Lateral Acceleration		x
	Longitudinal Acceleration		x
	Vehicle Speed		x
	Yaw Rate		x
	Roll Rate		x
	Engine Speed		x
	Transmission (PRNDL)		x
	Driver Requested Torque		x
	Engine Torque		x
	Brake Pedal Position		x
	Clutch Pedal Position		x
	Stability Traction Control (on/off)		x
General	Outdoor Temperature		x
	Global Time		x
	Time since Ignition on		x
Crash Pulse	Longitudinal Deceleration Pulse	x	

2.10 Summary of Existing and Potential EDR Data Elements

Table 2-15 presents a summary of existing and potential EDR data elements by their source. It is interesting to note how many data elements the NHTSA NPRM and the SAE J1698 have in common with EDRs currently in production vehicles.

Table 2-15. Existing and Potential EDR Elements by Source

Data Parameter	OEM EDR	NHTSA NPRM	SAE J1698	OBD-II	TMC	ACN	After market	Research EDR
Longitudinal acceleration	x	x	x				x	x
Lateral acceleration	x	x	x				x	x
Acceleration time stamp	x		x					
Longitudinal Delta-V vs. time	x		x					
Lateral Delta-V vs. time	x		x					
Time To Max Delta-V	x		x					
Max Delta-V	x	x	x			x		
Accelerator Pedal (%)	x		x	x	x		x	x
Brake Pedal Position (on / off)	x	x	x		x		x	x
Brake Pedal (%)	x							
Engine Speed (rpm)	x	x	x	x	x			x
Engine Throttle (%)	x	x	x					
Transmission / Gear Selection (PRNDL)	x		x	x				x
Vehicle speed	x	x	x	x	x		x	x
Pretensioner, Driver, Time to Deployment	x	x	x					
Pretensioner, Pass, Time to Deployment	x	x	x					
Frontal Airbag, Driver, Time to 1st Stage Deployment	x	x	x					
Frontal Airbag, Driver, Time to 2nd Stage Deployment	x	x	x					
Frontal Airbag, Passenger, Time to 1st Stage Deployment	x	x	x					
Frontal Airbag, Passenger, Time to 2nd Stage Deployment	x	x	x					
Seat Belt Status, Driver (buckled / unbuckled)	x	x	x	x		x		x
Seat Belt Status, Passenger (buckled / unbuckled)	x	x	x			x		
Frontal Air Bag Suppression Switch, Passenger	x	x	x	x				
Seat Position, Driver, Seat in Forward Seat Position	x	x	x					
Seat Position, Passenger, Seat in Forward Seat Position		x	x					

Data Parameter	OEM EDR	NHTSA NPRM	SAE J1698	OBD-II	TMC	ACN	After market	Research EDR
Occupant Size Classification, Driver (Adult, Small Adult)		x						
Occupant Size Classification, Passenger (Adult, non-Adult)	x	x						
Side Airbag Driver, Time to Deployment	x	x	x					
Side Airbag, Passenger, Time to Deployment	x	x	x					
Side Curtain/Tube Driver, Time to Deployment	x	x	x					
Side Curtain/Tube Passenger Time to Deployment	x	x	x					
Diagnostic Codes Active When Event Occurred	x		x					
Event Counter	x	x						
Event Recording Complete	x	x	x					
Time between Events	x	x						
Prior Deployment Flag	x							
Frontal Airbag Warning Lamp Status	x	x	x	x				
EDR Model Version	x							
Ignition Cycles @ Event	x	x	x					
Ignition Cycles @ Investigation	x	x	x					
Frontal air bag deployment level – driver		x						
Frontal air bag deployment level – right front passenger		x						
Normal Acceleration		x					x	x
Vehicle Roll Angle		x				x		
Antilock braking (engaged / non-engaged)		x	x					
Stability control (on / off / engaged)		x	x					x
Steering Input (steering wheel angle)		x	x				x	x
Frontal air bag deployment nth stage disposal – driver		x						
Frontal air bag deployment nth stage disposal – passenger		x						
Occupant Position, Driver, out of position		x						
Occupant Position, Passenger out of position		x						
Driver Controls - Turn Signal			x	x			x	x
Engine Torque (%)			x					x

Data Parameter	OEM EDR	NHTSA NPRM	SAE J1698	OBD-II	TMC	ACN	After market	Research EDR
Yaw Rate			x				x	x
Traction Control Status			x					x
Vehicle Identification Number			x					
Indicator Status - VEDI			x					
Indicator Status - Tire Pressure Monitoring System			x					
Indicator Status - Service Engine Lamp			x					
Indicator Status - Door Ajar			x					
Indicator Status - Ignition Off Device			x					
Vehicle Mileage			x		x			
Hours in Operation			x				x	x
Crash Location (Latitude and Longitude)			x			x		x
Crash Date			x		x	x	x	
Crash Time			x		x	x	x	x
Temperature - Ambient Air			x					x
Temperature - Cabin Air			x					
Cruise Control System Status			x	x	x			
Parking Brake Switch			x					
Headlight Switch			x				x	
Front Wipers Switch			x					
Hazard Lights Switch				x				
Brake Status, Engine (on / off)					x			
Crash Type (Frontal, Side, Rear)						x		
Principal Direction of Force						x		
Number of Occupants						x		
Accident Notification – Date and Time						x		
Driver Video Camera							x	x
Driver's Eye View Video Camera								x
Microphone							x	
Engine - time started							x	

Data Parameter	OEM EDR	NHTSA NPRM	SAE J1698	OBD-II	TMC	ACN	After market	Research EDR
Vehicle Direction / Heading							x	
Distance Traveled							x	
Siren Status (On / Off)							x	
Cell Phone (On / Off)								x
Distance to car in front / headway								x
Lateral Lane Position								x
Roll Rate								x
Pitch Rate								x
Driver Requested Torque								x
Clutch Pedal Position								x

2.11 Conclusions

The objective of the preceding analysis was to determine existing and potential EDR data elements. Table 2-16 groups these data elements into three categories based on their technical and economic feasibility:

1. Current EDR Technology. This category contains the publicly disclosed EDR formats of GM and Ford. Because the automakers record the data elements shown under Existing Data Elements in their production vehicles, we may assume that these data elements are both technically and economically feasibility.

2. Near-Term EDR Technology. This category includes data elements from sensors which are currently on production vehicles, but are not currently recorded in an EDR. Because the sensors are currently installed on production vehicles, we may assume both technical and economic feasibility of the sensor. The category 'Near-Term EDR Technology' includes (1) data elements specified in the NHTSA NPRM on EDRs, (2) data elements defined in SAE J1698, (3) safety-related diagnostic parameters available through the OBD-II connector, and (4) data elements defined by the Technology and Maintenance Council.

3. Future EDR Technology. This category includes data elements associated with sensors which are either commercially available or used in research. The sensors are not standard equipment on current production vehicles. These sensors are technically feasible, but the economic justification for installing them as standard equipment is unknown at this time. Elements in this category include (1) data elements used in Automated Crash Notification systems, (2) data elements currently stored in aftermarket EDRs, and (5) longer-term safety-related sensors stored in research EDRs.

Table 2-16. Current and Potential EDR Data Elements

Data Element / Description	Current EDR Technology	Near Term EDR Technology	Future EDR Technology
Accelerator Pedal (%)	x		
Brake Pedal (%)	x		
Brake Pedal Position (on / off)	x		
Diagnostic Codes Active When Event Occurred	x		
EDR Model Version	x		
Engine Speed (rpm)	x		
Engine Throttle (%)	x		
Event Counter	x		
Event Recording Complete	x		
Frontal Air Bag Suppression Switch, Passenger	x		
Frontal Airbag Warning Lamp Status	x		

Data Element / Description	Current EDR Technology	Near Term EDR Technology	Future EDR Technology
Frontal Airbag, Driver, Time 2nd Stage Deployment	x		
Frontal Airbag, Driver, Time to 1st Stage Deployment	x		
Frontal Airbag, Passenger, Time to 1st Stage Deployment	x		
Frontal Airbag, Passenger, Time to 2nd Stage Deployment	x		
Ignition Cycles @ Event	x		
Ignition Cycles @ Investigation	x		
Longitudinal acceleration	x		
Lateral acceleration	x		
Acceleration time stamp	x		
Longitudinal Delta-V vs. time	x		
Lateral Delta-V vs. time	x		
Max Delta-V	x		
Occupant Size Classification, Passenger (Adult, non-Adult)	x		
Pretensioner, Driver, Time to Deployment	x		
Pretensioner, Pass, Time to Deployment	x		
Prior Deployment Flag	x		
Seat Belt Status, Driver (buckled / unbuckled)	x		
Seat Belt Status, Passenger (buckled / unbuckled)	x		
Seat Position, Driver, Seat in Forward Seat Position	x		
Side Airbag Driver, Time to Deployment	x		
Side Airbag, Passenger, Time to Deployment	x		
Side Curtain/Tube Driver, Time to Deployment	x		
Side Curtain/Tube Passenger Time to Deployment	x		
Time between Events	x		
Time To Max Delta-V	x		
Transmission / Gear Selection (PRNDL)	x		
Vehicle speed	x		
Antilock braking (engaged / non-engaged)		x	
Brake Status, Engine (on / off)		x	
Crash Date		x	
Crash Location (Latitude and Longitude)		x	
Crash Time		x	
Cruise Control System Status		x	
Driver Controls - Turn Signal		x	
Engine Torque (%)		x	
Front Wipers Switch		x	
Frontal air bag deployment level – driver		x	
Frontal air bag deployment level – right front passenger		x	
Frontal air bag deployment nth stage disposal – driver		x	
Frontal air bag deployment nth stage disposal – passenger		x	
Hazard Lights Switch		x	
Headlight Switch		x	

Data Element / Description	Current EDR Technology	Near Term EDR Technology	Future EDR Technology
Hours in Operation		x	
Indicator Status - Door Ajar		x	
Indicator Status - Ignition Off Device		x	
Indicator Status - Service Engine Lamp		x	
Indicator Status - Tire Pressure Monitoring System		x	
Indicator Status - VEDI		x	
Normal Acceleration		x	
Occupant Position, Driver, out of position		x	
Occupant Position, Passenger out of position		x	
Occupant Size Classification, Driver (Adult, Small Adult)		x	
Parking Brake Switch		x	
Seat Position, Passenger, Seat in Forward Seat Position		x	
Stability control (on / off / engaged)		x	
Steering Input (steering wheel angle)		x	
Temperature - Ambient Air		x	
Temperature - Cabin Air		x	
Traction Control Status		x	
Vehicle Identification Number		x	
Vehicle Mileage		x	
Vehicle Roll Angle		x	
Yaw Rate		x	
Cell Phone (On / Off)			X
Siren Status (On / Off)			X
Clutch Pedal Position			X
Crash Type (Frontal, Side, Rear)			X
Distance to car in front / headway			X
Distance Traveled			X
Driver Requested Torque			X
Driver Video Camera			X
Driver's Eye View Video Camera			X
Engine - time started			X
Lateral Lane Position			X
Microphone			X
Number of Occupants			X
Accident Notification – Date and Time			X
Pitch Rate			X
Principal Direction of Force			X
Roll Rate			X
Vehicle Direction / Heading			X

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3. EDR Data Needs for Roadside Safety Analyses: Identification and Prioritization

3.1 Objective

The success of roadside and vehicle safety research is critically dependent upon the validity and consistency of collected crash data. To date, a majority of the accident database elements are collected or derived based on post-crash investigation. The analysis of highway crashes has often been hindered by errors in the accuracy of the collected data as well as the unmet need for data which could not be collected with traditional methods.

The objective of this component of the study was to catalog and prioritize EDR data needs which support vehicle and roadside safety research and design. The specific objectives were to determine the potential of EDR technology (1) to augment data collection for existing roadside and vehicle accident databases, and (2) to support future roadside safety research needs by providing a new source of crash data previously not feasible to collect.

3.2 Methodology

The following section summarizes the overall methodology followed to achieve this objective. A more detailed description of each step is provided later in this report.

1. **Identify Roadside Safety Data Needs.** This study pursued several avenues to methodically identify additional data elements that could be captured using EDR technology. Candidate data elements fell into two categories: (1) data elements, currently being collected manually, which could be collected by EDRs, and (2) data elements which have not been collected because the data collection capabilities of EDRs were not previously available.

   <u>Analysis of Existing Accident Databases</u>**.** One important use of EDR data will be replace or improve data collection for the accident databases. The research team methodically examined eight existing crash databases and three recommended database formats for candidate EDR data element needs. The databases included U.S. national accident databases, state accident databases, specialized roadside safety databases, and specialized commercial truck accident databases. The research team also examined recommended database formats or extensions including the Minimum Model Uniform Crash Criteria (MMUCC), NCHRP 350 data requirements, and NCHRP 22-15 recommended data extensions to NASS/CDS.

Literature Review of Roadside Safety Data Needs. The research team conducted an extensive review of the roadside safety technical literature to identify recommended improvements to data elements presently collected, and to identify data elements not presently captured that could be of significant value to the roadside safety community.

2. **Develop a Catalog of Potential EDR Data Elements.** Not all data elements needed for roadside safety analysis can be captured in an EDR. Fundamentally, an EDR is a vehicle-mounted device and can record only what can be measured from the vehicle. The performance of roadside features however can sometimes be inferred from the performance of the vehicle. After analysis of the data elements in each database and the technical literature, a comparison was made with the listing of current and potential EDR capabilities to ascertain potential data elements. The extraction process resulted in a catalog of elements representing the intersection of feasible EDR data elements and matching data element needs. The data elements from each of these data sources were merged into a data catalog of recommended EDR Data Elements for highway crash data analysis.

3. **Prioritize Candidate Data Elements that could be collected from EDRs.** Because there may be insufficient memory in an EDR to store all data elements of interest, the candidate data elements were prioritized by their importance to roadside safety analyses. This chapter presents the results of a priority ranking exercise conducted in collaboration with the AASHTO Task Force for Roadside Safety.

3.3 Literature Review of Roadside Safety Data Needs

One of the crucial long-term benefits of EDRs will be their influence on highway crash safety research. The ready availability of real-world crash pulses in an EDR database will enable vehicle and roadside safety researchers to address a number of elusive research questions. Using EDR data it may be possible to conduct research to address several long-standing, and often technically controversial, issues. Many of these issues are the subject of current or previous NCHRP projects. Potential research questions on which EDR data may provide unique insights include:

- How relevant are the impact conditions used in NCHRP 350?
- For roadside crashes, is there a linkage between vehicle acceleration and occupant injury? How realistic is the flail space model when evaluated against actual EDR crash pulses and hospital injury records?
- Are current vehicle designs compatible with current roadside safety hardware designs?
- Do impacts with soft roadside safety devices, e.g. crash cushions, lead to late airbag deployments?

- Are advanced occupant restraint systems, e.g., dual stage inflator systems, performing as designed?
- How accurate are the delta-V estimates in U.S. national accident databases?
- What is the distribution of impact speeds as a function of roadside object struck?
- Coupling EDR pre-impact data with highway design data, what are the relationships between highway geometric design and the probability of a runoff road event?

The roadside safety literature was methodically reviewed to search for candidate EDR elements. Several previous research studies, described here, have explicitly recommended the collection of additional accident data elements to support improved roadside safety research. Although the original authors of these studies may have intended for these data to be collected with conventional accident investigation techniques, EDRs offer a promising new method of accident data collection. The availability of EDRs may allow access to data elements currently not collected, and may provide more accurate measurement of elements already being collected.

The technical literature is also an excellent source of future research needs from which future data needs can be inferred. In fact, most of the current literature focuses on research needs in general, as opposed to specific data needs. Note that our goal in identifying research needs was solely to deduce additional data needs. The list of research needs presented in this chapter is by no means exhaustive. Future research efforts, e.g. the vehicle rollover problem, will undoubtedly expand on this list, and lead to new data element requirements.

Table 3-1 presents a summary of the roadside safety data needs identified from the literature review. Each column indicates the source where a particular data element was suggested explicitly (designated with an “X”) or implied from research needs (designated with an “I”). An annotated bibliography of the sources used for this study is provided in the appendices. The data element needs were compared with the table of existing and potential EDR data elements. Because an EDR is vehicle-mounted, the device is, of course, limited to what can be measured on the vehicle. Table 3-2 shows that many of the recommended data elements can be obtained either from existing EDR devices or may be recorded in future EDR designs.

One critical data need, which can be provided by future EDRs, was knowledge of the pre- and post-crash vehicle trajectory. Another critical research need, which can be provided by future EDRs, is the orientation of the vehicle (yaw, pitch, roll) at the time of impact. Many of the data element needs can be obtained if the EDR contains VIN. The VIN contains complete information on the vehicle make, model, year, and curb weight. When these identifiers are combined with a database such as the NHTSA Vehicle Parameter database [McCullough et al, 1995], the data needs for vehicle geometry can also be obtained.

The first research which uses EDR data to study highway crash safety is now beginning to be published. The pioneering research in using EDR to study highway crash injuries was performed by Kullgren et al (1995, 1998, 2000) using the Crash Pulse Recorder, a retrofit EDR developed specifically for these research studies. Gabler et al (2004) used production vehicle EDR data to validate the accuracy of delta-V estimates of crash severity. Gabauer and Gabler (2004; 2005) utilized production EDR data to evaluate the the flail space model and the acceleration severity index used as injury criteria in roadside safety hardware crash testing.

Table 3-1. Data Needs for Roadside Safety Analysis as expressed in the Research Literature

Data Element	Viner, January 1995	Mak, 1995	Hunter and Council, 1996	Mak and Sicking, 1994	Ross et al., 1988	Viner, July 1995	Ray et al., 1995	Mak et al., 1986	Hall et al., 1994	Ray et al., 1986	Mak, 1983	Council et al., 1993	Michie, 1996	Powers et al., 1995	Mak et al, 2000	Eskandarian et al., 2002	Powers, 1996	Ray et al., 1998	Glennon & Wilton, 1974
Average Daily Traffic		X	X	X				I							X				
Roadway Horizontal Curvature		X	X	X				I			X				X				
Roadway Vertical Alignment		X	X	X				I			X				X				
Speed Limit								I											
Number of Lanes				X											X				
Lane Width				X				I			X				X				
Presence of Median				X							I				X				
Median Width				X							I				X				
Presence of Paved Shoulder				X							X				X				
Shoulder Width				X				I			I				X				
Presence of Intersection				X															
Clear Zone Width				X							I				X				
Roadside Slope		X		X	I	X		I			I				X				
Feature Type		X		X							X			I	X	X			
Feature Design (Dimensions)		X		X					I						X	X			
Feature Lateral Offset				X				I	I						X	X			
Feature Damage		X		X							X				X	X	X		
Feature Performance Assessment				X			I	I			X				X	X			
Feature Placed Properly							I												

Data Element	Viner, January 1995	Mak, 1995	Hunter and Council, 1996	Mak and Sicking, 1994	Ross et al., 1988	Viner, July 1995	Ray et al., 1995	Mak et al., 1986	Hall et al., 1994	Ray et al., 1986	Mak, 1983	Council et al., 1993	Michie, 1996	Powers et al., 1995	Mak et al, 2000	Eskandarian et al., 2002	Powers, 1996	Ray et al., 1998	Glennon & Wilton, 1974
Feature Failure Mechanism														I			X		
Vehicle Year				X											X				
Vehicle Make				X											X		X		
Vehicle Model				X											X		X		
Vehicle Dimensions				X											X	X			
Vehicle Mass				X											X	X			
Vehicle Impact Angle		X	X	X				I	I	X	X	X			X	X	X		
Vehicle Impact Velocity		X	X					I	I	X	X	X				X	X		
Vehicle Lateral Delta-V																X			
Vehicle Longitudinal Delta-V																X			
Vehicle Separation Angle											X					X			
Vehicle Separation Velocity											X								
Vehicle Encroachment Angle		X	X	X				I							X				I
Vehicle Encroachment Velocity		X						I											I
Vehicle Impact Orientation (Yaw)		X			I			I			X					X			
Vehicle Maneuver Prior to Encroachment				X											X				
Vehicle Trajectory (after encroachment but prior to impact)		X		X											X		X		
Vehicle Post-Impact Trajectory								I		X	X					X	X		
Vehicle Stability										X									

Data Element	Viner, January 1995	Mak, 1995	Hunter and Council, 1996	Mak and Sicking, 1994	Ross et al., 1988	Viner, July 1995	Ray et al., 1995	Mak et al., 1986	Hall et al., 1994	Ray et al., 1986	Mak, 1983	Council et al., 1993	Michie, 1996	Powers et al., 1995	Mak et al, 2000	Eskandarian et al., 2002	Powers, 1996	Ray et al., 1998	Glennon & Wilton, 1974
Event Description (sequence)		X	X	X											X				
Injury Severity				X											X		X		
Accident Location Relative to Horizontal Curve (inside or outside)	X																		
Object Struck	X	X	X			X			I										
Vehicle Damage Dimensions		X		X				I							X				
Vehicle Damage Location		X						I											
Lateral Extent of Encroachment		X																	I
Impact Lateral Distance (from roadway edge)			X																
Curb Type					I											X			
Curb Height																X			
Curb Face Slope					I														
Vehicle Center of Gravity Location					I											X			
Pole Trajectory (subsequent to impact)					I														
Vehicle Yaw Rate					I			I											
Roadside Soil Condition					I								X						

Data Element	Viner, January 1995	Mak, 1995	Hunter and Council, 1996	Mak and Sicking, 1994	Ross et al., 1988	Viner, July 1995	Ray et al., 1995	Mak et al., 1986	Hall et al., 1994	Ray et al., 1986	Mak, 1983	Council et al., 1993	Michie, 1996	Powers et al., 1995	Mak et al, 2000	Eskandarian et al., 2002	Powers, 1996	Ray et al., 1998	Glennon & Wilton, 1974
Roadside Soil Cover						X													
Ditch Configuration						X													
Tire Plow Indication						X													
Vehicle Intrusion Depth																		I	
Vehicle Intrusion Location																		I	
Vehicle Rotations (Rollover)													X						
Vehicle Frame Rail Spread																X			
Vehicle Frame Rail Height																X			
Vehicle Frontal Overhang																X			
Vehicle Bumper Height					I											X			

Key
X = Explicit research need
I = Implied from research needs

Table 3-2. Research Data Needs vs. EDR Data Element Availability

Data Element	Current EDR Technology	Future EDR Technology	Notes
Vehicle Year		x	1
Vehicle Make		x	1
Vehicle Model		x	1
Vehicle Dimensions		x	1
Vehicle Mass		x	1
Vehicle Impact Angle	x		2,3,4,6
Vehicle Impact Velocity	x		
Vehicle Lateral Delta-V	x		
Vehicle Longitudinal Delta-V	x		
Vehicle Separation Angle		x	2,3,4,6
Vehicle Separation Velocity		x	3
Vehicle Impact Orientation (Yaw)		x	
Vehicle Maneuver Prior to Encroachment	x		
Vehicle Trajectory (after encroachment but prior to impact)	x		3,4,6
Vehicle Post-Impact Trajectory		x	3,4,6
Vehicle Stability		x	5
Vehicle Yaw Rate		x	
Vehicle Rotations (Rollover)		x	
Vehicle Frame Rail Spread		x	1
Vehicle Frame Rail Height		x	1
Vehicle Frontal Overhang		x	1
Vehicle Bumper Height		x	1

Notes:

1. Can be derived from VIN and associated Vehicle Parameters Database
2. Impact angle and separation angle can be reconstructed by combining the vehicle trajectory with site measurement of the barrier location and orientation.
3. Will require longer recording time to capture the entire event including separation
4. Requires extension of current practice of recording pre-crash parameters to encompass the post-crash period
5. Assumes stability can be inferred from yaw, pitch, roll vs. time
6. Determination of the vehicle trajectory requires measurement of (a) acceleration along the longitudinal, lateral, and vertical axes (b) vehicle yaw, pitch, and roll rates, and (c) final resting position/orientation of the vehicle (obtained from site inspection). For planar collisions without rollover, trajectory can be obtained from a more limited set of parameters: (a) acceleration along the longitudinal and lateral axes (b) the vehicle yaw rate, and (c) final resting position/orientation of the vehicle (obtained from site inspection).

3.4 Examination of Existing Accident Databases

One of the most important near-term uses of EDR data will be to improve the collection of data for existing accident databases. This section describes the methodology, analysis, and results of a study to determine the potential of using EDR data to augment data collection for roadside and vehicle crashes. Our analysis examined the following wide spectrum of major accident databases, crash test databases, and recommended database formats:

- Fatality Analysis Reporting System (FARS)
- National Automotive Sampling System/Crashworthiness Data System (NASS/CDS)
- National Automotive Sampling System/General Estimates System (NASS/GES)
- Highway Safety Information System (HSIS)
- Longitudinal Barrier Special Studies (LBSS)
- Model Minimum Uniform Crash Criteria (MMUCC)
- NHTSA Vehicle Crash Test Database
- NCHRP Report 350 Roadside Feature Performance Test Elements
- NCHRP 22-15 Recommended NASS/CDS Data Elements
- Trucks Involved in Fatal Accidents (TIFA)
- Motor Carrier Management Information System (MCMIS) – Crash File

Our objective was to consider a broad array of database types to determine the potentially large range of EDR data uses. FARS, NASS/GES, and NASS/CDS are extensive U.S. accident databases. HSIS and LBSS are specialized highway and roadside safety databases. The NCHRP 22-15 data elements are recommended extensions to NASS/CDS to better capture the performance of roadside features. TIFA and the MCMIS crash file are specialized heavy truck and bus databases. MMUCC is a recommended database format to coordinate data collection efforts across states and thus is critical due to the potentially wide application of EDR technology.

The NHTSA Vehicle Crash Test Database Protocol and the NCHRP Report 350 Roadside Feature Performance Test Protocol are detailed descriptions of data for vehicle and roadside hardware testing, respectively. Barring limitations on instrumentation and data collection, these protocols are assumed to represent an ideal set of information. The NHTSA Crash Test Database for example contains the complete description and results of over 5000 vehicle crash tests conducted since the late 1970s. Because an EDR is in many ways analogous to the instrumentation used in laboratory crash tests, the NHTSA Crash Test Database and the NCHRP Report 350 are invaluable guides to the data required to perfectly describe a real world accident.

To better facilitate an understanding of the current state of accident data collection and how EDR technology may potentially augment current data collection, a data element classification methodology was developed. Due to its wide application in crash analysis, the FARS database was chosen as the test database for the methodology development.

All examples in the methodology refer to elements in the FARS database; this methodology has been applied to the remaining databases and collection protocols.

3.4.1 Classification Methodology

Due to the number of elements and range of data present in the existing databases, the research team recognized the need for a methodical approach to the classification of the data elements within each database. The classification scheme must provide a more definitive means of identification of candidate data elements as well as provide a measure of simplification for discussion and presentation purposes. A modified Haddon approach was chosen and is shown in Table 3-3.

Table 3-3. Modified Haddon Matrix

	Pre-Crash	Crash	Post-Crash	Time-Invariant
Human				
Vehicle				
Environment				

In this approach, the crash event has three components (1) the Human, (2) the Vehicle, and (3) the Environment. The Human is typically the crash victim and includes both vehicle occupants as well as non-occupants such as pedestrians. The Environment includes entities outside the human-vehicle pairing which may have influenced either the actions leading to the crash or the outcome of the crash. Examples of Environment factors would be the weather, road curvature, or guardrail systems. The event can be further broken down into three time phases: pre-crash, crash, and post-crash.

Each event phase has a characteristic time duration. The characteristic duration of the pre-crash phase is generally measured in seconds to minutes. The duration of the crash duration is measured in milliseconds to seconds. The characteristic duration of the post-crash phase is measured in minutes to hours.

The objective in conducting this classification exercise is to identify data elements that could potentially be collected more accurately or more effectively by systems such as an EDR. Our approach is to classify each data element both by where and when each data element could be measured by an electronic system such as an EDR. The location where a data element could be measured will include the occupant, the vehicle, or the environment. The time when a data element could be measured is the earliest time that a data element could be captured. Unlike an EDR that can capture some data elements in the pre-crash phase, current accident investigation must collect all data elements in the post-crash phase.

Note that this classification methodology is merely used as an analytical tool for seeking links between accident databases and EDR elements. Other methods may be more appropriate for other research objectives. For example, as a given crash may involve several vehicles and a number of persons, accident records are generally organized as relational databases of linked tables. FARS for example has three tables – (1) accident, (2) vehicle, and (3) person – with appropriate linking identifiers. A complete description of the crash using the Haddon Matrix approach would require a multi-layer Haddon Matrix with a separate matrix for each person-vehicle combination.

Classification Guidelines

Definitions for the corresponding rows and columns in the modified Haddon Matrix are illustrated below. Again, all variables used as examples are elements from the FARS database.

- **Time-Based Category Definitions.** Categorization by time or crash phase allows a lengthy list of data elements to be disaggregated by when the elements could be measured by a system such as an EDR.

  - Pre-Crash Variables**.** Data elements pertaining to the time prior to the event (not including Time Invariant Variables).

  - Crash Variables. Descriptors of the crash event and the surrounding environment at the time of the crash.

  - Post-Crash Variables. Characterization variables pertaining to the time after the incident.

  - Time Invariant Variables. Time invariant variables are fixed over the characteristic time of the event – loosely defined here to be one hour before and after the actual crash. Time-invariant variables would include a) fixed identifiers that are not time-dependant (e.g. VIN), (b) historical data (i.e. previous traffic violations), and (c) data elements unlikely to change over the course of the entire event sequence, (e.g. driver weight)

- **Location-Based Category Definitions**

  - Human Variables. This category includes identifiers that apply specifically to the human(s) involved in the incident. These identifiers may be a quantitative measure (i.e. driver weight) or may be based on a human judgment system (i.e. license status or regulatory compliance). Human variables would also include the response of the human(s) to the crash event (i.e. injury severity).

  - Vehicle Variables. This category includes (a) descriptive identifiers applying specifically to the vehicle(s) involved in the incident (i.e. vehicle body type), and (b) response of the vehicle(s) to the crash event (i.e. airbag deployment)

  - Environmental Variables. Descriptive identifiers applying specifically to the surroundings of the crash location.

- **Additional Classification Conventions.** The assumption that electronic instrumentation is available is based on the most probable method of instrumentation. For example, the AVOID variable describes the maneuver initiated by the driver to avoid the crash. Although it may be possible to instrument the driver of the vehicle in the future, a more plausible method of assessment would be to instrument the vehicle to indicate the steering and/or braking applied by the driver prior to the crash. Thus, this variable is classified as a pre-crash vehicle attribute.

Examination Results and Extraction of Potential Data Elements
After the data element classification was performed for a targeted database, a comparison was made with the listing of current and potential EDR capabilities to ascertain potential data elements. The extraction process resulted in a catalog of elements representing the union of feasible EDR data elements and matching elements present in each target database.

The classification and potential data element extraction results for each of the target databases are presented below. A brief description of each database is provided along with the data elements. Referenced tables use the following general tabular anatomy:

- A brief description of each variable in the database including information that is pertinent to its classification location.

- The source database table (if applicable).

- Major column divisions correspond to three "where" components (1) the Human crash victim, (2) the Vehicle, and (3) the Environment. Note that these were chosen as the major division based on the assumption that most of EDR elements will be contained within the Vehicle category.

- Each major column is divided into four minor columns corresponding to the time classifications: pre-crash, crash, post-crash, and time in variant.

- An indication of whether the variable is derived from other data. Note that these variables are not classified since each is generated from other information collected within the framework of the modified Haddon approach. For example, the VEH_NO variable is a unique numeric value used to identify each vehicle involved in a given accident case. As this value is simply an arbitrary vehicle identifier assigned by the database coders, it is listed as a derived variable.

3.4.2 FARS

FARS is a comprehensive census of all traffic related fatalities in the United States, which has been maintained and operated by the National Highway Traffic Safety Administration (NHTSA) since 1975 [Tessmer, 1999]. For a case to be included in this database, it must involve a motor vehicle traveling on a primarily public roadway and death of an individual involved within 30 days of the incident. Each incident is characterized by the collection of approximately 175 data elements split among an accident table, a vehicle table, and a person table.

Extraction of Potential EDR data elements from FARS

A complete listing and classification of the variables in the FARS database is provided in the appendices. The variables have been grouped according to the FARS table system, and arranged in alphabetical order within each table. Note that variables occurring in multiple tables are sorted alphabetically at the end of the listing, with a corresponding annotation describing in which tables they appear.

As the FARS database was not created based on the Haddon classification methodology, there are inherent nuances in the application of our methodology to this database. One particular nuance is the elements that span more than one category in either the time or characteristic dimension. For instance, the Driver Presence Variable, DR_PRES, has the following entry possibilities: (1) Driver operated vehicle, (2) Driver left scene, (3) No driver, and (4) Unknown. This variable spans the time dimension from pre-crash to post-crash as the earliest measure of whether the driver is operating the vehicle can be obtained in the pre-crash phase and the earliest measure of whether the driver leaves the scene can be obtained in the post-crash phase. In the other direction, the Notification Variables, NOT_HOUR and NOT_MIN, indicate the time of notification for need of medical services and span both the Human and Vehicle categories. The Human component would correspond to time of a 911 call placed for the particular accident while the Vehicle component would correspond to a vehicle equipped with an ACN system that sends the notification for the need of medical services.

Link between EDR and FARS

To complete the linkage between the potential EDR data elements and the variables captured in the FARS database, the classification methodology has been applied to the listing of potential EDR elements. By classifying both the EDR data and FARS database elements using the Haddon matrix and then matching the two classified lists, the FARS elements presented in Table 3-4 were identified as potential candidates for EDR data based on the current and future EDR technology. Note that the extraction results presented in this report are based on the assumption that there is no widespread database available to link GPS information to roadway data such as milepost, route number, and posted speed limit. This assumption is also applicable to all subsequent databases analyzed.

Table 3-4. FARS-EDR Compatibility

Variable Name	Variable Description	Current Technology	Future Technology	Notes
TRAV_SP	Estimation of vehicle travel speed	X		
DR_CF1	Driver related factors (often indicates the cause of the crash)	X	X	1
DR_CF2	Driver related factors (often indicates the cause of the crash)	X	X	1
DR_CF3	Driver related factors (often indicates the cause of the crash)	X	X	1
DR_CF4	Driver related factors (often indicates the cause of the crash)	X	X	1
DR_PRES	Driver presence (Driver operated vehicle, driver left scene, no driver, etc.)		X	2
VEH_CF1	Vehicle related crash factor (often indicates crash cause)	X	X	3
VEH_CF2	Vehicle related crash factor (often indicates crash cause)	X	X	3
MAN_COL	Manner of collision (head on, rear end, etc.)	X		
AXLES	Total number of axles on the vehicle		X	4
MODEL	Vehicle model (see MAK_MOD)		X	4
VIN	Vehicle identification number (up to the first 12 digits)		X	4
VIN_# (1-12)	x^{th} number of the VIN		X	4
VIN_LNGT	Actual length of the VIN number for the vehicle		X	4
BODY_TYP	Indicates vehicle body type based on NHTSA classification		X	4
VINA_MOD	Model of vehicle as obtained by the VINA program		X	4
VIN_BT	Vehicle body type from VINA program		X	4
VIN_WGT	Weight of the vehicle (excluding trucks)		X	4
WHLBS_LG	Longest wheelbase for the model vehicle (based on VINA program)		X	4
WHLBS_SH	Shortest wheelbase for the model vehicle (based on VINA program)		X	4
SER_TR	Truck version of VIN_BT (obtains vehicle body type)		X	4
AIR_BAG	For vehicle occupants, indicates whether air-bag deployed	X		
REST_USE	Indicates the type of restraint used		X	4
DAY	Day of the month of the crash		X	
DAY_WEEK	Day of the week of the crash (calculated from other date/time information)		X	
YEAR	Year that the crash took place		X	
ROLLOVER	Indicates whether a rollover occurred and if it was the first event or a subsequent event		X	
HOUR	Hour when the crash occurred		X	
MAKE	Indicates the make of the vehicle		X	4
MAK_MOD	Make information concatenated with the model information		X	4
MINUTE	Minute of when the crash occurred		X	

Variable Name	Variable Description	Current Technology	Future Technology	Notes
MOD_YEAR	Indicates the model year of the vehicle		X	4
MONTH	Month when the crash occurred		X	
EMER_USE	Indicates whether the vehicle was in emergency use at the time of the crash		X	10
DR_WGT	Indicates the weight of the driver in pounds		X	2
SCH_BUS	Indicates whether the accident involved a school bus functioning as such		X	5
PER_TYP	Indicates situation of occupant (driver, passenger of vehicle in motion, passenger of vehicle not in motion, etc.)		X	2
OCCUPANTS	Actual number of occupants in the vehicle at the time of the crash		X	2
WEATHER	Indicates atmospheric conditions at the time of crash		X	6
CITY	City code based on GSA codes		X	7
LATITUDE	Global position of the crash location (latitude)		X	7
LONGITUD	Global position of the crash location (longitude)		X	7
COUNTY	County of incident based on GSA codes		X	7
STATE	State where the crash occurred (GSA codes)		X	7
LGT_COND	Lighting condition at the scene of the crash		X	5
NOT_HOUR	Hour of notification for the need of medical services		X	8
NOT_MIN	Minute of notification for the need of medical services		X	8
SEAT_POS	Indicates the seating position of a particular occupant		X	2
AVOID	Driver executed maneuver to attempt to avoid the crash	X		9
SUR_COND	Surface conditions at crash site (i.e. wet, dry, snow, etc.)		X	9

Notes:

1. Some choices such as (45) Driving less than posted maximum can be inferred using current EDR technology while others like (56) Improper tire pressure may be inferred from future EDR technology.
2. Assumes a weight sensor in all vehicle seating positions.
3. Some choices such as (17) Airbag can be obtained from current EDR technology while others such as (12) Wipers may be inferred from future EDR technology.
4. Can be derived from VIN and associated Vehicle Parameters Database
5. May be inferred from usage of lights
6. May be inferred from usage of windshield wipers
7. Can be derived assuming GPS position data is recorded
8. Assuming implementation of ACN system
9. May be inferred from precrash information from ABS systems or steering or braking information
10. May be inferred from use of a siren.

In merging the classified data elements, the following categories emerged with respect to how EDR data may be useful to the FARS database:

Direct: EDR data can be obtained directly from the EDR and transferred to the database without any intermediate inference (note that mathematical operations to convert EDR raw data are ignored). Direct elements would include vehicle travel speed (TRAV_SP), time of the crash (HOUR, DAY, MINUTE), and deployment of air bags during the event (AIR_BAG). These appear to have the largest potential for increasing the accuracy and efficiency of the information present in accident databases.

Indirect: EDR data can be utilized to infer or derive a particular variable captured in a current accident database. An example would be the MILEPOINT variable that identifies the roadway mile point location of a particular crash event. Assuming that EDR has GPS capability and the roadway databases contain sufficient detail, one could determine the mile point of the crash from the EDR GPS latitude and longitude.

Partial Direct: EDR data can be utilized directly to fulfill a portion of a currently captured variable. A possible example could be the Related Factors – Vehicle Level variable (VEH_CF#), which indicates malfunctions in the vehicle that could have attributed to the crash event. Assuming EDR data could directly indicate the functionality of the brake system during the crash, this information could be used to choose or eliminate (02) Brake System as a crash related factor. It is unlikely, however, that EDR data will be able to directly determine a (31) Hit-and-Run Vehicle; thus, information from the EDR can only partially fulfill the requirements of the variable.

Partial Indirect: EDR data can be utilized to infer or derive a portion of a particular variable captured in a current accident database. Example variables in this category include all crash related factors. Consider the Related Factors - Driver Level variable (DR_CF#), in which the data coder has approximately one hundred possible choices for factors related to the cause of the crash. Two possible choices include (10) Deaf and (44) Driving too Fast for Conditions or in Excess of the Posted Speed Limit. An inference made from the EDR data may be useful in assessing whether the crash is speed related. It is unlikely, however, that EDR data will be useful in ascertaining whether the driver was deaf. Thus, EDR data could only be used to infer some of the subsets (choices) within a particular variable.

3.4.3 NASS/CDS

NASS/CDS provides a detailed record of a national sample of approximately 5,000 crashes investigated each year by NHTSA at 27 locations throughout the United States [NHTSA, 2000]. This database includes a random sample of minor, serious and fatal crashes involving cars, light trucks, vans and sport utility vehicles. Compared with the FARS and GES database, the data collected in NASS/CDS is much more detailed and includes approximately 400 data elements. Table 3-5 presents the results of the examination of the NASS/CDS database and subsequent extraction of potential EDR data elements.

Table 3-5. NASS/CDS Extracted Data Elements

Variable Name	Variable Description	Current Technology	Future Technology	Notes
DAYWEEK	Day of week of the accident		X	
EVENTS	Number of recorded events in accident	X		
MANCOLL	Manner of collision	X		
MONTH	Month of accident		X	
TIME	Time of accident		X	
YEAR	Year of accident		X	
ANGTHIS	Heading angle for this vehicle		X	
ANTILOCK	Antilock brakes		X	
BAGDEPFV	Air bag deployment, first seat frontal	X		
BAGDEPOV	Air bag deployment, other	X		
BODYTYPE	Vehicle body type		X	1
CARBUR	Carburetion		X	1
CURBWGT	Vehicle curb weight		X	1
DRIVE	Front/rear wheel drive		X	1
DRPRES	Driver presence in vehicle		X	2
DVEST	Estimated highest delta v	X		
DVLAT	Lateral component of delta v	X		
DVLONG	Longitudinal component of delta v	X		
DVTOTAL	Total delta v	X		
FOURWHDR	Four wheel drive		X	1
FRTWHLDR	Front wheel drive		X	1
IMPACTSP	Impact speed	X		
LGTCOND	Light conditions		X	3
MAKE	Vehicle make		X	1
MANEUVER	Attempted avoidance maneuver	X		6
MODEL	Vehicle model		X	1
MODELYR	Vehicle model year		X	1
PREISTAB	Pre-impact stability		X	5
RESTYPE	Restraint type		X	1
ROLINDIR	Direction of initial roll		X	
ROLLOVER	Rollover		X	
SERTR	VIN series truck		X	1
SURCOND	Roadway surface condition		X	6
VEHTYPE	Type of vehicle		X	1
VEHUSE	Vehicle special use (This trip)		X	8
VEHWGT	VIN vehicle weight		X	1
VIN	Vehicle identification number		X	1
VINAMOD	VIN model cars & trucks		X	1
VINBT	VIN body type		X	1
VINLNGTH	VIN length		X	1
VINMAKE	VIN make		X	1
VINMODYR	VIN model year		X	1
WEATHER	Atmospheric conditions		X	4
ABELTAVL	Automatic belt system availability/function	X		
ABELTUSE	Automatic belt (passive) system use	X		
ABELTYPE	Automatic (passive) belt system type		X	
BAGAVAIL	Air bag system availability	X		
BAGAVOTH	Other frontal air bag availability/function	X		

Variable Name	Variable Description	Current Technology	Future Technology	Notes
BAGDEPLY	Air bag system deployed	X		
BAGDEPOT	Other air bag system deployment	X		
BAGFAIL	Air bag system failure	X		
DVBAG	Longitudinal component of delta v for airbag deployment	X		
MANAVAIL	Manual belt system availability	X		
MANUSE	Manual belt system use	X		
ROLE	Occupant's role		X	2
SEATPOS	Occupant's seat position		X	2
WEIGHT	Occupant's weight		X	2
DOF1	Direction of force (highest)		X	
DOF2	Direction of force (2nd highest)		X	
PDOF1	Clock direction for principal direction of force in degrees (highest)	X		7
PDOF2	Clock direction for principal direction of force in degrees (2nd highest)	X		7
WHEELBAS	Original wheelbase		X	1

Notes:

1- Can be derived from VIN and associated Vehicle Parameters Database
2- Assumes a weight sensor in all vehicle seating positions.
3- May be inferred from usage of lights
4- May be inferred from usage of windshield wipers
5- Assumes stability can be inferred from yaw, pitch, roll vs. time
6- May be inferred from precrash information from ABS systems or steering or braking information
7- Assuming accelerometers in perpendicular horizontal directions
8- May be inferred from use of a siren.

The reader should refer to the appendices for a complete listing and classification of the variables contained in the NASS/CDS database. Note that the table is organized in a manner consistent with the forms present in the NASS/CDS collection format.

3.4.4 NASS/GES

The function of NASS/GES is to present a representative sample of all police-reported motor vehicle accidents in the United States [NHTSA, 2001]. Criteria for selection include the involvement of a motor vehicle traveling on a public road and a crash that results in property damage, occupant injury, a fatality, or any combination of these outcomes. The accident reports are sampled from approximately 400 police jurisdictions in 60 areas across the United States. Each area is selected with the intent of providing a spectrum that is indicative of geographical, roadway, population and traffic characteristics in the entire country. Complexity of collected crash information is analogous to that of the FARS database and includes approximately 130 data elements. Table 3-6 presents the results of the examination of the NASS/GES database and subsequent extraction of potential EDR data elements.

Table 3-6. NASS/GES Extracted Data Elements

Variable Name	Variable Description	Current Technology	Future Technology	Notes
MONTH	Month in which the crash occurred		X	
YEAR	Year in which the crash occurred (four digits)		X	
WEEKDAY	Day of the week in which the crash occurred		X	
HOUR	Hour in which the crash occurred		X	
MINUTE	Minute in which the crash occurred		X	
SUR_COND	Roadway surface condition at the time of the crash		X	5
LGHT_CON	General light conditions at the time of the crash		X	3
WEATHER	General description of atmospheric conditions at the time of the crash		X	4
MAKE	Indicates the make of the motor vehicle involved in the crash		X	1
MODEL	Indicates the model of the motor vehicle involved in the crash		X	1
MODEL_YR	Indicates the model year of the involved vehicle		X	1
VIN	First 11 characters of the Vehicle Identification Number		X	1
EMCY_USE	Indicates if the vehicle was in emergency use at the time of the crash		X	3
NUMOCCS	Indicates the number of persons (including drivers) within an involved vehicle		X	2
SPEED	Speed of involved vehicle prior to event (miles per hour)	X		
FACTOR	Indicates vehicle related factors that may have contributed to the crash (only one is coded)	X		5
ROLLOVER	Indication of a rollover for an involved vehicle (includes tripping mechanism)		X	
P_CRASH1	Description of the vehicle's activity just prior to the crash	X		5
P_CRASH3	Describes the driver actions in response to the impending crash (i.e. steering, braking, etc.)	X		5
P_CRASH4	Assessment of the stability of the vehicle just after the corrective action but prior to the initial impact		X	6
P_CRASH5	Identifies the path of the vehicle prior to its involvement in the crash	X		5
DR_PRES	Indicates the presence of the vehicle driver (used to identify driverless vehicles)		X	2
SPEEDREL	Indicates whether speed was a contributing factor in the crash	X		
PER_TYPE	Indicates the role of the person in the vehicle		X	2
SEAT_POS	Indicates the location of the occupants within the vehicle		X	2
REST_SYS	Indicates the occupant's use of available restraints within the vehicle	X		
AIRBAG	Indicates the presence of an airbag and it's function during the event	X		

Notes:

1- Can be derived from VIN and associated Vehicle Parameters Database
2- Assumes a weight sensor in all vehicle seating positions
3- May be inferred from usage of lights

4- May be inferred from usage of windshield wipers
5- May be inferred from precrash information from ABS systems or steering or braking information
6- Assumes stability can be inferred from yaw, pitch, roll vs. time

The reader should refer to the appendices for a complete listing and classification of the variables contained in the NASS/GES database. Note that the variables have been split according to the NASS/GES table system with a separate division for variables occurring in multiple tables.

3.4.5 HSIS

HSIS is a multi-state database that contains crash, roadway inventory, and traffic volume data for a select group of States [FHWA, 2000a, 2000b, 2000c, 2000d, 2001]. Created by the Federal Highway Administration (FHWA), this database fuses the information provided by each state to generate a homogeneous set of approximately 120 data elements. Table 3-7 identifies the states involved in the HSIS database and corresponding data contributions.

Table 3-7. Summary of HSIS Data Available

State	First Year Available	Average Crashes/Year	Roadway Mileage	Information Provided
California	1991	160,000	16,000	Crash, Roadway Inventory, Traffic Volume, Intersection, Interchange/Ramp
Illinois	1985	142,000	16,000	Crash, Roadway Inventory, Traffic Volume, Curve and Grade, VIN
Maine	1985	39,000	23,000	Crash, Roadway Inventory, Traffic Volume, Interchange/Ramp
Michigan	1985	136,000	9,700	Crash, Roadway Inventory, Traffic Volume, VIN, Guardrail/Barrier, Interchange/Ramp
Minnesota	1985	77,000	134,000	Crash, Roadway Inventory, Traffic Volume, Intersection
North Carolina	1991	116,000	35,000	Crash, Roadway Inventory, Traffic Volume, VIN
Ohio	2002	-	-	(To be added in 2002)
Utah	1985	46,000	14,000	Crash, Roadway Inventory, Traffic Volume, Curve and Grade, VIN
Washington	1991	35,000	8,600	Crash, Roadway Inventory, Traffic Volume, Curve and Grade, Interchange/Ramp

Table 3-8 presents the results of the examination of the HSIS database and subsequent extraction of potential EDR data elements.

Table 3-8. HSIS Extracted Data Elements

Variable Name	Variable Description	Current Technology	Future Technology	Notes
ACC_DATE	Accident date		X	
ACCYR	Accident year		X	
DAYMTH	Day of month		X	
HOUR	Hour of occurrence		X	
MONTH	Month of accident		X	
WEEKDAY	Day of week		X	
LIGHT	Light condition		X	3
RDSURF	Surface road condition		X	5
WEATHER	Weather condition		X	4
CONTRIB1	Accid contrib factor(s)	X		5
CONTRIB2	Accid contrib factor(s)	X		5
CONTRIB3	Accid contrib factor(s)	X		5
VEHTYPE	Vehicle type		X	1
VEHYR	Vehicle year		X	1
VIN	VIN number		X	1
MISCACT1	Driver intent	X		5
SEATPOS	Occupant position in vehicle		X	2
REST1	Occupant safety equipment	X		
COUNTY	County		X	

Notes:

1- Can be derived from VIN and associated Vehicle Parameters Database
2- Assumes a weight sensor in all vehicle seating positions.
3- May be inferred from usage of lights
4- May be inferred from usage of windshield wipers
5- May be inferred from precrash information from ABS systems or steering or braking information

The reader should refer to the appendices for a complete listing and classification of the variables contained in the HSIS database. Note that the variables have been split according to the data categories used in the HSIS database and that each variable is accompanied by an indication of the state(s) which provide information for that variable.

3.4.6 Longitudinal Barrier Special Study (LBSS)

The LBSS was developed within NASS to examine accidents involving longitudinal barriers [Erinle, 1994]. Collected between 1982 and 1986, data exists for a total of 1,146 NASS cases. Approximately 250 data elements are collected and organized into six separate data files: the accident data file, barrier accident file, barrier contact file, driver data file, occupant data file, and the vehicle data file. Table 3-9 presents the results of the examination of the LBSS database and subsequent extraction of potential EDR data elements.

Table 3-9. LBSS Extracted Data Elements

Variable Name	Variable Description	Current Technology	Future Technology	Notes
LGTCOND	Light conditions at the time of the accident		X	3
MANCOLL	Manner of collision based on first harmful event	X		5
TIME	Time of the accident		X	
WEATHER	Atmospheric conditions at the time of the accident		X	4
B62	Impact angle	X		5
B63	Vehicle yawing angle at impact		X	5
B64	Impact speed	X		
B65	Separation angle		X	5,6
B67	Post-impact trajectory		X	6
B69	Rollover		X	
B71	Confidence of impact angle	X		
B72	Confidence of yawing angle at impact		X	
B73	Confidence of separation angle		X	6
B74	Confidence of final rest distance		X	6
AVOIDMAN	Attempted avoidance maneuver	X		7
OCUPANTS	Number of occupants (this vehicle)		X	2
SURCOND	Roadway surface condition		X	7
AUTAVAIL	Passive restraint system - availability	X		
AUTFNCT	Passive restraint system - function	X		
MANAVAIL	Active restraint system - availability		X	1
MANUSE	Active restraint system - use	X		
ROLE	Occupant's role		X	2
SEATPOS	Occupant's seat position		X	2
BODYTYPE	Vehicle body type		X	1
CURBWGT	Vehicle curb weight		X	1
DOF1	Direction of force (highest)		X	5
DRIVE	Front/rear wheel drive		X	1
DVLAT	Lateral component of delta V	X		
DVLONG	Longitudinal component of delta V	X		
DVTOTAL	Total delta V	X		
GVWR	Gross vehicle weight rating		X	1
MAKE	Vehicle make		X	1
MODEL	Vehicle model		X	1
MODELYR	Vehicle model year		X	1
ROLLOVER	Rollover involvement		X	
SPECUSE	Vehicle special use (this trip)		X	3
TRAVELSP	Vehicle travel speed	X		
WHEELLNG	Wheelbase long		X	1
WHEELSHT	Wheelbase short		X	1
YEAR	Year of accident	X		

Notes:

1- Can be derived from VIN and associated Vehicle Parameters Database
2- Assumes a weight sensor in all vehicle seating positions.
3- May be inferred from usage of lights
4- May be inferred from usage of windshield wipers
5- Assumes horizontal accelerometers in perpendicular directions
6- Requires extension of recording to post-crash time period

7- May be inferred from precrash information from ABS systems or steering or braking information

The reader should refer to the appendices for a complete listing and classification of the variables contained in the LBSS database. The variables have been split according to the file system used in the LBSS database. Note that variables occurring in multiple tables are sorted alphabetically at the end and the corresponding tables in which they appear are identified.

3.4.7 Model Minimum Uniform Crash Criteria (MMUCC)

The Model Minimum Uniform Crash Criteria (MMUCC) is a minimum set of 75 crash data elements with standardized definitions that are relevant to injury control, highway and traffic safety. NHTSA and FHWA in collaboration with the Governor's Highway State Association (formerly the National Association of Governors' Highway Safety Representatives) to develop model minimum uniform crash criteria [NHTSA and FHWA, 1998]. MMUCC was developed in response to studies that have concluded that the use of state crash data is often hindered by the lack of uniformity between and within states. The MMUCC was developed with extensive input from the states DOT's, and has been officially adopted by a number of states.

Table 3-10 presents the results of the examination of the MMUCC protocol and subsequent extraction of potential EDR data elements.

Table 3-10. MMUCC Extracted Data Elements

Variable Name	Variable Description	Current Technology	Future Technology	Notes
C2	Crash Date and Time		X	
C3	Crash County		X	
C4	Crash City/Place		X	
C8	Manner of Crash/Collision Impact		X	
C11	Weather Condition		X	4
C12	Ambient Light		X	3
C13	Road Surface Condition		X	5
V4	Vehicle Make		X	1
V12	Gross Vehicle Weight Rating of Power Unit		X	1
V13	Total Occupants In Vehicle		X	2
V15	Emergency Use		X	3
V19	Direction of Travel Before Crash		X	
V21	Vehicle Maneuver/Action	X		5
V25	Direction of Force to Vehicle	X		6
P3	Person Type		X	2
P6	Seating Position		X	2
P7	Occupant Protection System Use	X		
P8	Air Bag Deployed	X		
P14	Contributing Circumstances, Driver	X		5
CD8	Day of Week		X	
VL1	Vehicle Identification Number		X	1
VD1	Vehicle Model Year		X	1

Variable Name	Variable Description	Current Technology	Future Technology	Notes
VD2	Vehicle Model		X	1
VD3	Vehicle Body Type		X	1

Notes:

1- Can be derived from VIN and associated Vehicle Parameters Database
2- Assumes a weight sensor in all vehicle seating positions.
3- May be inferred from usage of lights
4- May be inferred from usage of windshield wipers
5- May be inferred from precrash information from ABS systems or steering or braking information
6- Can be estimated for EDRs that record acceleration on multiple axes

The reader should refer to the appendices for a complete listing and classification of the variables contained in the MMUCC. The variables have been organized according to the MMUCC variable type system structure.

3.4.8 NHTSA Vehicle Crash Test Database Protocol (VEHDB)

NHTSA collects detailed engineering data which describes the impact response of vehicles subjected to a crash test. The data is typically used to evaluate the ability of the vehicle structure and restraints to protect the occupants during a crash. Approximately 180 data elements are collected per test and stored in the NHTSA Vehicle Crash Test Database [ISSI, 2001]. Data elements include the acceleration profile of the vehicle and force and acceleration data for various components of anthropomorphic crash test dummies.

Table 3-11 presents the results of the examination of the NHTSA Vehicle Crash Test Database (VEHDB) and the subsequent extraction of potential EDR data elements.

Table 3-11. NHTSA VEHDB Extracted Data Elements

Variable Name	Variable Description	Current Technology	Future Technology	Notes
TKCOND	Description of the test track condition		X	
TEMP	Temperature at the test location at the time of the test		X	
IMPANG	Impact angle (magnitude of the angle between the longitudinal axis of vehicle 2 and the longitudinal axis of vehicle 1 or barrier in a clockwise direction)		X	3
MAKE	Manufacturer of the vehicle		X	1
MODEL	Model of the test vehicle		X	1
YEAR	Model year of the test vehicle		X	1
BODY	Test vehicle body type		X	1
VIN	Vehicle Identification Number as assigned by the manufacturer		X	1
ENGINE	Engine type of the vehicle		X	1

Variable Name	Variable Description	Current Technology	Future Technology	Notes
ENGDSP	Test vehicle engine displacement (liters)		X	1
WHLBAS	Measured or published value for the vehicle or impactor's wheelbase		X	1
VEHLEN	Measured or published value for the length of the vehicle or impactor		X	1
VEHWID	Maximum width of the vehicle or impactor		X	1
VEHSPD	Resultant speed of the vehicle immediately before impact	X		
PDOF	Principal direction of force - angle between the vehicle's longitudinal axis and the impulse vector (clockwise is positive)	X		3
OCCLOC	Indication of the location of the test occupant in the vehicle		X	2
OCCWT	Weight of the non-dummy test occupant		X	2
RSTTYP	Type of restraint system in use at a given occupant location	X		
DEPLOY	Describes deployment performance of inflatable restraints (or firing of belt pretensioners)	X		
SENTYP	Indicates the type of sensor used for collecting measurements	X		
SENATT	Indication of where the sensor is attached (i.e. right A pillar, engine, etc.)	X		
AXIS	Axis direction for sensors measuring vector quantities	X		
YUNITS	Unit used to measure the signal of the sensor data	X		
INIVEL	Initial velocity of the sensor (linear accelerometers)	X		
DELT	Time increment of the measurement (microseconds)	X		
DASTAT	Indicates the status of the data as it appears in the submission (indicates signal validity)	X		

Notes:

1- Can be derived from VIN and associated Vehicle Parameters Database
2- Assumes a weight sensor in all vehicle seating positions.
3- Assumes horizontal accelerometers in perpendicular directions

The reader should refer to the appendices for a complete listing and classification of the variables contained in the NHTSA Vehicle Crash Test Database.

3.4.9 NCHRP Report 350 Roadside Feature Performance Test Elements

These roadside hardware performance testing procedures are the current standard utilized in the industry for longitudinal barriers, crash cushions, breakaway devices, truck-mounted attenuators and work zone traffic control devices. Analogous to the NHTSA VEHDB, NCRHP 350 is used to assess the performance of roadside safety hardware for a given set of standardized conditions. Approximately 100 data elements are collected which describe the physical characteristics and dynamic performance of both the vehicle and the tested device [Ross et al, 1993].

Table 3-12 presents the results of the examination of the NCHRP Report 350 protocol and subsequent extraction of potential EDR data elements.

Table 3-12. NCHRP Report 350 Extracted Data Elements

Variable Name	Variable Description	Current Technology	Future Technology	Notes
N/A	Date of the test		X	
N/A	Vehicle Identification Number		X	1
N/A	Vehicle make		X	1
N/A	Vehicle model		X	1
N/A	Vehicle model year		X	1
N/A	Mileage just prior to test		X	
N/A	Tire inflation pressure		X	
N/A	Engine Type		X	1
N/A	Engine Cylinder Inside Diameter		X	1
N/A	Curb mass - total		X	1
N/A	Vehicle impact speed	X		
N/A	Vehicle exit speed		X	3
N/A	Vehicle impact angle	X		2
N/A	Vehicle exit angle		X	2,3
N/A	Vehicle acceleration	X		
N/A	Vehicle trajectory		X	3
N/A	Vehicle roll rate throughout event		X	3
N/A	Vehicle yaw rate throughout event		X	3
N/A	Vehicle pitch rate throughout event		X	3
N/A	Final rest position of test vehicle		X	
N/A	Occupant Impact Velocity (X-direction)	X		
N/A	Occupant Impact Velocity (Y-direction)	X		2
N/A	Theoretical Head Impact Velocity	X		2
N/A	Ridedown acceleration (X-direction)		X	3
N/A	Ridedown acceleration (Y-direction)		X	2,3
N/A	Post-Impact Head Deceleration		X	2,3
N/A	Acceleration Severity Index		X	2,3
N/A	Post-impact max vehicle roll angle		X	3
N/A	Post-impact max vehicle pitch angle		X	3
N/A	Post-impact max vehicle yaw angle		X	3

Notes:

1- Can be derived from VIN and associated Vehicle Parameters Database
2- Assumes horizontal accelerometers in perpendicular directions
3- May require extension of recording to post-crash time period

The reader should refer to the appendices for a complete listing and classification of the variables contained in the NCHRP Report 350 Roadside Feature Performance Test Protocol.

3.4.10 NCHRP 22-15 Recommended NASS/CDS Data Elements

The main objectives of NCHRP Project 22-15, entitled "Improving the Compatibility of Vehicles and Roadside Safety Hardware", were to investigate the compatibility between vehicles and roadside safety hardware and to assess opportunities and barriers to improving compatibility. While fulfilling these objectives, Eskandarian et al (2002) suggested an improved NASS/CDS data collection form to facilitate further research in the area of vehicle-hardware compatibility. The revised data collection sheets are comprised of approximately 60 elements focused mainly on the physical and performance characteristics of the impacted roadside safety hardware.

Table 3-13 presents the results of the examination of the NCHRP 22-15 Recommended NASS/CDS Data Elements and subsequent extraction of potential EDR data elements.

Table 3-13. NCHRP 22-15 Extracted Data Elements

Variable Name	Variable Description	Current Technology	Future Technology	Notes
N/A	Accident year		X	
N/A	State where the accident occurred		X	
N/A	County where the accident occurred		X	
N/A	Impact angle (longitudinal axis of vehicle and primary axis of feature)		X	1
N/A	Separation angle (longitudinal axis of vehicle at last contact and primary axis of feature)		X	1,2
N/A	Vehicle yawing angle at impact (between longitudinal axis of vehicle and direction of travel)		X	1
N/A	Vehicle rotation at impact (about vertical axis)		X	
N/A	Impact speed (based on vehicle/barrier deformation)	X		
N/A	Post-impact vehicle trajectory (qualitative)		X	2

Notes:

1- Assumes horizontal accelerometers in perpendicular directions
2- Requires extension of recording to post-crash time period

The reader should refer to the appendices for a complete listing and classification of the variables recommended by the NCHRP 22-15 research program.

3.4.11 Trucks Involved in Fatal Accidents (TIFA)

The TIFA database combines information from the FARS database pertaining to accidents involving medium and heavy trucks (GVWR > 10,000 lbs) with more detailed information about the involved truck and operating authority [Matteson and Blower, 2003]. Maintained by the University of Michigan Transportation Research Institute (UMTRI) since 1980, this comprehensive database consists of approximately 250 elements.

Table 3-14 presents the results of the examination of the TIFA database and subsequent extraction of potential EDR data elements.

Table 3-14. TIFA Extracted Data Elements

Variable Name	Variable Description	Current Technology	Future Technology	Notes
AccidentFactor1	First factor related to accident	X		5
AccidentFactor2	Second factor related to accident	X		5
AccidentFactor3	Third factor related to accident	X		5
AccidentHour	Hour in which accident occurred (hh)		X	
AccidentMinute	Minute in which accident occurred (mm)		X	
AirBag	Air bag availability/function	X		
AvoidType	Crash avoidance maneuver	X		5
Axles	Number of axles		X	1
BodyType	Vehicle body type		X	1
City	GSA geographical city code		X	
County	County in which accident occurred		X	
DayofMonth	Day of month in which accident occurred		X	
DayofWeek	Day of week in which accident occurred		X	
DriverFactor1	First driver factor related to accident	X		5
DriverFactor2	Second driver factor related to accident	X		5
DriverFactor3	Third driver factor related to accident	X		5
DriverFactor4	Fourth driver factor related to accident			5
DriverPresent	Driver presence	X	X	2
DriverWeight	Driver weight		X	2
HoursDriving	Hours driving		X	
InitialImpact	Initial impact (clock direction)		X	6
JulianDate	Accident date - Julian		X	
LightCondition	Light condition		X	3
Maneuver	Vehicle maneuver	X		5
MannerCollision	Manner of collision		X	
ModelYear	Vehicle model year		X	1
Month	Month in which accident occurred		X	
OccupantType	Type of occupant		X	2
PowerUnitType	Power unit type		X	1
PwrUnitAxles	Power unit, number of axles		X	1
PwrUnitMake	Power unit, make		X	1
PwrUnitYear	Power unit, year		X	1
Restraint	Restraint system use	X		
Rollover	Rollover		X	
SeatingPos	Seating position of occupant in accident	X		2
Speed	Estimated travel speed at time of accident	X		
State	State in which accident occurred		X	
StateName	State name in which accident occurred		X	
StraightBodyStyle	Straight truck, body style		X	1
SurfaceCondition	Roadway surface condition			5
TruckModel	Truck model		X	1
TruckType	Type of truck (using VIN series)		X	1
VIN	Vehicle identification number		X	1
VINLength	Length of the vehicle identification number		X	1
VehicleFactor1	First vehicle factor related to accident	X	X	5
VehicleFactor2	Second vehicle factor related to accident	X	X	5

Variable Name	Variable Description	Current Technology	Future Technology	Notes
VehicleMake	Vehicle make		X	1
VehicleModel	Vehicle model		X	1
Weather	Weather condition		X	4
WeightClass	Vehicle weight (using VIN series), by weight class		X	1
Year	Year in which accident occurred		X	

Notes:

1- Can be derived from VIN and associated Vehicle Parameters Database
2- Assumes a weight sensor in all vehicle seating positions.
3- May be inferred from usage of lights
4- May be inferred from usage of windshield wipers
5- May be inferred from precrash information from ABS systems or steering or braking information
6- Assumes horizontal accelerometers in perpendicular directions

The reader should refer to the appendices for a complete listing and classification of the variables contained in the TIFA Database.

3.4.12 Motor Carrier Management Information System (MCMIS) – Crash File

Operated and maintained by the Federal Motor Carrier Safety Administration (FMCSA), the MCMIS crash file contains information from state police reports pertaining to crashes involving drivers and vehicles of motor carriers [FMCSA, 2004]. The database was started in 1993 and contains approximately 100 data elements for every federally recorded crash involving a motor carrier.

Table 3-15 presents the results of the examination of the MCMIS database and subsequent extraction of potential EDR data elements.

Table 3-15. MCMIS Extracted Data Elements

Variable Name	Variable Description	Current Technology	Future Technology	Notes
Acdtcnty	The 3-digit worldwide geographical code for the county in which the crash occurred.		X	
Acdtdate	The date on which the crash occurred.		X	
Acdtmun	The name of the municipality (city or township) in which the crash occurred.		X	
Acdtmuncd	The 5-digit code for the municipality (city or township) in which the crash occurred as implemented by FIPS PUB 55-2.		X	
Acdttime	The military time at which the crash occurred.		X	
Cmlvehicax	The number of axles, including auxiliary axles, under the motor vehicle. Axles include all common axis of rotation of one or more wheels, whether power driven or freely rotating.		X	1
Light	Light condition at the time and place of the crash.		X	2
Month	Month of crash		X	

Variable Name	Variable Description	Current Technology	Future Technology	Notes
Rdsurf	The condition of the road surface at the time and location of the crash.		X	4
State	State abbreviation in which crash occurred		X	
StateName	State name in which crash occurred		X	
Truckbus	Indication of whether the vehicle involved in the crash was a truck (t) or bus (b).		X	
Vehicgvwr	Weight rating of the power unit of the vehicle.		X	1
Vehicidno	Vehicle Identification Number (VIN) of the motor vehicle.		X	1
Weather	The predominant weather condition at the time and place of the crash.		X	3
Year	Year of crash		X	

Notes:

1- Can be derived from VIN and associated Vehicle Parameters Database
2- May be inferred from usage of lights
3- May be inferred from usage of windshield wipers
4- May be inferred from precrash information from ABS systems or steering or braking information

The reader should refer to the appendices for a complete listing and classification of the variables contained in the MCMIS Database.

3.4.13 Accident Database Needs vs. EDR Data Element Availability

One important use of EDR data will be replace or improve data collection for the accident databases. The research team has methodically examined eight existing crash databases and three recommended database formats for candidate EDR data element needs. As shown in Table 3-16, EDR data promises to significantly improve the efficiency of database collection for existing accident statistic databases.

Table 3-16. Accident Database Needs vs. EDR Data Element Availability

Database or Database Format	Number of Database Variables	Variables which could be provided by EDR data	
		Current Technology	Future Technology
FARS	175	10	45
NASS/CDS	400	23	39
NASS/GES	130	8	19
HSIS	120	5	14
LBSS	250	13	27
MMUCC	75	5	19
VEHDB crash tests	180	11	15
NCHRP 350 test	100	6	24
NCHRP 22-15	60	1	8
TIFA	250	15	37
MCMIS	100	-	16

3.5 Summary of Data Elements Which Could Be Collected by EDRs

A universal catalog was assembled containing the potential EDR data elements extracted from the literature review and the target databases. EDR elements not currently collected for the target databases but representing a possible contribution to roadside safety have been identified and integrated into this listing. Table 3-17 presents the results of the assimilation of extracted data elements.

Table 3-17. Catalog of Database Elements Which Could Be Collected by EDRs

Variable Description	EDR Element(s)	Notes
Date of accident	Crash Date	
Time of accident	Crash Time	
Location of the Crash (includes latitude, longitude, state, county, and city or municipality)	Crash Location (GPS Coordinates)	4
Number of recorded events in accident	Event counter	
Manner of collision	PDOF	
Heading angle for this vehicle	Vehicle Direction / Heading	
Air bag deployment (Driver, passenger, other)	Airbag Deployment Parameters	
Air bag system failure	Airbag Diagnostic Codes	
Max delta V	Longitudinal, Lateral, and Normal acceleration	11
Lateral component of delta V	Lateral Acceleration	11
Longitudinal component of delta V	Longitudinal Acceleration	11
Impact speed	Vehicle Speed	
Impact angle	X,Y,Z acceleration and yaw, pitch, and roll rates	3
Vehicle yaw angle at impact	Yaw Rate	
Vehicle separation angle	X,Y,Z acceleration and yaw, pitch, and roll rates	3
Vehicle exit speed (i.e. redirectional crash)	Vehicle Speed	
Vehicle stability (before, after and during event)	Yaw, roll, and pitch rates	5
Vehicle pitch rate	Pitch Rate	
Vehicle roll rate	Roll Rate	
Vehicle yaw rate	Yaw Rate	
Direction of initial roll	Roll Rate vs. time	
Rollover event indication	Roll Rate vs. time	
Vehicle trajectory (before, after and during event)	x,y,z Acceleration, Yaw, Pitch, Roll rates	2
Tire inflation pressure	Indicator - Tire inflation pressure	
Vehicle mileage	Vehicle mileage	
Attempted avoidance maneuver	Pre-crash steering angle, braking, engine speed, throttle position, stability control system status, and accelerator position	6
Roadway surface condition	Anti-lock braking and traction control systems	7
Light conditions	Headlights, crash date/time	8

Variable Description	EDR Element(s)	Notes
Acceleration (X,Y,Z directions)	Acceleration (X,Y,Z directions)	
Atmospheric conditions	Windshield Wipers, Outside Temperature	9
Vehicle in emergency use at the time of the crash?	Siren Indicator	
Number of occupants within vehicle	Occupant Classification Sensor or Number of Occupants Sensor	
Occupant location in the vehicle	Occupant Classification Sensor	
Occupant weight	Occupant Classification Sensor	10
Manual belt system use	Belt Status	
Principal direction of force	PDOF	
Vehicle identification number	VIN	
Antilock brakes	Indicator – Antilock brakes	
Vehicle body type	VIN	1
Vehicle curb weight	VIN	1
Front/rear wheel drive	VIN	1
Driver presence in vehicle	Occupant Classification Sensor	
Four wheel drive	VIN	1
Vehicle make	VIN	
Vehicle model	VIN	
Vehicle model year	VIN	
Type of vehicle	VIN	1
Restraint type	Belt Status, Airbag parameters	
Wheelbase (original)	VIN	1
Test vehicle engine displacement (liters)	VIN	1
Maximum width of the vehicle	VIN	1
Gross vehicle weight rating	VIN	1
Point of Impact (on vehicle)	PDOF	
Indicates the type of sensor	EDR Model	
Location of sensor on vehicle	EDR Model	
Axis direction for sensors measuring vector quantities	EDR Model	
Time increment of the measurement (microseconds)	Time Stamp	
Data status (validity)	EDR diagnostic codes, VEDI status, Event Recording Complete	
Power unit and Engine Specifications (heavy trucks)	VIN	1
Occupant Impact Velocity (X-direction)	Longitudinal Acceleration	
Occupant Impact Velocity (Y-direction)	Lateral Acceleration	
Theoretical Head Impact Velocity	Longitudinal and Lateral Acceleration	
Ridedown acceleration (X-direction)	Longitudinal Acceleration	
Ridedown acceleration (Y-direction)	Lateral Acceleration	
Post-Impact Head Deceleration	x,y,z Acceleration	
Acceleration Severity Index	x,y,z Acceleration	
Post-impact max vehicle roll angle	Roll Angle / Roll Rate	
Post-impact max vehicle pitch angle	Pitch Rate	
Post-impact max vehicle yaw angle	Yaw Rate	
Date and Time of accident notification	ACN - Date and Time of accident notification	
Roadway Departure	Lateral Lane Position Sensor	

<u>Notes</u>

1. Vehicle Identification Number + Vehicle Parameter Database
2. The vehicle trajectory can be reconstructed knowing the (a) vehicle acceleration on the longitudinal, lateral, and vertical axes (b) vehicle yaw, pitch, and roll rates, and (c) final resting position/orientation of the vehicle (obtained from site inspection). For planar collisions without rollover, trajectory can be obtained from a more limited set of parameters: (a) acceleration on the longitudinal and lateral axes (b) the vehicle yaw rate, and (c) final resting position/orientation of the vehicle (obtained from site inspection).
3. Computed from the vehicle trajectory. In the case of a collision with a roadside feature, the location and orientation of the fixed object must also be measured from site inspection.
4. County, city, municipality, or state can be obtained by use of GPS coordinates combined with a Geographic Information System (GIS).
5. Assumes that vehicle stability can be inferred from yaw, pitch, and roll rates
6. Assumes that crash avoidance maneuvers can be inferred from pre-crash braking, engine speed, steering angle, and accelerator pedal position.
7. Assumes that roadway surface condition can be inferred from anti-lock braking and traction control systems time history or activation.
8. Light conditions can be inferred from headlights, the time of day, and date.
9. The possibility of rain can be inferred from the use of windshield wipers.
10. Assuming occupant size determined using weight sensors.
11. Delta-V versus time can be computed by integrating acceleration versus time.

3.6 Prioritization of EDR Data Elements for Roadside Safety Analysis

This section presents a prioritization of EDR data elements by their importance to roadside safety analysis. Earlier sections of this report have presented (1) existing and potential EDR data elements, and (2) Roadside Safety data needs which could be fulfilled by EDRs. The following section describes the results of an exercise in which the research team drew upon the in-depth expertise of subject specialists in roadside safety from the AASHTO Technical Committee on Roadside Safety (formerly the AASHTO Task Force for Roadside Safety) to prioritize EDR data elements by their importance to roadside safety.

3.6.1 Approach

On September 25, 2002, the PI met with the AASHTO Technical Committee on Roadside Safety in St. Louis, Missouri, and made a presentation entitled "NCHRP 17-24, Use of Event Data Recorder (EDR) Technology for Roadside Crash Data Analysis: A Status Report". The PI followed the presentation with a breakout group exercise designed to prioritize EDR Data Elements for Roadside Safety Analysis.

The Task Force participants were broken into nine teams. Each team was composed of three to four persons. To facilitate the discussion, each breakout group was assigned one of the following three hypothetical case studies and asked to consider the use of EDR data to analyze the case:

Scenario

1. Revision of NCHRP 350. In the year 2015, NCHRP 350 is revised yet again. Evaluate the 'relevancy' of NCHRP 350 test requirements.

2. Super-SUVs. In the year 2020, Super-SUVs (Ford Excursions and Chevy Surburbans) have become extraordinarily popular and now account for one-half of the fleet. Evaluate how roadside safety hardware performs with this massive new segment of the vehicle fleet.

3. Accidents on Rural Roads. Evaluate the safety problem of two-lane rural roads and ditches.

The participants were each given the table of 37 EDR data elements shown in Table 3-18. The table was assembled from existing or proposed EDR data elements compiled from several different automakers. The participants were told that, because of limited memory in a hypothetical future EDR design, only ten of these elements could be recorded in the event of a crash. They were asked to discuss their scenario and pick the 10 elements which would be most useful in analyzing the case. Finally, the participants were asked to rank order each element by its importance to the analysis. A score of 10 was to be assigned to the most important of the 10 data elements, a score of 1 was to be assigned to the least important of the 10 elements, and a blank score assigned to any unranked elements. The teams were also encouraged to suggest additional elements which were not on the list of EDR data elements. At the completion of the exercise, a quick synopsis of the results was presented to the group for discussion. A more complete analysis of the results is presented below.

3.6.2 Results

The results of the prioritization exercise are presented in Table 3-19. Eight of nine teams completed the exercise: three Scenario 1 teams, two Scenario 2 teams, and three Scenario 3 teams. As shown in Table 3-19, the scores assigned to each element were summed first by all teams assigned to a scenario and then for all teams. The maximum score possible was 80 (10 times 8 teams). In addition to the list of given EDR data elements, the combined teams suggested six other data elements, listed at the bottom of Table 3-19, which would be useful for the evaluation of roadside safety.

Table 3-20 presents the prioritization of the data elements based on the combined rank ordering of the breakout group participants. The highest priority element was vehicle speed. Second highest priority was yaw rate presumably chosen to determine if the vehicle was tracking upon impact. Third highest priority was the crash location which, given an accurate geographical inventory of roadside safety devices, could be used to correlate the crash with the type of device struck.

These top ranked data elements were remarkably consistent across all scenario groups. With few exceptions, the teams independently assigned highest priority to the same top ten data elements despite the fact that the teams were analyzing three very different scenarios. Knowledge of the pre-crash configuration of the striking vehicle was considered paramount. Knowledge of the impact loads as measured by delta-V or crash pulse was a close second in priority. The participant responses were not completely uniform of course. While the participants analyzing Scenario 1 (NCHRP 350 revisions) and Scenario 3 (Rural Road Accidents) were very consistent, participants analyzing Scenario 2 (Super-SUVs) indicated the need for even more in-depth knowledge pre-impact configuration.

3.6.3 Findings

This section has described the results of an exercise in which the collective judgment of subject experts in roadside safety from the AASHTO Technical Committee on Roadside Safety was systematically captured to prioritize EDR data elements by their importance to roadside safety. The collective judgment of the AASHTO group indicated that:

- Data elements that measure the pre-crash configuration of the vehicle are very important to the analysis of roadside safety. Four of the top ten data elements measured the pre-impact configuration including vehicle speed, yaw rate, roll rate, and lateral acceleration.

- Data elements measuring crash performance of the vehicle-roadside system were also of high priority (4 of the top 10) and included lateral delta-V, longitudinal delta-V, lateral crash pulse, and longitudinal crash pulse.

- Crash location is of high priority. Given an accurate geographical inventory of roadside safety devices, crash location could be used to correlate the crash with the type of device struck.

- Data elements which measured performance of the occupant restraint system, environmental conditions, or driver performance were considered to be important but not of high priority.

Table 3-18. OEM Event Data Recorder Data Elements

Category	Data Element/Description	Priority
PreCrash	Acceleration - lateral	
	Acceleration - longitudinal	
	Brake Position (% where 0 is no brake and 100 is full brake)	
	Clutch status (position or %)	
	Engine RPM	
	Engine RPM Quality Factor	
	Engine Torque	
	Engine Torque Quality Factor	
	Roll rate	
	Steering wheel angle	
	Throttle position	
	Time from ignition on (measured in # of 15 min intervals)	
	Traction control	
	Transmission / gear selection (PRNDL position)	
	Vehicle speed	
	Yaw Rate	
Vehicle Crash	Crash-pulse lateral	
	Crash-pulse longitudinal	
	Delta-V lateral	
	Delta-V longitudinal	
	Time to Max Delta V	
Restraint	Air bag deployment attempt made (yes/no)	
	Air bag(s) inflation time (from time of crash to time of inflation)	
	Air bag(s) status (Front & Side)	
	Airbag(s) on/off switch position (Suppression system status)	
	Belt pre-tensioner status of each passenger	
	Manual Belt Status (On / Off)	
	Time from algorithm wake up to deployment attempt	
Environment	Global Time and date	
	Location of Crash (Latitude / Longitude)	
	Outside Temperature	
Identifier	EDR Serial Number / Model / Version	
	VIN	
	Ignition Cycles	
Maintenance	Battery system voltage	
	Data Validity Check	
	Diagnostic Codes	
Other	*(Please List Below and on back of page)*	

Table 3-19. Results of EDR Data Elements Prioritization Exercise

Category	Data Element/Description	Scenario 1 – Revised NCHRP 350			Scenario 2 – Super SUVs		Scenario 3 – Rural Roads w/ Ditches			Scenario 1 Score	Scenario 1 Score	Scenario 1 Score	Total Score
		Team1	Team2	Team3	Team4	Team5	Team6	Team7	Team8				
PreCrash	Acceleration - lateral	2	3		9			5		5	9	5	19
	Acceleration - longitudinal	1	4		8			4		5	8	4	17
	Brake Position	7			4		3		8	7	4	11	22
	Clutch status (position or %)												
	Engine RPM												
	Engine RPM Quality Factor												
	Engine Torque												
	Engine Torque Quality Factor												
	Roll rate	8	8	3		4	5		3	19	4	8	31
	Steering wheel angle			2	5		4		1	2	5	5	12
	Throttle position						2		2			4	4
	Time from ignition on												
	Traction control												
	Transmission / gear selection (PRNDL position)												
	Vehicle speed	10	10	5	10	10	7	7	9	25	20	23	68
	Yaw Rate	9	9	4	6	3	6	8	4	22	9	18	49
Vehicle Crash	Crash-pulse lateral			7	3	2	10			7	5	10	22
	Crash-pulse longitudinal			8	2	1	9			8	3	9	20
	Delta-V lateral		6	9		9		9	6	15	9	15	39
	Delta-V longitudinal		7	10	1	8		10	7	17	9	17	43
	Time to Max Delta V												

Results of EDR Data Elements Prioritization Exercise (continued)

Category	Data Element/Description	Scenario 1 – Revised NCHRP 350			Scenario 2 – Super SUVs		Scenario 3 – Rural Roads w/ Ditches			Scenario 1 Score	Scenario 1 Score	Scenario 1 Score	Total Score
		Team1	Team2	Team3	Team4	Team5	Team6	Team7	Team8				
Restraint	Air bag deployment attempt made (yes/no)												
	Air bag(s) inflation time	6								6			6
	Air bag(s) status (Front & Side)												
	Airbag(s) on/off switch position												
	Belt pre-tensioner status of each passenger							3				3	3
	Manual Belt Status (On / Off)	5					1	2		5		3	8
	Time from algorithm wake up to deployment attempt	4								4			4
Environment	Global Time and date												
	Location of Crash (Latitude / Longitude)		5	6	7	6	8	6	10	11	13	24	48
	Outside Temperature	3	1							4			4
Identifier	EDR Serial Number / Model / Version												
	VIN		2			5		1	5	2	5	6	13
	Ignition Cycles												
Maintenance	Battery system voltage												
	Data Validity Check												
	Diagnostic Codes												
Other	Compass Heading					7					7		7

Other Elements Suggested by the Groups:

Steering Wheel Angle History (to capture evasive action)
Tire Air Pressure
Axle Weight
Cell Phone Signal
Headlight / Tail lights on

Table 3-20. Summary of Results of the EDR Data Elements Prioritization Exercise

Overall Priority	Data Element	Data Element Category	Scenario 1 Rank	Scenario 2 Rank	Scenario 3 Rank	Total Score
1	Vehicle speed	Precrash	1	1	2	68
2	Yaw Rate	Precrash	2	6	3	49
3	Location of Crash	Environment	6	2	1	48
4	Delta-V longitudinal	Crash	4	5	4	43
5	Delta-V lateral	Crash	5	4	5	39
6	Roll rate	Precrash	3	14	9	31
7	Brake Position	Precrash	8	13	6	22
8	Crash-pulse lateral	Crash	9	10	7	22
9	Crash-pulse long.	Crash	7	15	8	20
10	Acceleration - lateral	Precrash	11	3	11	19
11	Acceleration – long.	Precrash	12	7	13	17
12	VIN	Identifier	17	12	10	13
13	Steering wheel angle	Precrash	16	11	12	12
14	Manual Belt Status	Restraint	13		16	8
15	Compass Heading	Precrash		8		7
16	Air bag(s) inflation time	Restraint	10			6
17	Outside Temperature	Environment	14			4
18	Throttle position	Precrash			14	4
19	Time from algorithm wake up to deployment attempt	Restraint	15			4
20	Belt pre-tensioner status of each passenger	Restraint			15	3

Table 3-21. EDR Data Element Priority for Roadside Safety Analysis

Overall Priority	Data Element	Data Element Category	Current EDR Technology	Future EDR Technology
1	Vehicle speed	Precrash	X	
2	Yaw Rate	Precrash		X
3	Location of Crash	Environment		X
4	Delta-V longitudinal	Crash	X	
5	Delta-V lateral	Crash	X	
6	Roll rate	Precrash		X
7	Brake Position	Precrash	X	
8	Crash-pulse lateral	Crash	X	
9	Crash-pulse long.	Crash	X	
10	Acceleration - lateral	Precrash		X
11	Acceleration – long.	Precrash		X
12	VIN	Identifier		X
13	Steering wheel angle	Precrash		X
14	Manual Belt Status	Restraint	X	
15	Compass Heading	Precrash		X
16	Air bag(s) inflation time	Restraint	X	
17	Outside Temperature	Environment		X
18	Throttle position	Precrash	X	
19	Time from algorithm wake up to deployment attempt	Restraint	X	
20	Belt pre-tensioner status of each passenger	Restraint	X	

3.7 Recommended EDR Data Elements

As the preceding analysis has shown, the use of EDR technology is a promising method to augment data collection for existing roadside and vehicle accident databases. In addition, EDR technology can support future roadside safety research needs by providing a new source of crash data previously not feasible to collect. Based upon the preceding analysis, we recommend that the catalog of 66 data elements presented in Table 3-22 be included in future EDRs to support highway crash analysis. Each data element in the table is annotated according to whether it is currently stored in a production vehicle EDR, is included in the NHTSA NPRM on EDRs, or is one of the priority roadside safety data elements identified by the AASHTO Technical Committee on Roadside Safety.

Table 3-22. Recommended EDR Data Elements for Highway Crash Data Analysis

Data Element / Description	Current EDR Technology	NHTSA NPRM Element	Priority Roadside Element
Accelerator Pedal (%)	x		
Brake Pedal (%)	x		
Brake Pedal Position (on / off)	x	x	
Diagnostic Codes Active When Event Occurred	x		
EDR Model Version	x		
Engine Speed (rpm)	x	x	
Engine Throttle (%)	x	x	
Event Counter	x	x	
Event Recording Complete	x	x	
Frontal Air Bag Suppression Switch, Passenger	x	x	
Frontal Airbag Warning Lamp Status	x	x	
Frontal Airbag, Driver, Time to 1st Stage Deployment	x	x	x
Frontal Airbag, Driver, Time to 2nd Stage Deployment	x	x	x
Frontal Airbag, Passenger, Time to 1st Stage Deployment	x	x	x
Frontal Airbag, Passenger, Time to 2nd Stage Deployment	x	x	x
Ignition Cycles @ Event	x	x	
Ignition Cycles @ Investigation	x	x	
Longitudinal acceleration	x	x	x
Lateral acceleration	x	x	x
Acceleration time stamp	x		
Occupant Size Classification, Passenger (Adult, non-Adult)	x	x	
Pretensioner, Driver, Time to Deployment	x	x	x
Pretensioner, Pass, Time to Deployment	x	x	x
Seat Belt Status, Driver (buckled / unbuckled)	x	x	x
Seat Belt Status, Passenger (buckled / unbuckled)	x	x	x
Seat Position, Driver, Seat in Forward Seat Position	x	x	
Side Airbag Driver, Time to Deployment	x	x	

Data Element / Description	Current EDR Technology	NHTSA NPRM Element	Priority Roadside Element
Side Airbag, Passenger, Time to Deployment	x	x	
Side Curtain/Tube Driver, Time to Deployment	x	x	
Side Curtain/Tube Passenger Time to Deployment	x	x	
Time between Events	x	x	
Vehicle speed	x	x	x
Antilock braking (engaged / non-engaged)		x	
Brake Status, Engine (on / off)			
Crash Date			
Crash Location (Latitude and Longitude)			x
Crash Time			
Front Wipers Switch			
Frontal air bag deployment level – driver		x	
Frontal air bag deployment level – right front passenger		x	
Hazard Lights Switch			
Headlight Switch			
Indicator Status - Tire Pressure Monitoring System			
Indicator Status - VEDI			
Normal Acceleration		x	
Occupant Position, Driver, out of position		x	
Occupant Position, Passenger out of position		x	
Occupant Size Classification, Driver (Adult, Small Adult)		x	
Seat Position, Passenger, Seat in Forward Seat Position		x	
Stability control (on / off / engaged)		x	
Steering Input (steering wheel angle)		x	x
Temperature - Ambient Air			x
Traction Control Status			
Vehicle Identification Number			x
Vehicle Mileage			
Vehicle Roll Angle		x	
Yaw Rate			x
Cell Phone (On / Off)			
Siren Status (On / Off)			
Lateral Lane Position			
Number of Occupants			
Accident Notification – Date and Time			
Pitch Rate			
Principal Direction of Force			
Roll Rate			
Vehicle Direction / Heading			x

Notes

Following are a few notes of explanation for the preceding data element recommendations:

- The Ignition Cycle Count, a data element currently being stored in some EDRs, is recommended as an interim measure of when the crash occurred. Once EDRs begin to store crash date and time, Ignition Cycle Count should no longer be needed.

- Most accident database, e.g. FARS or NASS/CDS, store some information about the occupant restraint system as this facet of a highway crash is well known to be indicative of injury outcome. To date however, information about the restraint system has been limited to data elements such as whether an occupant was buckled and whether the airbag deployed. EDRs provide copious information about the performance of the occupant restraint system components, including airbag deployment level, performance of belt pretensioners and occupant position at the time of deployment. These parameters are an example of the new data elements which are crucial to understanding the outcome of a highway crash, but have never before been available to investigators. They are included in the list of recommended EDR data elements.

- Note that if it acceleration versus time is available, then it becomes unnecessary to store delta-V vs. time. Delta-v can be computed by integrating acceleration.

Discussion
Thirty-two, or almost half of these data elements, are already being stored in production vehicle EDRs. Thirty-eight (38) of these elements are defined in the NHTSA NPRM on Event Data Recorders. In the near-term, we recommend adopting the data elements proposed in the NHTSA NPRM and adding the following five priority roadside safety data elements: (1) Vehicle Identification Number, (2) crash location, (3) yaw rate, and (4) roll rate. In the longer term, we recommend that the entire list be included in the data elements which are stored in future EDRs.

3.8 Recommendations for EDR Enhancement

Current EDR capabilities will need to be enhanced to better support roadside crash analysis. Following is a list of recommendations:

- **Increase the EDR recording duration.**
  To capture roadside feature crash performance, future EDRs need to record for a greater length of time than is the current practice. Roadside safety analyses require knowledge of not only the pre-crash trajectory, but also the post-crash trajectory. Currently, this data could be obtained if EDRs, such as the GM SDM, stored 'pre-crash' parameters such as vehicle velocity for 5 seconds before and after a crash. Likewise, impacts with roadside features such as a guardrail are relatively long events in comparison with vehicle-to-vehicle crashes. To capture the entire vehicle-to-roadside event, it would be useful if the crash pulse could be recorded for a minimum of 300 milliseconds.

- **Increase the number of events recorded.**
  A crash is frequently characterized by multiple events. For example as shown in Figure 3-1, a car may first inadvertently leave the road and glance off a guard-rail – the first event, careen into the path of an oncoming car – the second event, and finally strike a tree on the opposite side of the highway – the third event.

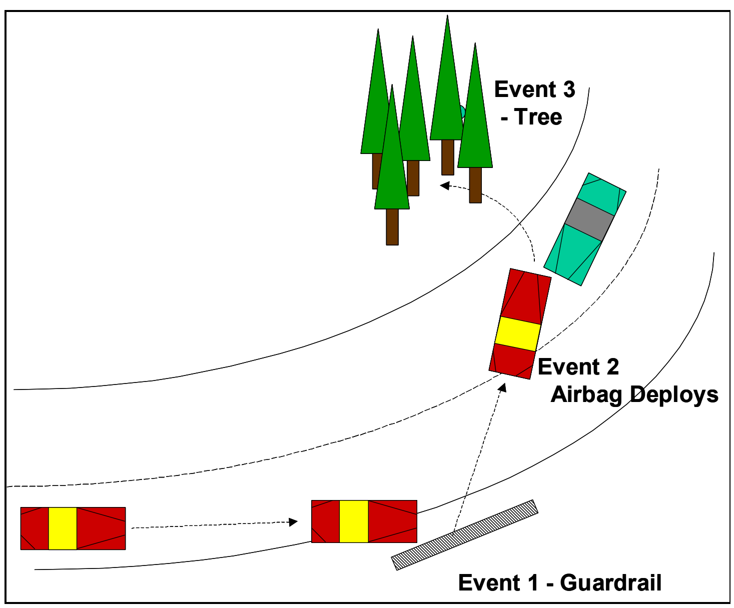

Figure 3-1. Current EDRs may not capture all events in a crash.

Most current EDRs are not equipped to record all the events that may occur in a crash. GM EDRs, for example, are capable of capturing two events: a non-deployment event and a deployment event. For some later GM EDR designs, a deployment level event, which occurs after bag deployment, can record over a non-deployment event. Even these newer GM devices however can only capture two events. Some automakers' EDRs, e.g. the Ford RCM, are only capable of capturing a single event. As the typical event captured is the event that deployed the air bag, any subsequent events may not be recorded even if these events are more harmful.

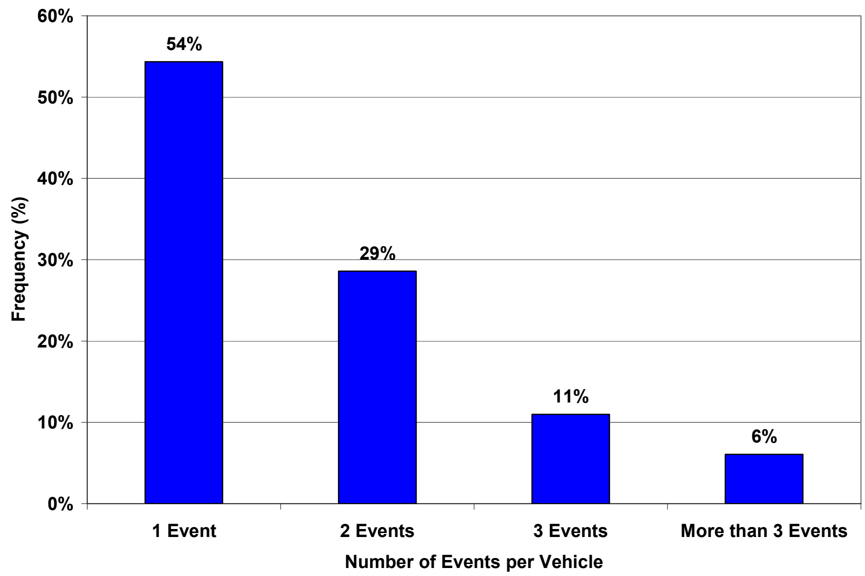

Figure 3-2. Events per Vehicle for NASS/CDS 2000-2002 EDR Cases

Figure 3-2 presents the distribution of events per vehicle for the 2000-2002 NASS/CDS cases with a successful EDR download (Gabler et al, 2004). 46% of the EDR cases involved two or more events. In 17% of the cases, the vehicle was involved in three or more events. As GM EDRs can only store a maximum of two events, it is likely that potential EDR data were "lost" from one or more events in these crashes.

- **Expand the Definition of an Event**
  The literature also suggests that the definition of an 'event' will be an important design consideration for future EDRs. Currently, an event is a crash. In addition to this type of event, the literature indicates that roadway departure, with or without an impact, is also an important event. Lane-keeping and roadway departure warning systems are now entering the market which could be adapted for this purpose. Accurate recording and retrieval of roadway departure events would be invaluable for encroachment studies.

3.9 Conclusions

The objective of this chapter was to catalog and prioritize EDR data needs which support vehicle and roadside safety research and design. The specific objectives were to determine the potential of EDR technology (1) to augment data collection for existing roadside and vehicle accident databases, and (2) to support future roadside safety research needs by providing a new source of crash data previously not feasible to collect. Because an EDR is vehicle-mounted, the device is, of course, limited to what can be measured on the vehicle. However, the preceding analysis has shown that many data elements needed for roadside safety research or collected in for accident databases can be provided by EDR technology.

Our findings are as follows:

- A review of the roadside safety literature suggests that many of the data elements recommended for collection by previous research studies can either be obtained by current EDR devices or in future EDR designs. Examples of critical research data needs are pre-crash vehicle trajectory, post-crash vehicle trajectory, and the orientation of the vehicle (yaw, pitch, roll) at the time of impact.

- Many of the data element needs can be obtained if future EDRs begin to store VIN. The VIN contains complete information on the vehicle make, model, year, and curb weight. When these identifiers are combined with a database such as the NHTSA Vehicle Parameter database, the data needs for vehicle geometry can also be obtained.

- EDR data has the promise to significantly improve the efficiency of database collection for existing accident statistic databases. Based upon the methodical examination of eight existing crash databases and three recommended database formats, we conclude that a significant fraction of data elements currently being collected could be provided by either existing or future EDR data elements. For example, 55 of the 175 FARS data elements could be provided by EDRs. For state accident databases designed to meet MMUCC format, 24 of the 75 recommended data elements could be provided by EDRs.

- The priority of EDR data elements was ranked in an exercise in which the collective judgment of subject experts in roadside safety from the AASHTO Technical Committee on Roadside Safety was systematically captured to prioritize EDR data elements by their importance to roadside safety. The collective judgment of the AASHTO group indicated that data elements that measure the pre-crash orientation of the vehicle was of highest priority to the analysis of roadside safety. Crash location was also deemed to be of high priority. It is interesting to note that six of the ten highest priority data elements can be collected by current EDR technology. Only four of the highest priority data elements will require enhancements to existing EDR technology

Our recommendations are:

- Based on a comparison of EDR capabilities and highway crash data analysis needs, a catalog of 66 recommended data elements has been developed. Nearly half of these data elements, are already being stored in production vehicle EDRs. Thirty-eight (38) of these elements are defined in the NHTSA NPRM on Event Data Recorders. In the near-term, we recommend adopting the data elements proposed in the NHTSA NPRM and adding the following four priority roadside safety data elements: (1) crash location, (2) Vehicle Identification Number, (3) yaw rate, and (4) roll rate. In the longer term, we recommend that automakers store the entire list of data elements in future EDRs.

- To capture roadside feature crash performance, future EDRs need to record for a greater length of time than is the current practice. Roadside safety analyses require knowledge of not only the pre-crash trajectory, but also the post-crash trajectory. Currently, this data could be obtained if EDRs, such as the GM SDM, stored 'pre-crash' parameters such as vehicle velocity for 5 seconds before and after a crash. Likewise, impacts with roadside features such as a guardrail are relatively long events in comparison with vehicle-to-vehicle crashes. To capture the entire vehicle-to-roadside event, it would be useful if the crash pulse could be recorded for a minimum of 300 milliseconds.

- EDRs need to record an increased number of events. EDRs which record only a single event, e.g. the current Ford design, lose approximately one-half of the events. EDRS which record only two events, e.g. the current GM design, lose approximately 17% of the events. An EDR which records 3 events, on the other hand, would capture 94% of the crash events.

- The definition of an 'event' should be expanded to include roadway departures. Currently, an event is a crash. In addition to this type of event, roadway departure, with or without an impact, is also an important event. Lane-keeping and roadway departure warning systems are now entering the market which could be adapted for this purpose. Accurate recording and retrieval of roadway departure events would be invaluable for encroachment studies.

3.10 References

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4. EDR Retrieval and Archival Methods: Current Methods, Limitations, and Issues

4.1 Introduction

This objective of this section is to discuss current methods for retrieval and storage of EDR crash data for highway crash safety analysis. The discussion will also identify key issues and problems associated with these methods. Finally, this chapter provides recommendations for improved retrieval and archival methods.

4.2 EDR Data Retrieval Methods and Issues

Currently, there is no standardized method to download data from EDRs. As a step towards resolving this issue, some manufacturers have teamed with Vetronix Corporation, a third party vendor, to produce a publicly available EDR reader. The automakers that have not made arrangements with Vetronix retrieve data from their EDRs or airbag control modules through proprietary devices of their own design. Another optional, but less frequent, practice used by some automakers is to physically remove the EDR or airbag control module from the car, and send the unit back to the supplier for data retrieval.

4.2.1 Vetronix Crash Data Retrieval System

As shown in Figure 4-1, the Vetronix CDR system allows a user to directly connect to and read an EDR from a laptop computer. The laptop computer connects to a CDR interface box which connects to the EDR through a cable. The CDR system provides two methods for connecting to the EDR: (a) through the Onboard Diagnostic connector, and (b) through direct cable connection with the EDR itself.

In 1999, GM awarded the Vetronix Corporation with an exclusive contract to develop the Crash Data Retrieval (CDR) system. The CDR System became available to the public in March 2000 [Kerr, 2002]. In spring 2003, Vetronix, under a similar agreement with Ford, released version 2.0 of their software which could decode EDRs from some Ford models. We are also aware that additional automakers are currently in negotiation with Vetronix to allow the decoding of their EDRs. The Vetronix CDR system is available for public purchase for $2500 per unit.

Figure 4-1. Rowan University Research Assistant downloads an EDR removed from a Saturn passenger car using the Vetronix Crash Data Retrieval System

The preferred method is to connect to the Onboard Diagnostic connector (OBD-II) located in the occupant compartment under the instrument panel. The OBD-II connector shown in Figure 4-2 has been EPA-mandated equipment on all U.S. passenger cars and light trucks manufactured since model year 1996. Although the primary purpose of the OBD-II connector is to allow access to engine and emissions diagnostics data, the OBD-II connector is also increasingly used as an access point to the other on-vehicle computers including the EDR or airbag control module. Specifications for the OBD-II connector are standardized under SAE J1962.

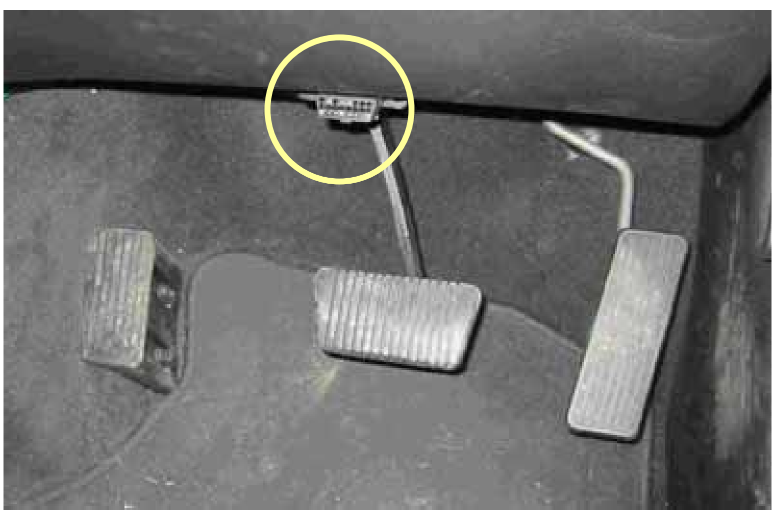

Figure 4-2. OBD-II Connectors are located under the Driver Instrument Panel

If the OBD-II connector cannot be used due to crash damage, the Vetronix system allows the user to directly connect to the EDR for downloading as shown in Figure 4-3.

Vetronix provides a selection of cables to allow direct connection with different types of EDRs.

Figure 4-3. GM EDR shown connected to Vetronix CDR download cable [Kerr 2002, used with permission of the Vetronix Corporation]

This downloading method has two disadvantages over the OBD-II method. First, the EDR is frequently located in a difficult to access location. GM EDRs are typically installed under one of the front seats as shown in Figure 4-4 or embedded behind the center console. Accident investigators have told us that in many cases, the car must be partially dismantled to gain access to the EDR. This process is time consuming and may be unacceptable to the owner who seeks to prevent further damage to their car.

Second, this method is only successful if the field investigator has a cable which matches the particular EDR of interest. Because there is no standard for the EDR connector, the field investigator must carry a large number of cables having different connectors. The current Vetronix system comes with a dozen different cables corresponding to different EDR designs. Accident investigators have told us that they have attempted to directly download the EDR in some cars only to find that they did not have a matching cable to allow the download to proceed.

After successfully establishing a connection using either download method, the Vetronix system retrieves and saves the EDR information in hexadecimal format as a Vetronix CDR file. The CDR file can be opened at any later date by the Vetronix CDR software to view the downloaded EDR information.

Figure 4-4. EDRs are frequently located in difficult to access locations [Kerr 2002, used with permission of the Vetronix Corporation]

Standards Groups Activities in Retrieval Methods

The SAE J1698 Standards Working Group on Vehicle Event Data Interfaces is actively developing proposals for standardized retrieval methods. The SAE J1698 group appears to be leaning toward leveraging the OBD-II connector standard as a standardized access point [Kreeb, 2003].

4.2.2 NHTSA Experience with EDR Data Retrieval

In the field, NHTSA has found that it is not always possible to download data from the EDR [Gabler et al, 2003; Hinch et al, 2004]. As shown in Figure 4-5, NASS investigators could not recover data in approximately one-third of all attempts to download an EDR-equipped vehicle. While this rate was consistent in both NASS 2002 and 2003, the reasons for unsuccessful downloads in 2002 were quite different from those reasons noted in 2003.

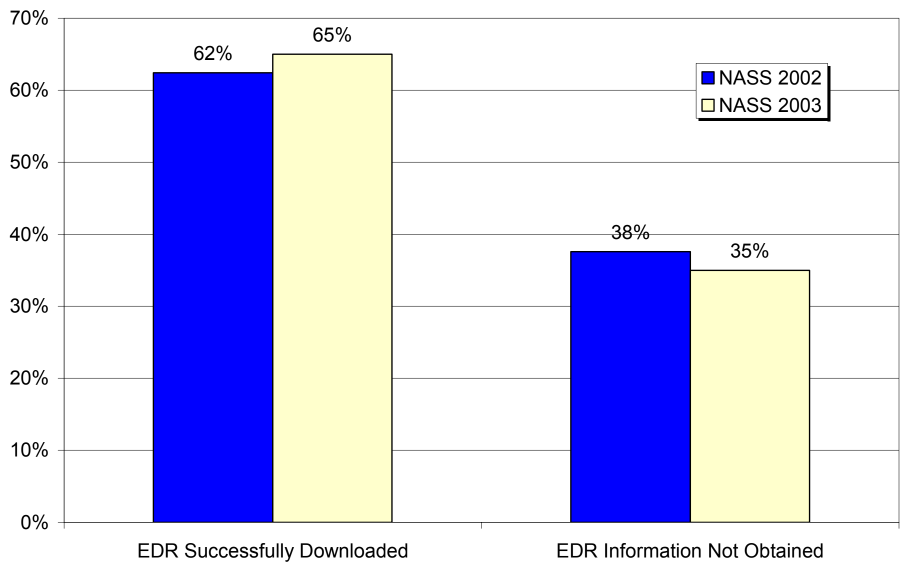

Figure 4-5. NHTSA Success Rate in Downloading Event Data Recorders in NASS/CDS 2002-2003 crash investigations (adapted from Hinch et al, 2004)

The reasons for the inability to obtain the EDR data were culled from case comments entered by NASS/CDS researchers, and grouped into the categories shown in Figure 4-6.

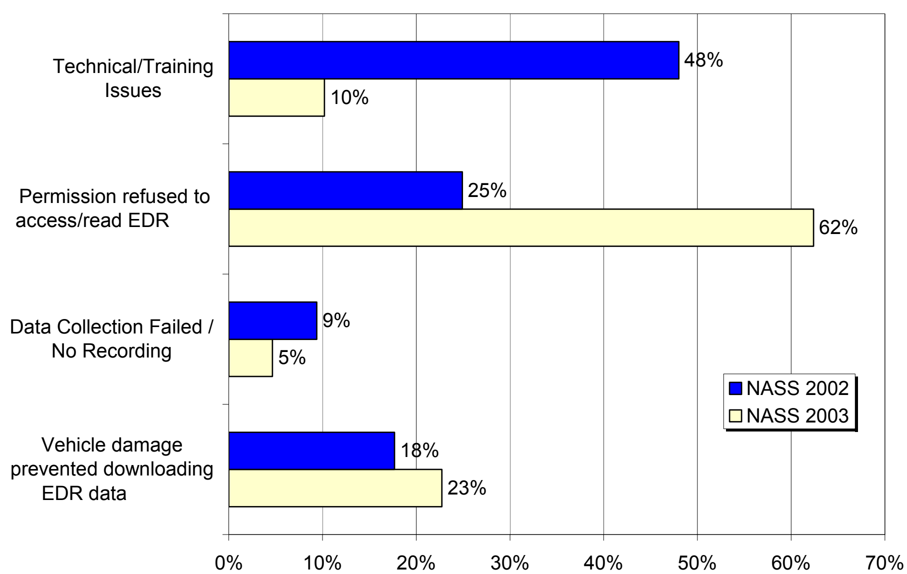

Figure 4-6. Reasons for Unsuccessful Downloads in NASS/CDS 2002-2003 (Adapted from Hinch et al, 2004)

The categories are discussed below:

1. Technical/Training Issues. Technical / training problems were the leading cause of unsuccessful downloads in 2002 (48%), but after an aggressive training program in late 2002, training problems resulted in only 10% of the unsuccessful downloads in

2003. This category included circumstances where the crash data was not available due to technical issues such as, inability to access the data-recording device without causing undue damage to the vehicle, partial inspections of vehicles, time constraints as well as a lack of problem solving and technical assistance at the time of the vehicle inspection.

2. No Permission. NHTSA requires owner permission prior to interrogating the vehicle EDR. In 2003, failure to obtain the owner's permission accounted for nearly two-thirds of the unsuccessful EDR downloads – a dramatic upsurge from 2002 in which this reason accounted for only 25% of unsuccessful downloads. This category included situations when permission was not given to perform any vehicle inspection as well as situations in which permission was given to perform a full vehicle inspection less the EDR interrogation.

3. Data Collection Failed / No Recording. Data collection failed in only 5-9% of the EDRs investigated for this study. This category included situations where the recording device did not record any or all of the expected data or the criteria to record data were not met in the crash. Compromise of the vehicle's electrical system during the crash was believed to be the most frequent cause of failed recordings. The air bag control modules are equipped with capacitors to deploy the occupant protection systems. These capacitors do not always have the sufficient power to also record crash data.

4. Crash Damage Prevented Access. Crash damage accounted for approximately 20% of all unsuccessful EDR downloads. This category includes situations where the EDR data could not be accessed due to crash induced deformation. This includes situations where the actual recording-device could not physically be accessed or the interior of the vehicle itself could not be accessed due to crash damage. This category included those situations where it was impossible to interrogate the EDR via the OBD-II vehicle diagnostic connector, and the case annotation mentioned no attempt to directly connect to the EDR.

Proper training of crash investigators in the use of EDRs is essential. In November 2002 NHTSA's National Center for Statistics and Analysis', Crash Investigation Division produced a NASS Event Data Recorder Data Collection Guideline (Roston, 2002). This Guideline was provided to all NASS, SCI and CIREN personnel and will be provided to new researchers as they attend NASS Basic Training. Additionally, the NASS Basic Training EDR curriculum was reviewed and updated. This additional training in EDR download protocol appears to have had a positive impact on EDR download success rates. In 2002, training/technical problems accounted for nearly half of all unsuccessful downloads. In 2003, after NHTSA initiated its EDR training program, technical / training problems were listed as the reason for only 10% of the unsuccessful downloads.

Of concern to all users of EDR data is the frequency with which the OBD-II diagnostic connector was listed as inoperable. This phenomenon should be considered before recommending that the OBD-II diagnostic connector also serve as a universal connection to EDRs. Use of the OBD-II connector requires vehicle power. Generally, vehicles that are involved in a crash of significant severity will be without vehicle power. This can be due to either crash-induced damage or due to actions taken by first responders to render the vehicle safe. Without vehicle power the OBD-II plug is basically useless, and connections must be made to the EDR directly. When one considers the requirement that at least one vehicle in a NASS selected case must be towed due to damage, the need for a crashworthy OBD-II connection becomes very apparent.

4.2.3 Interviews with NASS Field Accident Investigators

NHTSA has reported that approximately one-third of all EDR download attempts in 2002 and 2003 by NASS/CDS investigators were unsuccessful [Gabler et al, 2003; Hinch et al, 2004]. To examine the reasons for this lack of success, the research team, with permission from NHTSA, interviewed two NASS/CDS teams about their perceptions of the EDR download process in the field.

The first team was located in Ocean County, New Jersey [Sarnecky, 2003 and Parkinson, 2004]. The second team was located in Philadelphia, PA [Zyck, 2003 and Zyck, 2004]. In our interviews, we asked the field investigators to comment on their experiences with EDR data retrieval and specifically on any problems or issues they had encountered during EDR data retrieval. Our findings are summarized below:

<u>EDR Access and Connection</u>. The preferred method for accessing EDRs is via connection to the vehicle's On-Board Diagnostics (OBD-II) port usually located somewhere under the driver's side dash panel. The OBD-II port was readily accessible to the NASS investigators as it would be to any service personnel that need access to it for other diagnostic purposes. However, downloading an EDR from this location was not always possible.

The Ocean County NASS team originally estimated that only one in eight of their EDR download attempts were successful through the OBD-II port [Sarnecky, 2003]. A more recent interview suggested a much higher download rate through the OBD-II port, approximately four out of five vehicles [Parkinson, 2004]. Parkinson noted, however, that this higher rate may simply be the result of investigating less severe crashes since the previous interview. He explained that the vehicle's electrical system must be intact in order to download the EDR data from the OBD-II port. The Philadelphia NASS team reported that less than half of the EDRs were read through the OBD-II port [Zyck, 2004]. When OBD-II access fails, the Vetronix CDR tool will report the error: "Unable to connect to Module". In these instances, the NASS investigator must physically locate the EDR in the vehicle and plug directly into it via the cables provided with the Vetronix CDR tool.

With OBD-II download impossible in a significant number of cases, direct connection to the EDR is the only other option. Since most EDR boxes are located under one of the front seats, under the carpet, or in the center dash panel depending on make / model, both accident investigation teams originally reported that getting access to the EDR is their greatest challenge. With the EDRs located in these places, the accident investigator must cut through carpet under the front seat or directly into the central dash panel to obtain access to the EDR. It is understandable that a vehicle owner who intends on having their vehicle fixed or salvaged would not want an investigator cutting their carpet or dash panel.

Although EDR access is still a major issue, both NASS teams indicated that automobile manufacturers are improving EDR access in newer vehicle models. Examples of access improvements include placement of the EDR in the center console/tunnel as well as pre-cut carpet to allow for access to EDRs located underneath a seat [Zyck, 2004]. In particular, Zyck noted the accessible EDR placement in newer Saturn models. The module is located in the center console and can be accessed by removing a mere three screws and detaching the center console cover. Although the pre-cut carpet aids access, Zyck indicated that under-seat mounted EDRs are sometimes difficult to access in collisions where the seat track is damaged (usually in high severity side impacts). In this case, the entire seat assembly has to be removed to gain access to the EDR; a task that may be avoided if the EDR is located in the center console.

For vehicles that are salvageable but have experienced an airbag deployment event, the EDR must be replaced before the vehicle's safety systems can operate properly due to the permanent storage of deployment in an EDR's memory. The problem that arises here is that often by the time accident investigators get to a vehicle, the vehicle has already been in for repairs or the repair personal have already serviced the area of the vehicle that entails the EDR. Since this repair is usually done days before accident investigators arrive, the EDR that was in the subject vehicle is discarded and cannot be recovered for download. In addition, the Philadelphia NASS team has found that repair shop owners frequently do not want accident investigators plugging into any diagnostics or other electronics just before or while they are working on the vehicle.

<u>EDR Download Failure</u>. EDR durability is another concern for crash investigators and researchers. An EDR can be designed to record many different types of data, but if it cannot withstand the rigors of the crash pulse then it is of little use. The Ocean County team originally estimated that up to one in five of the EDRs that fail could not be downloaded due to some other internal malfunction. This was true whether the EDR was accessed through either the OBD-II port or by direct connection with the access cables. They reported no correlation between EDR download failure and crash severity. This means that a crash investigation of a vehicle that collided with a curb at less than five mph is as likely or unlikely to fail at download as a vehicle that collided head on into a bridge abutment at 30 mph.

Although still a concern, both NASS teams indicate that EDR download failure is not typically a significant issue. Of the recent cases investigated by the Philadelphia NASS team, the only instance of internal EDR malfunction occurred because the vehicle was submerged in water [Zyck, 2004].

Lack of Correct Cables for Direct Connection. Another requirement, and one particularly important to downloading the EDRs though direct connection, is having the correct cables readily available for the Vetronix CDR tool. Both teams reported that if they had the correct cables for the EDR in question, finding the correct one and plugging into the EDR was straightforward. However, since automakers are constantly upgrading and updating their systems, the cables that are required for downloading certain boxes are not always available to the NASS investigation teams at the time of investigation.

Although this has previously been observed to be a problem with some of the latest model GM vehicles and the more recently added Ford vehicles and still continues to be an issue, both teams agreed that improvements have been made in this area. Zyck indicated recently acquiring three new Ford cables and that the team is confident that it can download data from most GM and Ford modules [Zyck, 2004].

Both NASS teams believed that a seemingly trivial solution to this problem would be to have a standard universal cable for all types of EDRs including all manufacturers' makes and models. The standard cable interface would take the same shape and contain all the pins that could be used in an EDR box. Different makes and models may not use all of the pins however. This solution is very similar to the idea employed by the OBD-II standard in that all manufacturers' makes and models must conform to the standard. This would allow anyone with a tool for reading the information from one manufacturers' EDR the ability plug in and view data from any other manufacturer.

Overall Perception of Vetronix Data Retrieval. Use of the actual Vetronix CDR tool was reported as simple, provided that the accident investigators have access to the EDR and the correct cables to download the data. The Ocean County team reported that the downloading process was one of the fastest procedures completed by the investigation team.

Other EDR Downloading Concerns. Assuming that the accident investigation teams are able to download the EDR from the OBD-II port, they need to obtain the vehicles keys to operate the ignition. Contrary to overall NHTSA findings, the Ocean County team reported that obtaining the vehicles keys was not a problem, making this method of download a simple process when OBD-II download functions correctly.

Another concern was the vehicle's owner's rights. Currently, the NASS investigation teams obtain permission from the vehicle's owner when they download an EDR. If the vehicles' owner cannot be contacted at the time of the investigation, then the data is not downloaded. In cases where the vehicle is totaled, permission is obtained from the salvage yard (the current owner of the car) at the time when the vehicles' keys are obtained and the data is downloaded. The investigators get the box, download the information and go about the rest of the investigation.

Conclusions. Although the percentage of EDR downloads possible through the OBD-II port appears to be improving, there are still a significant number of instances where direct access to the EDR is required. This has important repercussions for the standards groups who are considering future EDR retrieval methods.

GM Experience with EDR Data Retrieval

The research team followed up these interviews with a phone interview with a subject EDR expert at GM [Floyd, 2003]. GM reports significantly higher success rates at downloading their EDRs through the OBD-II connector. GM uses a technique of externally powering the airbag control module through the fusebox when the car has lost power or no key is available. GM reports that this technique works unless there is significant intrusion or unless the OBD-II connection has been grounded. It should be noted that this technique is not however part of the currently recommended practice when using the Vetronix CDR tool.

Using techniques such as these, however, GM estimates that their EDRs can be downloaded through the OBD-II connector 80% of the time. Only an estimated 20% of the attempted downloads require direct connection with cables. In an estimated 5% of all cases, no data can be recovered for reasons including water immersion, fire, or severe crash damage.

4.3 Exporting EDR Data to Accident Databases: Issues and Recommendations

4.3.1 Need for Automated Method to Export EDR Data to Accident Databases

The Vetronix CDR software is designed to read and display information for a single EDR case. There is currently no provision for exporting EDR data either to a database or a spreadsheet. The Vetronix CDR software does provide the option to write a report in PDF format, but this format is also not compatible with any databases. While the current form of the Vetronix software is acceptable for individual cases, this design places a huge and growing burden on data collection agencies such as NHTSA or state DOTs which must store thousands of cases.

Currently, all EDR data entered into large databases such as the NHTSA NASS/CDS must be manually transcribed from the Vetronix screens into the database. This is a tedious and very error-prone process. NHTSA requires each of their 27 NASS teams to manually transcribe the data as part of their submission for each case. This process requires a significant amount of time to accomplish.

Under a separate NHTSA contact to analyze NASS/CDS EDR data, the research team has gained first-hand experience in this tedious process [Gabler et al, 2003]. During the last three years, Rowan University has developed an EDR database of over 1000 cases. For each of these cases, a research assistant has carefully transcribed the EDR data from the Vetronix screens into our database format. Because we were concerned that this process was error-prone, a second research assistant then re-examined each case to ensure that it had been properly entered into our database, and made any necessary corrections.

While the process is currently merely burdensome, the rapidly growing number of EDR datasets collected by NHTSA threatens to overwhelm the NASS teams data entry capabilities unless EDR data can be loaded into the accident databases electronically. As can be seen in Table 4-1, the number of EDR datasets retrieved by NHTSA each year is growing rapidly.

Table 4-1. Contents of Rowan University EDR Database by Source

Source	Total Number of Cases
NASS/CDS 2000	21
NASS/CDS 2001	192
NASS/CDS 2002	314
NASS/CDS 2003	500+
Total	1000+

4.3.2 Recommendation

Adding an option in the Vetronix software to export the contents of each EDR in an electronic form could eliminate this cumbersome manual data entry process. As part of this study, we contacted Vetronix to determine if there are any plans to add an option to the CDR software to improve the method of data export. Vetronix reports that the bulk of their CDR users are crash investigators who download and analyze single EDR cases. However, the company is developing a CDR-to-XML converter for applications such as NASS/CDS. NHTSA plans to use CDR-to-XML conversion to automatically populate their NASS/CDS database beginning in 2005.

Vetronix has provided the research team with a beta version of this promising CDR-to-XML converter for evaluation purposes. To date, we have used the program to convert a Ford case, and a GM case with a Deployment and Deployment Level event. An example of the GM output in XML format is contained in the appendices. As the program is not officially supported by Vetronix, there is no documentation. To support the use of this program by other Vetronix users, we have written a guide to installing and running the converter which is also provided in the appendices.

4.4 EDR Data Archival Methods

Use of EDR data for highway crash research and policy studies requires the collection, storage, and analysis of large numbers of accident cases. These EDR records are most useful when linked with existing databases, e.g. state or national accident databases, which describe other aspects of the traffic accident. This section discusses current methods for archiving EDR data. The next section provides a recommended format for a standardized EDR database.

4.4.1 Current EDR Data Archival Methods

To date, there is no standardized format for storing EDR data in a database to support highway crash safety studies. Most current users of EDR data are accident investigators and store their EDR data in a simple ad hoc fashion on a personal computer. A few groups discussed below have developed rudimentary database formats tailored to their specific needs for the EDR data.

Automakers Storage Methods

None of the automakers interviewed as part of this project maintains a database of their EDR downloads in the context of a classic relational database. A typical approach is that undertaken by GM which maintains a central repository of information on its accident investigations. In the GM database, the CDR file for each case is stored electronically with other electronic documents which are part of the database. The individual data elements of each CDR file however are not decoded. The rationale is that since both the EDR format and the Vetronix CDR tool are continuously being upgraded, any database format designed with a fixed format would be quickly made obsolete. The belief is that if EDR information needs to be recovered for a particular case, it is better to interpret it each time with the most up to date software. It should be noted however, that while this approach may be appropriate for single cases, it makes database queries based upon this information very difficult.

NHTSA Archival of EDR Files

When NHTSA initially began to collect EDR data in 1999, the agency stored screen shots of Vetronix screens in BMP format in their Electronic Data Collection System (EDCS). EDCS is an Oracle database which maintains all data associated with NASS/CDS, SCI, and CIREN accident investigation cases. Beginning in 2002, NHTSA expanded the EDCS to allow data entry of all EDR measurements associated with NASS/CDS. EDR data is no longer being entered as BMP format files. In 2005, NHTSA will begin to store the Vetronix CDR files as part of the EDCS database.

NHTSA's current practice is to publicly release the NASS/CDS database as a collection of eleven SAS tables which are populated with data extracted from the EDCS database. The current SAS tables do not contain provision for distributing EDR data. NHTSA however is currently developing a revamped format for the NASS/CDS SAS tables which will include the EDR data. NHTSA is expanding NASS/CDS from the current number of eleven (11) SAS tables to an extended set of twenty-six (26) SAS tables. At the time of this report, NHTSA has released NASS/CDS 2002 and 2003 only in the original eleven table format. NHTSA is expected to release NASS/CDS 2002 and 2003 in the expanded twenty-six table format, containing EDR data, in spring 2005.

The proposed SAS format for NASS/CDS EDR data is provided in the appendices. EDR data is stored in three (3) tables – (1) EDR Data table, (2) EDR Crash data table, and (3) the EDR Precrash data table. At the time of this report, the proposed NASS/CDS format did not support multiple events and did not store any of the airbag performance parameters contained in the Vetronix CDR files.

Rowan University EDR Database

Under sponsorship from NHTSA, Rowan University has developed a database of the NHTSA EDR cases collected to date from NASS/CDS. Currently, the database contains the records of approximately 1000 EDR downloads. Because the formats of the GM and Ford EDRs are so different, Rowan maintains a separate database format for each automaker's EDR.

The GM cases are stored in a spreadsheet consisting of the six (5) tables below. The data elements contained in each of these tables are presented in the appendices.

- NASS case description
- Non-Deployment Event – Crash Parameters
- Deployment Event – Crash Parameters
- Non-Deployment Event – Pre-crash parameters
- Deployment Event – Pre-crash parameters

The Ford cases are stored in a spreadsheet consisting of the five (5) tables listed below:

- NASS case description
- Ford EDR Model 1FA Parameters
- Ford EDR Model 2FA Parameters
- Ford EDR Model 1FA Crash Pulse
- Ford EDR Model 2FA Crash Pulse

The Ford database contains records from two different EDR designs. The approach for the Ford data was to store data from each different EDR model in a separate table, rather than agglomerate the data from each EDR into a common database format.

The structure of the Rowan database is regularly modified to accommodate new EDR versions. For ease of numerical analysis, the database is currently stored in the format of a spreadsheet. Both characteristics are acceptable for a research database of modest size, but are not expected to scale well to large databases containing hundred of thousands of records, e.g. state accident databases, which require a standardized database format.

4.5 Recommendations for a Standardized EDR Database

This section provides the recommended format for storing EDR data for highway crash data analysis. The EDR database was designed to meet three objectives: (1) the database should accommodate data from diverse existing EDR download formats including all publicly released GM and Ford formats, (2) the database should be able to store the future EDR data elements needed to comply with the NHTSA NRPM on EDRs, and (3) the database should include the recommended list of data elements for Highway Crash Data analysis developed by this research program.

4.5.1 Recommended EDR Database Format

The recommended EDR database format stores EDR data in five tables – (1) an EDR Accident table, (2) an EDR Event data table, (3) an EDR Time History data table, (4) an EDR Occupant data table, and (5) an EDR Occupant Restraint data table. The summary which follows lists the contents of each of the database tables. A schematic of the database layout is presented in the figure below:

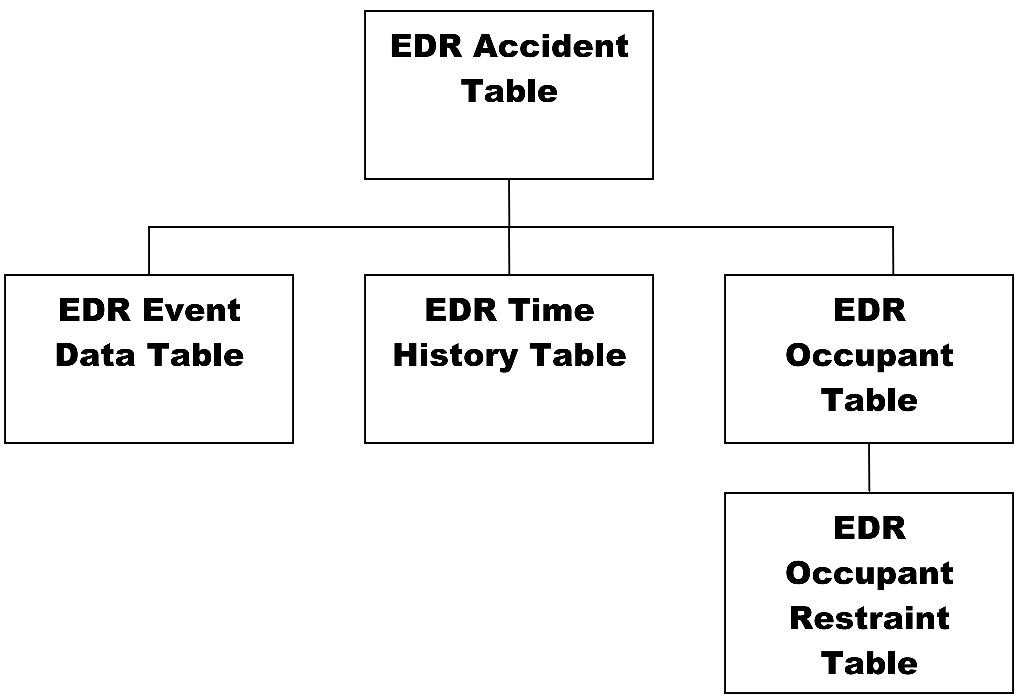

Figure 4-7. Recommended EDR Database Structure

EDR Accident Record

This is the master record for each EDR download. Each EDR download will have exactly one EDR accident record.

Name	Description	Data Type
CaseID	Case Identification for Linkage with Existing Accident Database	Alphanumeric
Vehno	Vehicle Number for Linkage with Existing Accident Database	Integer
VIN	Vehicle Identification Number	Alphanumeric
EDRMod	EDR Model	Alphanumeric
IgCrash	Ignition Cycles at Crash	Integer
IgDown	Ignition Cycles at Download	Integer
ABLamp	Frontal air bag warning lamp	On/Off
ABSupp	Frontal air bag suppression switch status - right front passenger	On/Off
NEvents	Number of Events (1,2,3)	Integer
EDRStat	Complete File Recorded (yes/no)	Extended Boolean

Extended Boolean Codes

0 = No
1 = Yes
-9 = Not specified / Unknown

On/Off Codes

0 = Off
1 = On
-9 = Not specified / Unknown

EDR Event Record

This record is repeated for each event recorded by the EDR.

Name	Description	Data Type
CaseID	Case Identification for Linkage with Existing Accident Database	Alphanumeric
Vehno	Vehicle Number for Linkage with Existing Accident Database	Integer
Eventno	Event Number	Integer
Maxdvx	Maximum Delta-V, Longitudinal	Floating Point
Maxdvy	Maximum Delta-V, Lateral	Floating Point
Units	Units for Delta-V measurements	Coded
Tevent	Time from Event 1 (seconds)	Floating Point
DepLvl	Deployment level of event	Coded

DepLvl	Deployment Level of Event
0	= Non-deployment
1	= Deployment
2	= Deployment-Level

Units	Description
0	none
1	G's
2	Miles/hour
3	Kilometers/hour
4	Degrees
5	Degrees/second
6	Revolutions / Minute (RPM)

EDR Time History Record

A number of EDR data elements are time histories. One example is delta-V vs. time. This record is repeated for each data element time history.

Name	Description	Data Type
CaseID	Case Identification for Linkage with Existing Accident Database	Alphanumeric
Vehno	Vehicle Number for Linkage with Existing Accident Database	Integer
Occno	Occupant Number for Linkage with Existing Accident Database	Integer
ElementID	Code for Time History Data Element	Coded
TimeHistID	Sequential code for multiple instances of Element ID	Integer
Units	Units of measure	Coded
Tstart	Seconds from beginning of event Eventno (may be negative to capture pre-impact data)	Floating Point
Tinterval	Time (in seconds) between data samples	Floating Point
Npoints	Number of Points in DataArray	Integer
DataArray	Array of Data Points	Array

ElementID	Description
1	Acceleration, Longitudinal
2	Acceleration, Lateral
3	Acceleration, Normal
4	Delta-V, Longitudinal
5	Delta-V, Lateral
6	Delta-V, Normal
7	Speed, Vehicle indicated
8	Engine Speed (RPM)
9	Engine Throttle (% full)
10	Service Brake (on/off)
11	Vehicle Roll Angle
12	Vehicle Roll Rate
13	Vehicle Pitch Rate
14	Vehicle Yaw Rate
15	ABS activity (engaged / non-engaged)
16	Stability control (on / off / engaged)
17	Steering Input (steering wheel angle)

Units	Description
0	none
1	G's
2	Miles/hour
3	Kilometers/hour
4	Degrees
5	Degrees/second
6	Revolutions / Minute (RPM)

EDR Occupant Record

This record is repeated for each occupant sensed and recorded by EDR.

Name	Description	Data Type
CaseID	Case Identification for Linkage with Existing Accident Database	Alphanumeric
Vehno	Vehicle Number for Linkage with Existing Accident Database	Integer
Occno	Occupant Number for Linkage with Existing Accident Database	Integer
Occloc	Occupant Location (using NASS Seat Position Code)	Coded
SeatBelt	Safety belt buckled?	Extended boolean
SeatPos	Seat position, (Is the seat is in a forward seat position?)	Extended boolean
OccSize	Occupant Size Classification	Coded
OccOOP	Occupant Position, (is occupant out of position? yes/no)	Extended boolean

OccLoc	Seat Position *
11	= Driver
12	= Front Seat, Center
13	= Front Seat, Right
21	= Driver
22	= Front Seat, Center
23	= Front Seat, Right

* Other Seating position follow the NHTSA NASS/CDS coding convention for occupant location.

OccSize	Occupant Size Classification
0	= Not Specified
1	= Female, 5th percentile
2	= Not a 5th percentile female
3	= Child
4	= Not a Child

Extended Boolean Codes

0	= No
1	= Yes
-9	= Not specified / Unknown

EDR Occupant Restraint Record

This record is repeated for the deployment of each occupant restraint device.

Name	Description	Data Type
CaseID	Case Identification for Linkage with Existing Accident Database	Alphanumeric
Vehno	Vehicle Number for Linkage with Existing Accident Database	Integer
Occno	Occupant Number for Linkage with Existing Accident Database	Integer
RestCode	Code for Occupant Restraint	Coded
Eventno	Event Number during which restraint deployed	Integer
DepTime	Time of deployment w.r.t. event (seconds)	Floating point
Disposal	Was the device deployed for disposal rather than occupant restraint?	Extended Boolean

RestCode	Description
1	Frontal Air bag, Stage 1 (or only stage, if single stage bag)
2	Frontal Air bag, Stage 2 (or only stage, if single stage bag)
10	Side air bag
11	Side curtain/tube
12	Pretensioner

Extended Boolean Codes

0 = No
1 = Yes
-9 = Not specified / Unknown

4.5.2 Standalone EDR File Archive

We recommend that transportation agencies maintain a separate backup copy of each Vetronix CDR file. Both the EDR format and the Vetronix CDR tool are continuously being upgraded. Changes to the CDR tool are occasionally made which may require that the CDR files be decoded again for a more accurate interpretation of the EDR data. As an example, the first 200 cases in the Rowan database were initially decoded using version 1.2 of the Vetronix CDR tool. When v2.0 was released, we decoded these initial 200 cases again and found changes, sometimes dramatic, in the reinterpreted data. Saving the CDR files separately of the database allows the database to be regenerated at any time in the future if this becomes necessary. We recommend that each CDR file should be identified by using the VIN as the file name.

4.6 Conclusions

This section has discussed current methods for retrieval and storage of EDR crash data for roadside safety analysis. The discussion has identified several key issues, problems, and recommendations for improvement of these methods. Our conclusions are as follows:

1. Need for a standardized EDR retrieval method. Currently, there is no standardized method to download data from EDRs. Two automakers have awarded an exclusive license to the Vetronix Corporation to market an EDR retrieval tool for their EDRs. The remaining automakers use proprietary tools for EDR data retrieval.

2. Needed for an Automated Method to Export EDR Data. The Vetronix Crash Data Retrieval software does not have any feature which allows electronic export of EDR data to Accident Databases such as NASS/CDS. Currently, all EDR data must be manually transcribed from Vetronix CDR screens into a database – a tedious and error-prone process. Vetronix is however developing a CDR-to-XML conversion program which has promise for federal and state DOTs with existing or planned EDR databases. Follow-on projects should evaluate the use of this EDR data export tool to ease data entry costs for federal and state DOTs.

3. Need for a Reliable, Universal EDR Download Connector. NHTSA has found that in a significant fraction of crashes, accident investigators were unable to use the OBD-II port, the primary Vetronix access point, to access the EDR data. Investigators have the option to directly connect to the EDR. Direct connection however is plagued by the need to partially dismantle the crashed vehicle and the fact that there is no universal EDR connector. We recommend that NHTSA either require a crashworthy OBD-II connection to the EDR, or that NHTSA mandate a universal connector for direct connection to the EDR.

4. Recommended EDR Database Format. Prior to this project, there was no standardized method or recommended practice for archiving EDR data to support

roadside or vehicle crashworthiness studies. This project has developed a recommended format for EDR data storage for state or federal transportation agencies wishing to archive EDR data.

5. Need for Training. NHTSA has found that, when its accident investigators were unable to download EDR data, a large fraction of these retrieval failures were because of insufficient training. NHTSA's rate of successful EDR downloads was greatly improved after the agency established a specialized training program on EDR data retrieval for its investigators. State DOTs who wish to extract EDR data, for applications such as accident databases, should anticipate and plan for this need for specialized training in EDR data retrieval.

4.7 References

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5. Legal Issues Surrounding the Implementation and Use of Event Data Recorders

5.1 Conclusions

The objective of this report is to examine the legal issues surrounding the implementation and use of Event Data Recorders (EDRs). The report addresses several specific issues: (1) whether the Fourth Amendment to the United States Constitution in any way bars the collection of data recorded by Event Data Recorders, (2) whether the United States Department of Transportation's (USDOT) has the authority to mandate the installation of EDRs in all new vehicles, (3) the admissibility of the data recorded by EDRs in court, and (4) whether the collection of such data violates privacy rights.

The report's conclusions are as follows: First, it is clear that the USDOT may require the installation of devices that demonstrably improve highway safety or advance some other significant public policy interest. The public policy interest in installing EDRs seems beyond peradventure. As a consequence, the USDOT presumably enjoys the authority to mandate the installation of such devices on new automobiles.

Second, with respect to Fourth Amendment concerns, it appears that the police (or other government accident investigators) may properly seize such devices (or otherwise collect the data therefrom) without a warrant during post-accident investigations. This authority is premised upon two legal issues: either because seizure of a required safety device does not constitute a search implicating the Fourth Amendment, or in the alternative, because seizure of a safety device qualifies under the exemptions for conducting a warrantless search. The police's authority to conduct warrantless searches may be affected by how soon after the accident the search occurs. The more immediate the search occurs following the accident, the greater the officers' authority to conduct a warrantless search. Absent an accident, however, unless there are changing expectations with respect to an individual's reasonable expectation of privacy regarding EDR data, police may not be able routinely to seize such data either without a warrant or express legislative authorization. Of course, police should have little trouble in obtaining a warrant to seize EDR data (or even the device itself).

Third, although the data (and the recorder itself) may be "owned" by the automobile's owner or lessee, that data may almost certainly be used as evidence against that owner (or other driver) in either a civil or a criminal case. Certainly nothing within the Federal Rules of Evidence (FRE) or the Fifth Amendment's protection against compelled self-incrimination would exclude the use of data recorded by the EDRs. Similarly, owners might be prohibited from tampering with the data if litigation is pending.

At bottom, the issue here is not one so much of legal authority to use EDR data in court, but instead what the public will accept. While the statutory authority to require EDRs may exist, the public may not want a device installed in their automobiles that appears to encroach upon their personal privacy interests. Understood in this way, the problem is less a legal concern than it is a battle to mold public perception. Not every life-saving device that is deployed with the best of intentions will be accepted by the public. Personal privacy and public safety must exist within the same sphere. Occasionally, respecting privacy rights will mean that harmful things may come about, but this is the cost of living in a free society.

5.2 Background

EDRs act as automobile "black boxes" providing critical information about an automobile's operation and the status of its various systems in the seconds immediately preceding an accident and during the crash itself.[1] This type of information may assist (among others) police agencies, accident reconstructionists, lawyers, rental car companies, safety researchers, vehicle fleet managers and insurance companies. The National Highway Traffic Safety Administration (NHTSA) has explained that:

> "The information collected by EDRs aids investigations of the causes of crashes and injury mechanisms, and makes it possible to better define safety problems. The information can ultimately be used to improve motor vehicle safety."[2]

Despite the obvious safety benefits that might accrue, however, the use of EDRs has not been without controversy.[3] Privacy concerns seem to have been a particular sore spot for those advocating the general use of EDRs.[4] Oftentimes, the concern is less about the data EDRs presently collect, but instead what future devices might be capable of recording. Presumably, the devices could be engineered to collect considerably more data and do so over even longer periods of time. On-board cameras could record driving habits, sensors could determine cell phone use, and even breathalyzers could be installed to monitor alcohol consumption. One could argue that each of these innovations might improve highway safety. Such improvements, however, would plainly come at a decrease in

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[1]*See*, Department of Transportation, National Highway Traffic Safety Administration Event Data Recorders—Request for Comments, 67 Fed. Reg. 63493 (Oct. 11, 2002). Depending on vehicle type, EDRs can provide important crash data including such variables as vehicle speed (in five one-second intervals preceding impact), engine speed (in five one-second intervals preceding impact), brake status, whether seatbelts were engaged, whether airbags were enabled or disabled, and other information critical to crash investigators. Of course, EDRs may, in the future, include additional information as well. Presently, separate devices such as global positioning systems (GPS), can provide data such as vehicle location and speed.

[2] *Id.* at 63493.

[3] *See* Matthew L. Wald, The Debate over Event Data Recorders, New York Times, (Sunday, Dec. 29, 2002) (discussing potential controversies surrounding the deployment of EDRs); *See, also* Dean Narciso, Sensors Tell How Teen Driver Crashed, Columbus Dispatch (Jan. 5, 2002) (discussing EDR benefits versus privacy concerns).

[4] Barry Brown, Warning! Your trip may be tracked, MSNBC News (July 10, 2002), http://www.msnbc.com/news/596601.asp.

personal privacy. Faced with such potential intrusions upon personal privacy, the public would doubtless be more willing to permit the collection of certain types of data as opposed to others.

After all, the use of EDRs to collect telemetric data is not new. General Motors Corporation (GM) allegedly first began installing EDRs in its cars in 1990, equipping nearly six million cars to date.[5] Since 1990, the quantity and type of data collected by EDRs has dramatically expanded. Initially, EDRs were limited to recording data from the time between a collision and the air bag's deployment. In 1994, however, GM modified its EDRs to record and save additional information, including: the change in velocity during an accident; the change in velocity of an event even if the air bag did not deploy; whether or not the seat belt was fastened; and the time between the moment of vehicle impact and the moment of maximum change in velocity.[6] Since the 1994 modifications, GM has enhanced the EDRs to record such information as the vehicle's overall speed, engine RPMs, brake status, and its throttle position.[7]

The data collected by currently available EDRs remains saved in the device for approximately 60 days for non-deployment services, but is stored permanently for deployment events (accidents), which also require that the air bag device be replaced.[8] A subsequent serious accident or other event could erase the data. It cannot be erased otherwise (with the exception of intentional destruction).[9] To make it easier to download data from the scene of an accident, GM partnered with Vetronix Corporation to produce a decoder that downloads the data from the automobile.[10] As of this writing, at least 26 of the 50 state trooper organizations have purchased the Vetronix Crash Data Retrieval system for highway use.[11] In order to avoid the manual, on-site method of data collection, Dr. Ricardo Martinez, a former NHTSA administrator, has proposed to create a "Global Safety Data Vault"[12] through which the data from the EDRs will be downloaded automatically through telematic systems like those already in existence.[13]

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[5] Bob Van Voris, Black Box Car Idea Opens Can of Worms, Nat'l L. J., June 14, 1999, at A1. Similar types of devices have long been installed in airplanes, trains, and other forms of (usually public or commercial) transportation. See, e.g., 14 C.F.R. 121.343 (Dec. 10, 1972) & 121.344 (Sept. 12, 1997) (flight data recorders); 14 C.F.R. 121.359 (Jan. 1, 1967) (airplane cockpit voice reorders); 49 C.F.R. 229.5 & 135 (May 26, 1995) (locomotive event recorders).

[6] *Id.*

[7] *Id.*

[8] *See* Recording Automotive Crash Event Data, available at http://www.nhtsa.dot.gov/cars/problems/studies/record/chidester.htm (last checked March 28, 2004).

[9] *Id.*

[10] *See* Don Gilman, Automotive Black Box Data Recovery Systems, available at http://www.tarorigin.com/art/Dgilman/ (last checked March 28, 2004).

[11] E-mail from James Kerr, Program Manager, Vetronix Corporation (on file with author).

[12] *See* Cathy Orme, A Black Box Under Every Hood: Safety or Big Brother?, available at http://www.valvoline.com/carcare/articleviewer.asp?pg=dsm20020501bb (last checked March 28, 2004).

[13] Such existing systems include OnStar, Wingcast, Qualcomm, and the as yet unnamed AT&T system.

Although such a plan would doubtless prove controversial, the present future of EDR use appears secure. Ford and GM have signed agreements with Vetronix – presently the industry's leading supplier of crash data retrieval systems – to supply such devices in their new cars.[14]

The type of data collected by on-board sensors could readily be increased. For example, Dr. Martinez has suggested that data collection could easily be expanded to include any data that could be "gleaned from electronic sensors already installed on the vehicle."[15] Dr. Martinez was referring to the tire pressure data, telemetric data (currently used to contact emergency services), the functioning of anti-lock braking systems, electronic suspension information, and the routine diagnostic information used by mechanics.[16]

Although car manufacturers claim EDRs help their engineers refine on-board safety systems, privacy advocates (such as the American Civil Liberties Union) decry their use, claiming the devices unfairly erode personal privacy.[17] As a consequence of these ongoing concerns, the NHTSA commissioned a panel of experts that included members of the automobile industry, academia, and the government to study EDRs.[18] The panel concluded in its 2001 report that EDRs would "profoundly impact highway safety" by allowing for "better design of occupant protection systems and improved accuracy of crash reconstruction."[19] Additionally, the panel reported that studies of black boxes have shown that driver awareness of the devices can "reduce the number and severity of the crashes."[20]

The National Transportation Safety Board (NTSB) has recommended, since 1997, that the NHTSA "gather more and better real-world crash data" using EDRs.[21] Despite the benefits EDRs seem to deliver, and the positive recommendations from the NTSB, however, the NHTSA has twice rejected petitions that would require EDRs to be installed in all automobiles.[22]

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[14] E-mail from James Kerr, Program Manager, Vetronix Corporation (on file with author).

[15] Ed Gartson, *Ex-NHTSA Chief Works on Auto Data*, AP Online, Mar. 6, 2002.

[16] Id.

[17] American Civil Liberties Union, Are Vehicle "Black Boxes" a Black Hole for Privacy? (June 3, 1999), http://archive.aclu.org/news/1999/w060399a.html.

[18] Harry Stoffer, *Promise and pitfalls seen in black box*, 75 Automotive News 5948 (2001). The complete NHTSA report titled "Event Data Recorders, Summary of Findings by the NHTSA EDR Working Group", published in August 2001 is available at http://www-nrd.nhtsa.dot.gov/pdf/nrd-10/EDR/WkGrp0801.pdf (last checked March 28, 2004).

[19] *Id.*

[20] *Id.*

[21] *Id.*

Presently, the collection and use of EDR data exists in something of a legal vacuum. It has yet to be conclusively determined whether information provided by EDRs may be admitted at trial. Similarly, it is unclear whether the use of data recorded by EDRs may implicate Fourth Amendment or other privacy concerns. The federal and individual state governments are only now beginning to consider the legal implications of deploying such devices as EDRs or global positioning systems (GPS). For constitutional purposes, courts must address whether accessing EDR data at the scene of an accident constitutes a search for Fourth Amendment purposes. If such access qualifies as a Fourth Amendment search (and seizure), a court must then consider whether such a search is valid without a warrant.[23] Before discussing the Fourth Amendment issues raised by EDRs, it is worth determining at the outset whether the federal government may require the installation of EDRs.

5.3 Regulatory Authority and Use and Collection of EDR Data[24]

As a general matter Congress' authority to regulate interstate transportation is found within the Constitution's Commerce Clause.[25] The Constitution provides Congress the power "[t]o regulate Commerce with foreign Nations, and among the several States, and with Indian Tribes."[26] Congress' power under the Commerce Clause extends to any activities affecting commerce.[27] Courts have interpreted this grant of authority broadly.[28]

In the seminal case of *Gibbons v. Ogden,* the Supreme Court described the depth and breadth of the Commerce Clause as "complete in itself, [and] may be exercised to its utmost extent, and acknowledges no limitations, other than [those] prescribed in the Constitution."[29] The Court has recognized expressly that Congress has the authority to regulate the channels and instrumentalities of interstate commerce, which of course

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[22] *Id.*; *See, also,* Event Data Recorder Research History, (February 28, 2003) (detailing NHTSA's rejection of petitions to mandate EDRs), http://www-nrd.nhtsa.dot.gov/edr-site/history.html.

[23] Note that this overview will only consider relevant federal statutory and constitutional law. Individual states may provide greater privacy protections above and beyond the ambit of the Federal Constitution in their own constitutions and statutes. A general survey of state law, however, is beyond the scope of this paper.

[24] See generally, Donald C. Massey, Proposed On-Board Recorders For Motor Carriers: Fostering Safer Highways Or Unfairly Tilting The Litigation Playing Field?, 24 S. Ill. U. L.J. 453, 464-65 (Spring 2000) (provides an in-depth discussion of the commerce clause implications).

[25] U.S. Const. Art. I, § 8, cl. 3.

[26] Id.

[27] See Hodel v. Virginia Surface Mining & Reclamation Ass'n, 452 U.S. 264, 277 (1981) (quoting Perez v. United States, 402 U.S. 146, 150 (1971)).

[28] *See* Nevada v. Skinner, 884 F.2d 445, 450 (9th Cir. 1989), cert. den'd, 493 U.S. 1070 (1990).

[29] 22 U.S. 1, 196 (1824).

includes the regulation of motor vehicle safety.[30] This authority is quite broad. Nevertheless, any proposed legislation must pass rational relationship muster. In the commerce clause context, a rational relationship must exist "for concluding that a regulated activity sufficiently affected interstate commerce."[31]

Nevada v. Skinner[32] provides a useful example of the rationale basis test in the commerce clause context. In *Skinner*, Nevada had established a 70 mph speed limit on a thirty mile stretch of highway. In response, the federal government pursuant to the Emergency Highway Energy Conservation Act of 1973 informed Nevada that it would withhold all federal highway funds until Nevada reduced its speed limit to 55 mph, the national speed limit under the Act.[33] The state of Nevada decided to challenge the constitutionality of the national speed limit on, among others, the grounds that there was no rational relationship between a lower national speed limit and the goal of promoting rapid interstate commerce. The state of Nevada argued that "the lower national speed limit would inhibit rather than promote the goal of rapid commercial intercourse."[34] The Ninth Circuit found Nevada's argument without merit, holding that Congress' imposition of a lower national speed limit is rationally related to a safer highway system: "commerce that proceeds safely is more efficient than commerce slowed by accident or injury."[35]

As can be seen in *Skinner*, the rational relation need not be perfect. Nevada's argument is arguably just as rational as that of Congress. It even may be more so. However, under the rational relationship test, Congress does not have to choose the most rational option. Rather, its approach need only be rationally related to an otherwise permissible, socially desired end. In the case of EDRs, this is not a particularly difficult hurdle to overcome.

5.3.1 May the Federal Government Require Manufacturers to Install EDRs?

Pursuant to the Motor Vehicle Safety Act of 1966 (MVSA), the USDOT, on advice from the NHTSA, may promulgate through informal agency rulemaking federal highway safety standards.[36] Such standards may encompass manufacturer's safety component requirements. Both the Motor Vehicle Safety Act and the 1974 amendments concerning occupant crash protection standards indicate that motor vehicle safety standards are to be put into effect under the informal rulemaking procedures of the Administrative Procedure Act (APA).[37]

[30] See United States v. Lopez, 514 U.S. 549, 558-59 (1995) (citing United States v. Darby, 312 U.S. 100).

[31] *Id.* at 557.

[32] 884 F.2d 445, 450 (9th Cir. 1989).

[33] *Id.* at 446.

[34] Id. at 451.

[35] Id.

[36] 18 U.S.C. § 1381 et. seq.

[37] 15 U.S.C.A. § 1381 et seq.; 5 U.S.C.A. § 553.

For example, in 1967, based (in part) upon an understanding that seatbelts would save a substantial number of lives, the USDOT required manufacturers to install manual seat belts in all automobiles.[38] Similarly, after significant NHTSA testing revealed the utility of passive restraint systems, the USDOT required manufacturers either to install a passive restraint device, such as automatic seatbelts or airbags, or to retain manual belts and add an "ignition interlock" device that in effect forced occupants to buckle up by preventing the ignition from turning on if the seat belts were not engaged.[39]

The USDOT may also require manufacturers to install other "devices" in the interests of public policy. For example, in *New York v. Class*, the Supreme Court confirmed the validity of a USDOT rule requiring Vehicle Identification Numbers (VINs) in automobiles, noting that in light of the important interest served by a motor vehicle identification number, the federal and state governments were amply justified in making it a part of the web of pervasive regulation that surrounds the automobile.[40] In addition, although it acknowledged certain privacy interests, the Court had no difficulty in upholding the regulation requiring the VIN's placement in an area ordinarily in plain view from outside the passenger compartment.[41] The regulation, of course, required the public placement of the VIN to allow police officers easily to verify ownership.[42] Effectively, this regulation compelled owners to make their automobiles identifiable to police officers (and anyone else, for that matter). As with GPS devices, use of a VIN enables the dedicated investigator to track the location of a vehicle wherever it may be parked.

Thus, if it can be demonstrated that the installation of EDRs demonstrably improves highway safety, the USDOT might possess the authority under the Motor Vehicle Safety Act to require installation of these devices in all newly manufactured automobiles.[43]

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[38] 32 Fed.Reg. 2408, 2415 (1967).

[39] 37 Fed.Reg. 3911 (1972).

[40] New York v. Class, 475 U.S. 106 (1986) (holding that the police officer's actions in searching the car did not violate the fourth amendment because there is no reasonable expectation of privacy regarding the VIN placement).

[41] *Id.* The regulation in question stated, "The VIN for passenger cars [manufactured after 1969] shall be located inside the passenger compartment. It shall be readable, without moving any part of the vehicle, through the vehicle glazing under daylight lighting conditions by an observer having 20/20 vision (Snellen) whose eye point is located outside the vehicle adjacent to the left windshield pillar. Each character in the VIN subject to this paragraph shall have a minimum height of 4 mm." 49 CFR § 571.115 (S4.6) (1984).

[42] NHTSA also requires so-called high theft line vehicles to have identification numbers or symbols placed on major parts of certain passenger motor vehicles. 49 C.F.R. 541. Once again, this is to foil theft and to enable authorities to track stolen vehicles and parts.

[43]Motor Vehicle Mfrs. Ass'n of U.S., Inc. v. State Farm Mut. Auto. Ins. Co., 463 U.S. 29 (1983) ("Given the effectiveness ascribed to airbag technology by the National Highway Traffic Safety Administration, the

Even if the USDOT has the legal authority to do so, however, without popular support, it may be difficult to mandate the use of EDRs. In the wake of a public backlash, for example, Congress could always choose to override any USDOT regulations requiring EDR use.[44]

This is precisely what happened with so-called ignition interlock devices. These devices detect the presence of alcohol on the driver's breath and, when the alcohol level is too high, prevent the car from being started. Initially, ignition interlock devices were used primarily as a means to prevent those convicted of repeated drunk driving offenses from recidivating. The NHTSA, however, believing such devices to be a significant benefit to automobile safety, decided to require the installation of interlock devices in newly manufactured automobiles.[45] The NHTSA's decision was based upon solid research demonstrating the pervasive problem of drinking and driving—a problem widely understood by the public. Despite the anticipated benefits of installing ignition interlock devices, however, public opposition was so fierce that the NHTSA quickly rescinded the regulation. Thus, even though the statutory authority existed for the NHTSA to require installation of the device, the public's willingness to accept it was another matter.[46] The same is doubtless true for EDRs. Merely because EDRs may seem to be a positive force for promoting highway safety and giving vital information to engineers seeking to develop safer vehicles does not mean the public will embrace them.

The similarity between EDRs and Cockpit Voice Recorders (CVRs) has lead some to suggest that the NHTSA would be able to mandate use of EDRs in the same way the Federal Aviation Administration (FAA) is able to require CVRs and Flight Data Recorders ("FDR") in airplanes. This is a difficult analogy to draw, however, because the FAA has substantial authority to impose requirements upon aircraft by virtue of the highly regulated status of air travel. Indeed, the FAA regulates virtually every aspect of

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mandate of the Motor Vehicle Safety Act to achieve traffic safety would suggest that the logical response to the faults of detachable seatbelts would be to require the installation of airbags.").

[44]For example, the DOT's "interlock and buzzer" devices were most unpopular with the public. Congress, responding to public pressure, passed a law that forbade the DOT from requiring, or permitting compliance by means of, such devices. Motor Vehicle and School Bus Safety Amendments of 1974, § 109, 88 Stat. 1482 (previously codified at 15 U.S.C. § 1410b(b) (1988 ed.)).

[45] See, http://www.nhtsa.dot.gov/people/injury/enforce/Millenium/strategy_45.htm (discussing strategy for mandating interlock devices); Nat Barnes, Take a Breather, The Express, Saturday, July 13, 2002 (discussing efficacy of interlock devices).

[46] Motorcycle helmet laws are another interesting example of a good idea that has garnered slow, begrudging acceptance. Popular opposition to mandatory helmet laws was difficult to overcome, and met with considerable controversy, even though substantial evidence existed demonstrating their safety. See, generally, http://www.nhtsa.dot.gov/people/outreach/stateleg/mchelmetUpdateDec2000.htm (discussing efficacy of helmets); Gabe Mirkin, Riding Bikes or Motorcycles, Helmet use Remains Life-Saving, The Washington Times, September 15, 2002, p. C 8. (arguing against the repeal of helmet laws); Jessica Bujol, Bikers Battle Helmet Law, Associated Press, State & Local Wire, March 9, 2001 (reporting on opposition to mandatory helmet laws). Paul Hampel, Lawmaker's 10th Try at Motorcycle Helmet Rule Fails Again; Sponsor of the Bill Blames Strong Anti-Helmet Lobby, St. Louis Post-Dispatch, Tuesday may 28, 2002 (discussing opposition to mandatory helmet laws).

air travel, from product design,[47] to the licensing of pilots,[48] to air traffic control.[49] As was demonstrated in the wake of the September 11, 2001 terrorist attacks, the FAA even possesses the authority to deny the right to fly over the United States. The FAA can, and does, require that certain aircraft in certain configurations flying under certain conditions be equipped with a CVR and/or FDR. The FAA also enjoys authority to investigate problems with flight over the United States. As a consequence, the FAA can require that the FDR and CVR be turned over after an accident occurs to determine what caused the accident and to ensure the safety of future flights

The NTSB has jurisdiction over all civil aircraft accidents as well as those involving certain other aircraft as well as certain incidents, and upon such an occurrence, the owner or operator of the aircraft is obligated to preserve all evidence including CVR and FDR data for NTSB's examination as part of its investigation .[50] NTSB investigations result in a determination of probable cause as well as recommendations issued to regulatory authorities, operators, vehicle manufacturers and other organizations for the purpose of improving future safety of flight.

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Although the NHTSA has the ability to regulate certain aspects of driver behavior by requiring states to enforce certain laws, it does not have the authority to mandate that drivers reveal their driving habits via an EDR. Unlike airline pilots and even commercial vehicle drivers, no federal agency licenses the driver of a passenger vehicle. Therefore, the federal government has substantially less interest in how an individual operates a vehicle than how a pilot flies an aircraft. Nevertheless, substantial leeway for regulation in this area does exist.

5.3.2 What Authority Permits the NHTSA and the Various State Departments of Transportation to Include EDR Information in their own State Databases?

Congress has authorized the NHTSA to collect statistical data on motor vehicle crashes to aid in the development, implementation, and evaluation of motor vehicle and highway safety measures.[51] As a consequence, "since the early 1980s, the NHTSA has been obtaining crash data files derived from data recorded on PARs" (Police Accident Reports) from 17 states.[52] This State Data System (the term by which NHTSA refers to this collection of computerized state crash data files) is conducted by the National Center

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[47] 14 CFR 21.

[48] 14 CFR 61.

[49] 14 CFR 170.

[50] 49 CFR, Part 830.

[51] 15 U.S.C. 1395, 1401 & 23 U.S.C. 403.

[52] U.S. Department of Transportation, National Highway Traffic Safety Administration, National Center for Statistics and Analysis, State Data Systems available at http://www-nrd.nhtsa.dot.gov/departments/nrd-30/ncsa/TextVer/SDS.html (last checked March 28, 2004).

for Statistics and Analysis ("NCSA").[53] NHTSA requests the crash data files annually from the appropriate state agencies, primarily the state police, the state highway safety department and the state Department of Transportation.[54] These safety efforts, as implemented by the Secretary of Transportation, are authorized by federal statute, which provides in pertinent part:

> §401. Authority of the Secretary
>
> The Secretary [of Transportation] is authorized and directed to assist and cooperate with other Federal departments and agencies, State and local governments, private industry, and other interested parties, to increase highway safety.

In addition, the Secretary of Transportation has an obligation to Congress, as detailed further in section 401, to prepare, publish and ultimately to submit a report on the highway safety performance of each State in the preceding year.[55] This report must include data on highway fatalities, injuries, and motor vehicle accidents in urban as well as rural areas.[56] This data is geared to providing the Secretary of Transportation with the means for comparing highway safety performance of the States in an effort to provide overall improved national safety. Increasing safety and promoting highway safety are plainly legitimate state interests. Thus, the use of EDR and other accident data is rationally related to such interests.

At the federal and state levels, EDR data is used to save lives, reduce injuries and prevent property loss. Collecting this data also assists in forming a better safety management system for the highway and traffic systems. The federal government, through the NHTSA, uses this data to assess safety problems and solutions for issuing new and revised vehicle safety performance standards. State governments employ this crash data to help manage road systems and design better roadside safety hardware, such as guardrails and crash cushions.

In the future, it is not unlikely that new statutes will permit the use of EDR data to assist in emergency medical rescues; more specifically, statutes permitting the automatic dispatch of EDR data from the crashed vehicle to the Public Safety Answering Point (PSAP) center as well as other affected parties. Furthermore, EDR data would help the local authorities assign the "right" response teams early in the event, thus fostering a more efficient emergency response system.

The NHTSA's potential interest in making EDRs mandatory in the interest of safety serves if not a compelling national interest, at least a legitimate state interest. However,

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[53] *Id.*

[54] *Id.*

[55] 23 U.S.C. 401 (1987).

[56] *Id.*

without clarification of the NHTSA's authority to collect and use the data provided by EDRs, misunderstanding will continue to occur and the important public purpose of a cooperative, independent accident investigation may not be served.

Presumably, the NHTSA's potential intention to require the installation of EDRs is motivated by a desire to protect the public by improving highway safety. Technological advances, such as the EDR, allow the NHTSA to take effective actions in improving the timeliness, accuracy, completeness, uniformity, and accessibility of their highway safety data. EDRs have played major roles in the NHTSA's accident investigations and will continue to do so to a greater extent as their use becomes more widespread. For this reason, it might be useful to identify methods for expanding the use and function of recorders.

Nevertheless, as the present record stands, investigators are not empowered to halt an accident investigation and clean-up activities simply to obtain EDR data. All too often, valuable information is needlessly lost due to contradictory statutes and lukewarm mandates concerning EDR use. Consequently, it might be argued that the nation's highway safety could be greatly improved with a government mandate authorizing the NHTSA to retrieve, preserve, copy and use EDR data as it sees fit.

Congressional and public support for any such action, however, is vital. As an illustration, one need only consider the Environmental Protection Agency's (EPA) quest to promulgate regulations promoting a clean environment. In 1990, the EPA faced a similar predicament in its quest to protect public health and the environment through its recommendations for improving air quality. It lacked popular support, however. Alone, the EPA was severely limited in achieving its goals. By working closely with Congress, however, the EPA was able to garner support for its environmental quality recommendations. The resulting federal mandates, which regulate air emissions from area, stationary, and mobile sources, were quite controversial at the time.[57] In particular, the EPA sought the installation of catalytic converters on newly built cars.[58] The EPA prevented automobile owners from removing or otherwise interfering with the catalytic converters' function.[59] Without cultivating congressional support, it is unlikely such broad, potentially unpopular changes could ever have been made.

In similar fashion, by carefully securing legislative support of EDRs and being open with the public, the NHTSA might be able to accomplish its goal of enhancing highway safety through the routine deployment of such devices. The NHTSA's Vehicle Safety Rulemaking Priorities (July 2003) cites that its mission is to save lives, prevent injuries

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[57] 42 U.S.C §§ 7401 et seq. (1990).

[58] EPA Regulations on Automobile Exhaust Systems, Exhaust System Repair Guidelines, http://exhaust soundclips.com/epa_reg.html (noting that catalytic converters can neither be removed nor tampered with).

[59] *See generally*, 42 USC §§ 7521, 7522, 7541, 7545, et seq.

and reduce traffic related health care and other economic costs.[60] Without clarification of the NHTSA's authority to use the most advanced means available (including the use of EDRs), misunderstandings will continue to occur and the important public purpose of a cooperative, independent accident investigation may not be served.[61]

EDR data obviously offers a range of possibilities. EDRs could be the basis for an evolving data-recording capability that could be expanded to serve other purposes, such as emergency rescues, where their information could be combined with occupant smart keys to provide critical crash and personal data to paramedics. It is even possible that the NHTSA could prevent car owners from tampering with EDRs or otherwise interfering with their collection of data, much the same way the EPA prevented individuals from disabling or removing catalytic converters. The question of data ownership and data protection would have to be resolved, but it is entirely possible such interests can be balanced with the government's objective of ensuring consumer safety on the roads.

5.4 What Limitations do Private Parties Face When Attempting to Use the Information Contained in EDR?

The responsibilities and limitations affecting private parties are somewhat different from those affecting public entities. Although private parties are not constrained by Constitutional limitations, such as the Fourth's Amendment's protection against unreasonable searches and seizures, they are subject to other rules and regulations governing their ability to use EDR data.

5.4.1 May private parties obtain the data contained in EDRs without the consent of the vehicle owner as part of discovery in preparation for trial?

First, it is import to determine whether private parties (insurance companies, car manufacturers, private litigants, etc.) may obtain EDR data. At the outset, it must be noted that the Fourth Amendment does not govern the actions of private parties; rather, it

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[60] NHTSA Vehicle Rulemaking Priorities and Supporting Research, Calendar Years 2003-2006, available at http://www.nhtsa.dot.gov/cars/rules/rulings/PriorityPlan/FinalVeh/Index.html (last checked March 28, 2004).

[61] The NHTSA includes the following information on EDRs in their latest Vehicle Safety Reports: Information collected by crash data recorders, which are being introduced by some manufacturers, can provide the agency with useful information for crash and crash causation analysis. EDRs allow investigators to gain direct pre-crash and crash information such as pre-impact vehicle acceleration and driver steering and braking, air bag deployment timing, and whether safety belts were buckled. EDRs can provide more specific information to crash investigators, which will lead to a more accurate account of the events leading up to and following a crash. This, in turn, can contribute to more effective safety rulemakings and other safety actions. NHTSA is looking at the future potential for EDRs in crashworthiness evaluations. The agency is conducting a research program in which it collects EDR data from real world crashes to analyze the data's accuracy and to compare it to traditional forensic crash investigation methods. The agency will provide feedback so EDR manufacturers can improve their systems. (For more information on EDRs, see NHTSA's website at http://www-nrd.nhtsa.dot.gov/edr-site/index.html.)

applies exclusively to the actions of governmental authorities.[62] Although civil law (e.g. tort law trespass protections) may prevent a private party from obtaining EDR data without the owner's consent, those parties may nevertheless retrieve the data contained in an EDR without consent as part of discovery. Rule 26(b) of the Federal Rules of Civil Procedure ("FRCP") states "that a party may obtain discovery regarding any matter, not privileged, that is relevant to the claim…."[63] With respect to the nature of the materials that may be obtained under Rule 26, Rule 34(a)(1) allows for the discovery of "other data compilations."[64] This language has been interpreted to include electronic data, diaries and surveillance equipment.[65] While there is no case law that authoritatively endorses the discoverability of EDR data, the data contained in an EDR has been successfully discovered in recent cases.[66]

If EDRs come to satisfy (as they presumably will) evidentiary standards of reliability and accuracy,[67] the information they record will doubtless be admissible at trial. In fact, some commentators have declared their support for the admissibility of EDR data in court.[68] As with the adoption of any new technological innovation, however, praise is not

[62] *U.S. v. Jacobsen*, 446 U.S. 109 (1983) (Fourth Amendment's protection against unreasonable searches and seizures proscribes only governmental action, it is wholly inapplicable to a search or seizure, even an unreasonable one, effected by a private individual not acting as an agent of the government or with participation or knowledge of any government official).

[63] Fed. R. Civ. Pro. 26(b).

[64] Id.

[65]See, e.g., *Daewoo Electronics Co., Ltd. v. U.S.,*650 F.Supp. 1003 (1986) (computer files); *Rowe Entertainment, Inc. v. William Morris Agency, Inc.*, 205 F.R.D. 421 (2002) (computer files); *Nixon v. Freeman*, 670 F.2d 346 (1982) (diary); *Tran v. New Rochelle Hosp. Medical Center*, 740 N.Y.S.2d 11 (2002) (video surveillance*); Congleton v. Shellfish Culture, Inc*., 807 So.2d 492 (2002) (video surveillance).

[66]See, e.g., *Cansler v. Mills*, 765 N.E.2d 698 (2002) (holding that mechanic should have been able to testify regarding air bag and sufficient evidence was introduced to show air bag was defective); *Harris v. General Motors Corp*., 201 F.3d. 800 (2001)(evidence regarding air bag defectiveness should have been admitted); *Sipes v. General Motors Corp.*, 946 S.W.2d 143 (2000) (Automobile manufacturer can be held strictly liable for defect that produces injuries even if defect did not cause accident); Anderson-Barahona v. Gen. Motors Corp., No. 99A19714 (Ga., Cobb County Cir. Ct. Apr. 7, 2000).

[67] It goes without saying that EDRs must be demonstrated to be both reliable and reasonably accurate before the data they record may be admitted at trial. See, e.g., *Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579 (1993))* (establishing admissibility test for expert scientific testimony).

[68] Thomas Michael Kowalick, Proactive Use of Highway Recorded Data via an Event Data Recorder (EDR) to Achieve Nationwide Seat Belt Usage in the 90[th] Percentile by 2002, at http://www.ntsb.gov/events/symp%5Frec/proceedings/authors/kowalick.htm (last visited Jan. 26, 2003). Kowalick explains that:

> "On the question of whether crash recorder data should be admitted, the main point is whether the recorder is reliable, properly read out, and provides a record of the particular event in question. The data of itself is not dispositive of liability, but merely serves as certain evidence of the event. As indicated earlier in this report, there is good correlation between crash severity a recorder might measure and the extent of crash deformation to the vehicle in which it was installed; and it

uniform. Certain industry groups are concerned about the data's potential misuse in litigation and regulatory enforcement.[69] As a consequence, the American Trucking Association (ATA)—itself a target of potential regulations mandating the use of EDRs on commercial trucks—announced the following in a policy statement:

> In order to benefit from new technologies that can improve highway safety and efficiency, while providing protection against information misuse, the trucking industry supports creation of reliable data parameter standards only if: (1) they are developed and implemented for all vehicles, including passenger cars, concurrently; (2) all vehicle owners and operators are properly protected against the use of electronically-generated data in regulatory enforcement and civil litigation; (3) data are anonymous and used for safety research and trend analysis by a single lead agency or institution; (4) reasonable privacy can be assured regarding access and use of the information; (5) access to data is controlled; (6) data are recorded only for a limited period of time relative to an event; and (7) there is no burden on individual vehicle owners or operators for the reporting or collection of such data at any time.[70]

One prominent concern is the potential violation of privacy rights posed by the potential use of EDR data. This concern extends not only to the types of data EDRs presently record, but to the types of data EDRs might be able to record and store in the future. While it would be difficult to shield EDR data from civil discovery, legislation could be enacted to control the use the use of such data in evidence.

Although no federal statutory scheme directly touches upon EDR use in automobiles, there is a somewhat analogous federal statute that refers to "cockpit recordings and

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> would be difficult to refuse evidence on the crash severity magnitude as interpreted from vehicle deformation. Thus if the recorder provides good evidence of the event, it seems appropriate that the evidence should be admitted. It may be possible to restrict through legislation the admissibility of crash recorder evidence, particularly if the recorders are government-owned and the records are retrieved and interpreted by government employees. Consider, however, the objective of a very simple and widely used integrating accelerometer that is conveniently and readily read by any police accident investigator without special training. It would appear difficult to prevent testimony by a layman - say a tow-truck operator or an auto mechanic-as to what he saw immediately after the accident. In summary, we believe that (1) the data from a crash recorder would be admissible, if it meets necessary qualifications, in a court of law; 2) the data should be admitted if it is good evidence; (3) it will be difficult to prevent admitting crash recorder data, even by Federal law, if the record can be easily read by an untrained person."

Id. (citing Office of Technology Assessment, Automobile Collision Data: An Assessment of Needs and Methods of Acquisition (1975)).

[69] U.S. Department of Transportation: Federal Motor Carrier Safety Administration, A Report to Congress on Electronic Control Module Technology for Use in Recording Vehicle Parameters During a Crash, 16 (Sept. 2001) [hereinafter FMCSA Report]; see also American Trucking Associations, Inc., Technology & Maintenance Council, Recommended Practice, Proposed RP 1214(T): Guidelines for Event Data Collection, Storage and Retrieval (2001).
[70] Id.

transcripts"[71] and "surface vehicle recordings and transcripts"[72] in the context of use, admissibility, and discovery.[73] These statutes prevent the NTSB from publicly disclosing cockpit and surface vehicle voice/video recordings, while leaving disclosure of the transcripts/written depiction of those recordings at the discretion of the NTSB.[74] If the NTSB permits public disclosure, parties in a judicial proceeding are free to admit the information into evidence.[75] However, if the NTSB denies public disclosure, a party in a judicial proceeding may not use discovery to obtain the information, without a court order.[76] There also exist statutory safeguards to prevent public dissemination of the data in the event a court admits otherwise undisclosed data.[77] As differentiated from voice/video recordings and transcripts of such recordings, pure event data, collected from a recording device is generally admissible.[78] Of course, the policy considerations of prejudice and misinterpretation that may apply to graphic cockpit voice recordings from an airplane crash do not apply to basic factual EDR data. Such data would doubtless be admitted at either civil or a criminal trial unless expressly shielded by legislation.

Two cases illustrate the ways in which EDR data has been (and could be) used in civil litigation. In *Harris v. General Motors Corporation,*[79] the district court relied upon testimony from GM's expert witness regarding EDR crash data to grant GM summary judgment in a product liability suit alleging a defect in the airbag.[80] The trial judge found that the EDR data (and, presumably, the engineer's interpretation of that data) established beyond dispute that the airbag had functioned properly. Absent a factual dispute, the court felt obligated to grant GM's summary judgment motion. The court of appeals reversed the trial judge's decision to grant GM summary judgment. The appellate court determined that the trial judge erred in accepting the engineer's interpretation of the EDR

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[71] National Transportation Safety Board Amendments Act of 2000, 49 U.S.C. 1114(c), 1154(a) (2001).

[72] Id. 1114(d), 1154(a).

[73] Id. 1114(c)-(d), 1154(a).

[74] Id. 1114(c)-(d).

[75] Id. 1154(a)(1)(A).

[76] Id. 1154(a)(2)-(4).

[77] Id. 1154(a)(4)(A)-(B).

[78] Donald C. Massey, Discovery of Electronic Data from Motor Carriers - Is Resistance Futile?, *35 Gonz. L. Rev. 145, 173 (2000)* (noting that event data collected from train crashes is generally admissible) (citing *Stuckey v. Illinois Central R.R. Co., 1998 U.S. Dist. LEXIS 2648* (N.D. Miss. Feb. 10, 1998); *National R.R. Passenger Corp. v. H & P, Inc., 949 F. Supp. 1556 (M.D. Ala. 1996));* see also American Trucking Associations Website, Legislative Affairs, Trucking Victory: Truck Recorders Gain Protection Given Airplane Recorders, at http://www.truckline.com/legislative/101800<uscore>truck<uscore>recorders.html (last visited Jan. 26, 2003) (on file with the Rutgers Computer & Technology Law Journal) (explaining that the National Transportation Safety Board Amendments Act of 2000 does not extend its protection to data recorders).

[79] 201 F.3d 800, 804 (6th Cir. 2000

[80] *Harris, 201 F.3d at 804.*

data as an undisputed fact. Indeed, the appellate court raised the issue that the EDR evidence may not even have been admissible at all.[81] The Court noted:

> "[While the plaintiff] did not raise the *Daubert [v. Merrell Dow Pharm., Inc.*] issue before the district court, we note that on remand, the district court must, consistent with its gate keeping role, perform a *Daubert* analysis of the proposed testimony of the defense experts, particularly [the EDR expert]. Certainly, nothing in the record as it now exists evinces either the reliability or validity of [the EDR expert's] testimony as to the [EDR]. Our own research did not reveal a single reported case addressing the *Daubert* issue as to General Motors' automotive "black box."[82]

As will be discussed later in this paper, the appellate court was referring to the standard district courts must use in determining whether scientific or other expert testimony is admissible. The court did not opine on the reliability of EDR data, it merely held that summary judgment could not be granted on the basis of testimony regarding a novel device that was not subjected to rigorous analysis. First the trial court needed to determine whether the data should be admitted, and then the plaintiffs would have the opportunity to scrutinize the evidence during the course of cross examination and rebuttal.

Similarly, in the product liability case of *Batiste v. General Motors Corporation,*[83] a state trial court admitted expert EDR testimony from the same expert that testified in Harris.[84] In *Batiste*, that expert testified:

> "Based on my years of experience and training and the safety aspects of automobiles, it is my opinion that the evidence in this case demonstrates that the air bag was functioning properly and should not have deployed at the time of this accident. Moreover, if there was a malfunction of the system, it would be evident from the [EDR]. The [EDR] recorded no such malfunction. Accordingly, it is my further opinion that the air bag was not defective in any respect and performed as intended and therefore, did not cause Plaintiff's injuries, if any. Furthermore, it is my opinion that the injuries, if any sustained by Plaintiff, would not have been lessened had the air bag deployed."[85]

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[81] Id. at 804 n.2.

[82] Id. (citing *Daubert v. Merrell Dow Pharm., Inc., 509 U.S. 579 (1993))* (establishing admissibility test for expert scientific testimony based upon *Fed. R. Evid. 702* and a rough framework of criteria focusing on scientific validity, reliability, and relevance).

[83] 802 So. 2d 686, 688 (La. Ct. App. 2001).

[84] *Id. at* 688.

[85] Id.

There was little question that the EDR data, as well as the expert witness' interpretation of that data, should have been admitted. Therefore, as long as the EDR technology can pass the fairly liberal *Daubert* test, it would appear from these initial cases that EDR data and relevant expert testimony will be admissible in a civil trial.

There are a number of other data recording technologies that may be compared to the use of EDR devices. EDR data may, for example, be analogized to the information contained in a diary or that recorded by a surveillance camera. Similarly, EDR data may be compared to information contained in personal computer files, as both represent personal possessions saved in a digital format. It has long been the case that personal diaries, surveillance footage, and computer files (as well as the data contained therein) are discoverable.[86] Thus, there is little doubt that (absent special statutory protection) the data contained in an EDR would likewise be discoverable.[87]

It is often overlooked from a policy perspective that the admissibility of EDR data could be a positive advancement in ensuring the integrity of litigation. Once determined to be a reliable source, EDR data appears to provide credible and objective insight into the facts of a crash. If all relevant parties to litigation are provided initial accessibility to the data, equity will be ensured as all parties would be able to analyze and interpret the same facts. Although this may help an automobile manufacturer demonstrate that an airbag properly deployed or that the plaintiff failed to wear her seatbelt, it will also enable the plaintiff objectively to verify that he was not traveling above the posted speed limit or that the brakes failed. Objective factual determinations will greatly aid litigants and may, in fact, help reduce unnecessary litigation and impede patently fraudulent claims.

5.4.2 May private parties, such as insurance adjusters, private attorneys, and researchers, obtain the data contained in the EDR at the scene of the accident or through pre-trial discovery without the consent of the vehicle owner?

The simple answer is no. Private parties likely cannot obtain the information contained in the EDR without the consent of the vehicle's owner or as part of pre-trial discovery. The owner of property has superior title to all other private parties, and can lawfully refuse possession. The NHTSA and Federal Motor Carrier Safety Administration ("FMCSA") both take the position that the EDR and its data belong to the vehicle owner. Because the vehicle owner's possession of the EDR data would be superior to all others, no private party could force the individual to relinquish that data without the owner's consent.

However, private, market-based solutions may address this problem. Specifically, insurance companies, as a condition of writing an automobile insurance policy, may require that owners consent to the retrieval of EDR data. For example, Progressive Insurance, the nation's fifth-largest auto insurer, has placed hundreds of monitoring

[86] *See* note 47, *supra*.

[87] Donald C. Massey, *Discovery of Electronic Data from Motor Carriers - Is Resistance Futile?*, 35 Gonz. L. Rev. 145 (2000) (explaining that electronically-stored data is universally admitted into evidence).

devices in customers' vehicles to measure how, when, and where they drive.[88] According to public reports the device's patent describes a system of onboard sensors that could track whether a driver signals before turning, tailgates, or stops so sharply that anti-lock brakes engage. This is in contrast with standard EDRs, which apparently only record the last seconds before a crash. Progressive has also taken a different track in this area in that its test program consists of volunteers.[89] Customers can save up to 25% on insurance rates tailored to their individual driving habits. The insurance company expects to benefit by obtaining new business from consumers who are seeking to obtain favorable rates, or who perhaps have teenage drivers in the family whose driving habits they would like to monitor. In any event, the program is entirely voluntary and consumers are alerted to the potential uses to which collected data may be put.

Similarly, automobile manufacturers may include as boiler plate language within a sales or lease agreement, a promise by the vehicle's purchaser or leasee to waive any privacy interest in EDR data in the event that he sues the manufacturer at some later date. Private law solutions such as these may provide adequate coverage in situations in which private parties may need to have access to EDR data and the owner's consent might not be likely at the time the data is needed.

5.4.3 May Private Parties Obtain and Use EDR Data when Unrelated to Trial Discovery?

A different sort of circumstance arises when private parties seek to obtain EDR data for purposes other than formal litigation. For example, in a case of first impression, a car rental customer sued Connecticut-based ACME Rent-A-Car because the company fined him for exceeding the speed limit. The customer's driving information was discovered by use of an on-board global positioning system ("GPS").[90] The company was able to pinpoint the precise location where the consumer had violated the speed limit.[91] The customer sued because he claimed he had not been afforded adequate notice that his driving would be monitored by means of the GPS device. Despite the fact he was merely in temporary control of the vehicle as a renter, he was successful. [92] Rental agencies (at least in Connecticut) may still be able to track their vehicles using GPS devices, but apparently may not issue fines unless adequate notice to the consumer is first given. Indeed, many problems associated with the use of GPS and similar systems could be avoided by disclosing the information to the consumer at the outset. Just as rental car

[88]Associated Press, Insurer's "Black Box' Monitors Drivers, USA Today .com, at http://www.usatoday.com/life/cyber/tech/review/crg529.htm (Nov. 23, 1999).
[89] Id.

[90] Rental-car Firm Exceeding the Privacy Limit?, News.com, June 20, 2001, at http://news.com.com/2100-1040-268747.html?legacy=cnet&tag=tp_pr.

[91] Robert Lemos, Car spy pushes privacy limit, ZDNet News, June 19, 2001, http://zdnet.com.com/2100-11-5301115.html.

[92] Using GPS To Catch Speeders Found Illegal, Slashdot, July 3, 2001 at http://slashdot.org/articles/01/07/03/0423218.shtml.

companies routinely present information relating to insurance coverage to prospective renters, they could also offer information about EDRs or GPS. Leasing agencies could similarly include as standard language in lease agreements waivers related to the disclosure of recorded EDR data. Any interested party (e.g. banks, lien-holders) could potentially require the car's principal driver to agree to disclose information in the event of an accident or product liability litigation. Private solutions exist that would enable EDR data to be disclosed, when necessary.

5.5 Does the search of an automobile to obtain the information contained in an EDR raise a Fourth Amendment Question?

Important constitutional questions surround the use of, and accessibility to, EDRs devices and their data in the field. In particular, the Fourth Amendment to the Constitution protects individuals from "unreasonable" searches and seizures undertaken by the state.[93] Although the state may conduct searches of private property and effect seizures of evidence or contraband uncovered, when probable cause is present, questions arise whenever an individual's property is searched or seized without a warrant. Of course, no legal difficulty exists if the owner consents to a search.[94] However, even where affirmative consent is withheld (or at least not given) if an individual has no expectation of privacy in the thing to be searched, then no "search" has occurred for Fourth Amendment purposes. Accordingly, if the owner of an automobile has no expectation of privacy in the information contained in the EDR, then the acquisition of that data is not a "search," and no Fourth Amendment concern exists.

Aside from the Constitution, the most pertinent federal law governing this area is likely the Privacy Act of 1974 ("Act"), which provides that no federal agency shall disclose any of its records that 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 falls within certain specified exemptions.[95] The Act's purpose 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 and use of personal information.[96] While this Act would doubtless affect the use of EDR data, such novel technical innovations have yet to receive full legislative consideration. It is a near-certainty that they will in the future.

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[93] US. Const. amend. IV. The Fourth Amendment applies both to the federal and the state governments. *See, Wolf v. Colorado*, 338 U.S. 25, 69 (1949).

[94] *Schnekloth v. Bustamonte*, 412 U.S. 218 (1973) (One exception to the requirement of both a warrant and probable cause is a search that is conducted pursuant to consent.).

[95] 5 U.S.C. 552(a) (2002).

[96] Most states contain analogues to this act, but a full review of those statutes is beyond the purview of this paper.

The next section addresses the extent to which the Fourth Amendment will affect the process of obtaining the data contained in EDRs, I will assume *arguendo* that individuals do have an expectation of privacy in the data contained in their EDRs.[97] Even though such a privacy right may exist, however, it is plainly not without limitation.

5.5.1 May police officers seize EDR data during post-accident investigations without a warrant?

A slightly more complex, but readily answerable, question is whether police officers (or other government accident scene investigators) may seize data recorded by an EDR at the scene of an accident. A likely scenario is one in which an accident occurs and police officers arrive on the scene in short order to assist the injured and to investigate the crash's cause. What are their options for retrieving what may be crucial data?

The analytical framework evident in the Supreme Court's Fourth Amendment cases requires that a reviewing court must first assess whether the individual claiming Fourth Amendment protection has a reasonable expectation of privacy in the object searched.[98] If there is no such expectation, no "search" occurs for Fourth Amendment purposes. If a privacy right is implicated, the court must next determine whether probable cause existed for the search. Finally, if a search occurred, it must have been executed subject to a valid warrant, or qualified as an exception to the warrant requirement.

5.5.2 Do car owners have reasonable expectation of privacy in EDR devices as a component of their automobile?

1) Fourth Amendment Searches

Seizure of an EDR or the data contained therein will only implicate the Fourth Amendment if it constitutes a search into a constitutionally protected area. A "search" does not occur unless the individual manifested a subjective expectation of privacy in the searched object, and society is willing to recognize that expectation as reasonable.[99]

The nature of "searches" is not quite as clear-cut in today's world as might be expected. Traditionally, a "search" has required some sort of trespass upon property. Thus, if a

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[97] Indeed, DOT and the automakers appear to agree that the car's title-holder owns not only the physical EDR, but the data it collects as well.

[98] It is important to note that the Fourth Amendment does not act as a restraint on *private* actors, but only those acting under the color of state law. Thus, the Fourth Amendment does not prevent a private party (like an insurance company) from seizing data recorded by an EDR.

[99] *Katz v. United States*, 389 U.S. 347, 361 (1967) (holding that government's activities in electronically listening to and recording defendant's words spoken into telephone receiver in public telephone booth violated the privacy upon which defendant justifiably relied while using the telephone booth and thus constituted a 'search and seizure' within Fourth Amendment). *See also, Minnesota v. Olson*, 495 U.S. 91 (1990) (holding that a subjective expectation of privacy, for purposes of the Fourth Amendment, is legitimate if it is one that society is prepared to recognize as reasonable.).

police officer merely happened by an open window and, in his plain view, witnessed a crime, no "search" for Fourth Amendment purposes occurred.[100]

Automobile searches, however, present a different sort of a problem. *In United States v. McIver,*[101] the Ninth Circuit Court of Appeals upheld the warrantless placement of a global positioning system (GPS) tracking device by law enforcement on the undercarriage of a suspect's vehicle.[102] The court ruled that the officers' placement of the device was neither a search nor a seizure. The court held it was not a search because the undercarriage is part of the exterior of the vehicle, and pursuant to the Supreme Court opinion in *New York v. Class*,[103] there is no reasonable expectation of privacy in the *exterior* of a vehicle. The court determined that no seizure occurred because the device represented only a technical trespass on the automobile, and the device's placement did not deprive the defendant of dominion and control over his vehicle.[104]

The actual collection of EDR data may, or may not, require a specific trespass onto the owner's property. That may ultimately be a distinction without a difference, however, as the Supreme Court has recently considered a similar sort of situation in *Kyllo v. United States*.[105] In *Kyllo*, a narcotics agent used a thermal imaging scanner to determine whether the defendant was using high intensity lamps to grow marijuana in his home.[106] Use of the thermal imaging device did not require law enforcement officers to enter the defendant's property; rather, they simply had to point the device at the home and record the thermal image.[107] The defendant argued that the use of a thermal imaging device in this way constituted a "search" within the meaning of the Fourth Amendment even though the officers were stationed across a public street.[108] The Court agreed with the defendant, holding that when the government uses a device that is not in general public

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[100] *California v. Ciraolo*, 478 U.S. 1014 (1986) (The Fourth Amendment's protection of the home has never been extended to require law enforcement officers to shield their eyes when passing by a home on a public thoroughfare.).

[101] 186 F.3d 1119 (9th Cir. 1999).

[102] Id. at 1126-27.

[103] 475 U.S. 106 (1986).

[104] *McIver,* 186 F.3d at 1127. Cf. *Osburn v. Nevada*, 44 P.3d 523 (2002) (holding that officers' placement of a monitoring device to defendant's vehicle without first obtaining a search warrant was not an unreasonable search under the Nevada Constitution) *with Oregon v. Campbell,* 759 P.2d 1040 (1988) (holding that officers' placement of a tracking device to defendant's vehicle without first obtaining a search warrant constituted an unreasonable search under the Oregon Constitution). These cases demonstrate the differing standards under their respective state constitutions.

[105] 533 U.S. 27 (2001).

[106] *Id*.

[107] *Id*. at 29.

[108] *Id*.

use to explore details of a private home that would previously have been unknowable without physical intrusion, the surveillance is a Fourth Amendment "search," and is presumptively unreasonable without a warrant.[109]

Thus, while there was no physical "trespass," the Court nevertheless determined that a search had occurred. It might be possible to conclude that data retrievable through external means (like vehicular speed obtained through the use of a radar gun) may not constitute a search, while data collected by EDRs such as the functioning of air bags, seat belts, or braking, which could only previously have been done during a physical examination of the vehicle, would constitute a Fourth Amendment search. This analogy is difficult to draw, however, because homes have traditionally received far greater constitutional protections than have automobiles.[110] The *Kyllo* Court also suggested that should the use of such devices become routine or available to the general public, the privacy interest might diminish.[111] In other words, if such devices become so commonplace that the general public knows of their routine use, the scope of the privacy right itself might change.

Presently, of course, anyone who operates a motor vehicle knows that both the license plate and the vehicle identification numbers ("VIN") are readily accessible to the police (or other on-lookers). Drivers accept the fact that the police can run those identification numbers and find out a great deal about the car's owner. Physical descriptions, police records, driving records, home addresses, telephone numbers, and a good deal of other personal information is available to law enforcement authorities just by having access to VIN and license plate numbers. Yet, no one demands that the police obtain a warrant before obtaining such otherwise private information. If the general public is willing to accept such warrantless intrusions into their lives, it is possible that should wireless access to EDR data become customary, the public will also become comfortable with the notion of permitting authorities routine access to that data as well.

2) Privacy and the Fourth Amendment

It is unquestionable that car owners have a reasonable expectation of privacy in their cars.[112] That zone of privacy generally applies to the passenger compartment, but,

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[109] *Id*. at 35.

[110] *See, e.g.*, *Preston v. U.S.*, 376 U.S. 364 (1964) (Questions involving searches of motor cars or other things readily moved cannot be treated as identical to questions arising out of searches of fixed structures like houses, and what may be a reasonable search of a house may be reasonable in the case of a motor car.), *Cady v. Dombrowski,* 413 U.S. 433 (1973), (holding that there are Constitutional differences between searches of and seizures from houses and similar structures and from vehicles which stems both from ambulatory character of the latter), *California v. Carney*, 471 U.S. 386 (1985) (Although defendant's motor home possessed some attributes of a home, it was readily mobile, and there was a reduced expectation of privacy stemming from pervasive regulation of vehicles capable of traveling).

[111] *Kyllo* 533 U.S at 36.

[112] *New York v. Class*, 475 U.S. 106, 114-115 (1986) (holding that when police officers reached into interior of automobile to remove certain papers obscuring the vehicle identification number it was a search but was sufficiently unintrusive to be constitutionally permissible, thereby justifying officer's seizure of weapon found protruding from underneath driver's seat).

depending upon the circumstances, may not extend to cover containers located within the automobile.[113] Thus, analogizing EDRs to "containers" that may "hold" evidence, officers investigating car accidents may seize EDRs knowing the device "holds" critical crash data which will assist in the investigation. As the car owner has no privacy interest in the "container," [114] such a seizure does not implicate the Fourth Amendment.[115] However, this is not a particularly satisfactory analogy. A better comparison might be made to other data that is retrievable from the accident scene, such as skid marks or roadway conditions. Essentially, one must consider whether engineering data of this sort is really "owned." After all, a radar gun deployed by a police officer records data about auto speed. The car's owner, however, has no privacy interest in the data recorded by that radar gun. This analogy is also tricky, however, because the car's owner in essence controls the EDR as well, so the fit is a bit odd.

In addition, whether a car owner maintains a reasonable expectation of privacy in a car and its component parts after an accident may depend on the owner's actions. A property owner must manifest some intention to maintain the privacy of the property the police intend to search.[116] Analogizing to cases involving so-called "fire searches, " where property owners take affirmative steps to protect their damaged property, they retain a valid expectation of privacy.[117] Similarly, by voluntarily abandoning property, an individual forfeits any reasonable expectation of privacy in the property.[118]

Thus, if the vehicle is only slightly damaged and can be driven away, and the owner demonstrates an intention to drive the car away, the owner likely retains his or her privacy interest in the automobile and its component parts. However, if the car is damaged beyond reasonable repair, then the owner must make some further effort to secure the car to maintain the privacy interest. If the owner takes no affirmative steps to secure the car, then police officers may conduct a valid search for causal evidence

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[113] *See California v. Acevedo*, 500 U.S. 565 (1991) (holding that police may search a container located within an automobile, and need not hold the container pending issuance of a warrant, even though they lack probable cause to search the vehicle as a whole; it is enough that they have probable cause to believe the container itself holds contraband or evidence.)

[114] *Acevedo*, 500 U.S. at 574.

[115] *Katz*, 389 U.S. at 361, *Cf. United States v. Jacobsen*, 466 U.S. 109, 120 n.17 (1984) ("A container which can support a reasonable expectation of privacy may not be searched, even on probable cause, without a warrant.")

[116] *Id.*

[117] *Michigan v. Clifford*, 464 U.S. 287 (1984). (Where fire-damaged home was uninhabitable when fire investigator arrived, where personal belongings remained in home, and where owners had arranged to have house secured against intrusion while they were gone, owners retained reasonable privacy interest in fire-damaged residence and fire investigations were subject to warrant requirement).

[118] *United States v. Oswald*, 783 F.2d 663, 666 (6th Cir.1986) (Defendant abandoned property and did not attempt to retrieve in a reasonable time thus did not violate rights against unreasonable search and seizure).

without a warrant.[119] Similarly, if the driver (and any occupants) is injured or unconscious, the police may be able to retrieve the EDR and any data contained therein during the process of assisting the injured.

Finally, if an EDR is regarded as a safety or "other" device required under the Motor Vehicle Safety Act, and the data thereby recorded is considered important in advancing a significant public policy interest, a car owner may not necessarily possess a privacy interest in the data superior to the interest of the public. If one analogizes to the privacy interest that is abrogated by the use of mandatory VINs, it could similarly be argued that a car owner may have no reasonable expectation of privacy in EDR-recorded data. In *New York v. Class,*[120] for example, the Supreme Court stated that because of the important role the VIN plays in the pervasive government regulation of the automobile, and the efforts by the federal government to ensure that the VIN is placed in plain view, there is no reasonable expectation of privacy in the VIN, for Fourth Amendment purposes.[121] Thus, if the EDRs are required because they play an important role in government regulation of the automobile industry, there may be no reasonable expectation of privacy in EDR data for Fourth Amendment purposes.

5.5.3 Does a car owner have a reasonable expectation of privacy in the telemetry data provided by EDR devices?

Katz defines a legitimate expectation of privacy as one in which both the individual manifests a subjective expectation of privacy in the searched object, and society objectively recognizes the individual's expectation of privacy as reasonable.[122] In pursuing *Katz*'s second prong, or whether the expectation of privacy is objectively reasonable, the test of legitimacy is not whether the individual chooses to conceal assertedly "private activity," but whether the government's intrusion infringes upon the personal and societal values protected by the Fourth Amendment.[123] Thus, regardless of car owner's subjective expectations, it is unlikely the courts will validate an objective expectation of privacy in vehicle safety data.

In *Smith v. Maryland*, the Supreme Court held that the installation, at the request of the police, of a pen register[124] at the telephone company's offices to record the telephone numbers dialed on the petitioner's telephone did not violate the Fourth Amendment.[125]

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[119] It is important to distinguish searches for causal evidence from searches for evidence of criminal conduct. Causal evidence is subject only to the restraints of an administrative warrant, where the search for criminal evidence requires a criminal obtainable only on a showing of probable cause to believe that relevant evidence will be found on the place searched. *Michigan v. Clifford*, 464 U.S. 287, 294 (1984).

[120] 475 U.S. 106 (1986).

[121] *Id.*

[122] *Katz*, 389 U.S. at 361.

[123] Oliver v. US, 466 U.S. 170, 182-183 (1984).

[124] A pen register is a surveillance device that captures the phone numbers dialed on outgoing telephone calls. See, 18 USC 3121.

The petitioner had no legitimate expectation of privacy in the telephone numbers because he voluntarily conveyed them to the telephone company when he used his telephone. "This Court consistently has held that a person has no legitimate expectation of privacy in information he voluntarily turns over to third parties."[126] Telephone numbers dialed from one's home arguably raise more significant privacy concerns than the speed of one's vehicle immediately prior to a crash because vehicle speed could potentially be externally measured. For example, a police officer equipped with a radar gun, standing by the accident's scene immediately prior to the crash, could have obtained the vehicle speed without threatening the driver's privacy interest. Telephone numbers dialed from one's home do not enlist a reasonable expectation of privacy. Thus, it seems unlikely that vehicle safety data will be the subject of an inviolate privacy interest, when such data can be ascertained by means other than EDRs. Although some information, such as the engine's RPM's, may not be externally measurable and thus may not fit readily within this analysis.

In *Oliver v. United States*, in which the Supreme Court considered the legitimacy of police officers entering private property in order to gather evidence of criminal conduct, the Court opined that the privacy issue turns on "whether the government's intrusion infringes upon the personal and societal values protected by the Fourth Amendment."[127] While no single consideration has been regarded as dispositive, the Court has "given weight to such factors as the intention of the Framers of the Fourth Amendment, ... the uses to which the individual has put a location, ... and our societal understanding that certain areas deserve the most scrupulous protection from government invasion."[128]

It seems unlikely under *Oliver* that vehicle safety data warrants Fourth Amendment protection. Individuals presently make no use of EDR data. In fact, very few individuals are even aware their automobiles contain such a device. That could, of course, change in the future. Nevertheless, EDRs exist by and large to provide information to third parties, much the same way that a license plate or a registration certificate provides information to other parties. [129] Thus the "uses to which the individual" puts the EDR weighs against a reasonable expectation of privacy. Similarly, it is unlikely that our "societal understanding" supports protection of vehicle safety data. Many forms of data provided by EDRs (speed, brake application, seat belt use, airbag deployment) are readily and regularly gathered as part of accident reconstruction and investigation. This data is gathered without objection because it is not regarded as a search into a constitutionally

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[125] *Smith v. Maryland*, 442 U.S. 735 (1979) (The installation and use of the pen register was not a search within the meaning of the Fourth Amendment, and no warrant was required).

[126] *Id.* at 743-744. The standard exceptions to this include information provided to attorneys, treating physicians, or religious counselors. Such information is normally accorded "privileged" status and is not usable in the even of a criminal prosecution.

[127] *Oliver v. United States*, 466 U.S. 170, 182 - 183 (1984).

[128] *Id.* at 178.

[129] Even in situations in which individuals might want to use EDR data it seems most likely that it would either be to defend or prosecute legal actions or to permit, for example, parents to monitor the driving habits of their children.

protected area. Simply changing the method of collecting this data does not create a privacy interest where none previously existed.

Ownership of the vehicle, of course, may be the touchstone for determining when or whether a cognizable privacy interest exists. As a general rule, merely being a passenger in a vehicle does not create a privacy interest either in that vehicle or things contained therein.[130] Currently both the NHTSA and the Federal Highway Administration ("FHWA") have concluded that the vehicle's owner owns any data recorded by the EDR.[131] Specifically, the NHTSA takes the 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.[132]

Similarly, the FHWA's Office of Chief Counsel observes that:

> Vehicles are sold to consumers without any vestigial interests retained by the manufacturers... . 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 the state motor vehicle licensing laws, or by some other federal regulation that permits public authorities to access the data regardless of ownership.[133]

In addition to the NHTSA and FHWA, the Federal Motor Carrier Safety Administration ("FMCSA") branch of the Department of Transportation and American Trucking Associations, Inc. ("ATA") has asserted that the owner of a vehicle with an EDR is the exclusive owner of that EDR's data.[134]

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[130] Saltzburg & Capra, American Criminal Procedure, 327-331(6th ed. 2000).
[131] Event Data Recorders: Summary of Findings by the NHTSA EDR Working Group, Final Report, Aug. 2001, at 8.3, No. NHTSA-99-5218, available at http://www-nrd.nhtsa.dot.gov/edr-site/uploads/edrs-summary<uscore>of <uscore>findings.pdf (last visited Jan. 26, 2003) (recording position of National Highway Traffic Safety Administration regarding EDR data ownership) and 8.3.2 (recording position of Federal Highway Administration regarding EDR data ownership).

[132] Id.

[133] Id. at 8.3.2.
[134] U.S. Department of Transportation: Federal Motor Carrier Safety Administration, A Report to Congress on Electronic Control Module Technology for Use in Recording Vehicle Parameters During a Crash, 23 (Sept. 2001) [hereinafter FMCSA Report]; *see also* American Trucking Associations, Inc., Technology & Maintenance Council, Recommended Practice, Proposed RP 1214(T): Guidelines for Event Data

A potential implication of the ownership issue is that a vehicle owner, if found to be the owner of the EDR data, may preserve her right to withhold or erase the data if that decision is in her self-interest. The FMCSA notes that only the vehicle owner, or a party having the owner's consent, can access the EDR data, unless a law enforcement official has obtained a warrant to investigate a crash. As will be discussed, infra, I do not think this is necessarily correct.[135]

The data ownership issue is not quite as obvious as it might appear at first blush. It may be the case that no one really "owns" the data recorded by the EDR. To borrow an example from copyright law, it is clear that while original works, whether stored or communicated directly or indirectly with the aid of a machine or a device may be "owned" and therefore copyrighted, "[i]deas or facts . . . are not protected by copyright."[136] The reasoning that stands behind this well-known legal principle accepts that objective facts (like the rate of speed at which an automobile is traveling) may not be owned or otherwise controlled by a private party. Thus, while the data recorder itself is owned by the person who controls the vehicle's title, the data, which is not original work-product but rather merely factual information, may not be owned. For example, while I may own a piece of real estate, I do not "own" the information contained in the county plat recording its physical boundaries. A person may own an automobile, but she doesn't own the information relating to that vehicle's speed as it hurtles down the freeway. The issue may therefore be more one of access to the data, as opposed to ownership of the data itself.[137] It therefore seems unlikely that information gathered by EDRs is entitled to protection under the Fourth Amendment. As such, it may be subject to search without the Fourth Amendment's strictures.

5.5.4 Wireless Communications and Electronically Stored Data

An important issue meriting further consideration is the increasing use of wireless means to access electronically stored data. This is true not only in the context of data stored in EDRs, but access to wireless network connections that lead to data contained in hard drives or servers, or wireless connections to the internet where information may be maintained. With respect to EDRs, the issue is whether police need a warrant to access data stored on these devices if they can do so wirelessly—in other words, without directly trespassing on private property. In an early effort to deal with the nascent field of

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Collection, Storage and Retrieval (2001). While the FMCSA and ATA recommendations pertain to EDR's in trucks, as opposed to non-commercial vehicles, the same data ownership concerns apply.

[135] See FMCSA Report, supra note 68.

[136] See, e.g. *Worth v Selchow & Righter Co*., 827 F.2d 569 (9th Cir. 1987) (stating common legal maxim that facts are not owned and thus not subject to copyright protections).

[137] The Supreme Court's decision in *Kyllo v. United States*, 533 U.S. 27 (2001) does not undercut this analysis. In *Kyllo*, the Court had to decide whether the government's use of a thermal imaging device constituted a "search" for Fourth Amendment purposes. Although the Court concluded that it did, it did not address the question whether the heat signature left by the defendant's home was "owned" by him. The Court simply held that the government could not, without a warrant, obtain the home's thermal data.

wireless communications, Congress comprehensively overhauled federal wiretap law with the enactment of the 1986 Electronic Privacy Act ("ECPA").[138] The ECPA, which was designed to protect and secure the privacy of wire and oral communications between individuals, extended the wiretap provisions to include wireless voice communications and electronic communications such as e-mail or other computer-to-computer transmissions.[139] Among other things, the ECPA prohibits the willful interception or willful use of "wire" or "oral" communications.[140] As previously noted, most courts did not protect such communications. EDR data does not fall within these definitions, but it is useful to see the way in which Congress prohibited the interception of communications where no physical trespass was necessary. Although the interception of all wire communications is prohibited by the ECPA, the expectancy of privacy is a necessary precondition to obtaining the Act's protection for oral communication.

It is important to understand that EPCA only applies to "communications," fairly narrowly defined, and does not pertain to the wireless downloading of mere data. Arguably, the interception of communications between individuals merits even greater protection than the mere wireless downloading of data. Nevertheless, the majority of federal courts held that individuals had *no* reasonable expectation of privacy in such wireless communications, whether one or both of the parties communicated by a cordless LAN telephone or cellular telephone.[141] If one has no reasonable expectation of privacy

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[138]Electronic Communications Privacy Act of 1986, Pub. L. No. 99-508, 101-303, 100 Stat. 1848 (codified at 18 U.S.C. 1367, 2510-21, 2701-10, 3121-26).

[139] Edwards v. Bardwell, 632 F. Supp. 584, 586-87 (M.D. La.), aff'd, 808 F.2d 54 (5th Cir. 1986); Congressional Findings Act of 1968, Pub. L. No. 90-351, 801, 82 Stat. 211-12 (1968) (observing that wire communications form an interstate network susceptible to substantial eavesdropping and interception of wire, electronic, and oral communications; the purpose of the ECPA is to protect the privacy of such communications).

The ECPA defines wire and oral communications as follows:

"wire communication" means any aural transfer made in whole or in part through the use of facilities for the transmission of communications by the aid of wire, cable, or other like connection between the point of origin and the point of reception ... furnished or operated by any person engaged in providing or operating such facilities for the transmission of interstate or foreign communications ....

(2) "oral communication" means any oral communication uttered by a person exhibiting an expectation that such communication is not subject to interception under circumstances justifying such expectation, but such term does not include any electronic communication.
18 U.S.C. 2510(1)-(2) (1995).

[141] *See, e.g.*, United States v. Hall 488 F.2d 193 (9th Cir. 1973) (holding that a communication was protected as a "wire" communication if one party was on a cellular car phone and the other on a land-based line.; United States v. Smith, 978 F.2d 171, 180 (5th Cir. 1992) (holding that the defendant failed to prove that his expectation of privacy in a cordless phone conversation was reasonable under the Fourth Amendment; the court opined in dicta, however, that a more technologically advanced cordless phone may acquire a societal recognition of a reasonable expectation of privacy sufficient for Fourth Amendment protection), cert. denied, 113 S. Ct. 1620 (1993), Tyler v. Berodt, 877 F.2d 705 (8th Cir. 1989), cert. denied, 493 U.S. 1022 (1990). In Tyler, a cordless phone conversation to an unknown receiver was intercepted by one of Tyler's neighbors. Id. at 705. Information heard during the interception subsequently

in a telephone call, should one have a reasonable expectation of privacy in factual information recorded by an EDR? This is certainly not a clear-cut situation. Nevertheless, Congress and most states have intervened to ensure the privacy of such communications in light of these federal court decisions. Similarly, Congress (and the individual states) certainly could choose to protect EDR recorded data as well. It is difficult to conclude, however, that EDR data would receive *greater* privacy protections than those afforded to actual person-to-person communications.

Interestingly, the law treats electronically stored data, such as EDR data, quite differently from either data intercepted in real time or data stored in more traditional ways. The ECPA provides protection for e-mail and other forms of "electronic communication" held in "electronic storage," which could arguably include data stored in an EDR. In order for the government to seize any "electronic communications"[142] in "electronic storage"[143] for 180 days or less requires an ordinary warrant.[144] Seizure of electronic communications in storage for more than 180 days[145] on an "electronic communications service,"[146] requires a subpoena or an order issued pursuant to an offering of "specific and articulable" facts showing reasonable grounds to believe that the contents of an "electronic communication" are relevant to an ongoing criminal investigation.[147] Presumably, the government could create different requirements for EDR-stored data as well.

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provided the basis for the ensuing criminal charges against Tyler. Id. at 706. Although Tyler sued his neighbor for civil violations of the ECPA, the United States Court of Appeals for the Eighth Circuit affirmed the summary judgment against Tyler. Id. at 707; see also United States v. Hoffa, 436 F.2d 1243, 1247 (7th Cir. 1970) (communicating via a cellular car phone provides no reasonable expectation of privacy), cert. denied, 400 U.S. 1000 (1971); United States v. Carr, 805 F. Supp. 1266 (E.D.N.C. 1992) (holding that there is no reasonable expectation of **privacy** in communications via at least one cordless phone and either a cordless or land-based line).

[142] 18 U.S.C. § 2510(12) (defining "electronic communication" as, with certain exceptions, "any transfer of signs, signals, writing, images, sounds, data, or intelligence of any nature transmitted in whole or in part by a wire, radio, electromagnetic, photoelectronic or photo optical system that affects interstate or foreign commerce").

[143] 18 U.S.C. § 2510(17) (defining "electronic storage" as "(A) any temporary, intermediate storage of a wire or electronic communication incidental to the electronic transmission thereof; and (B) any storage of such communication by an electronic communication service for purposes of backup protection of such communication").

[144] 18 U.S.C. § 2703 (a) (2001).

[145] If the communication has been in electronic storage for 180 days or less, the government must obtain a warrant. See 18 U.S.C. § 2703(a) (2001).

[146] 18 U.S.C. § 2510(15) (2001) (defining ECS as "any service which provides to users thereof the ability to send or receive wire or electronic communications").

[147] 18 U.S.C. §§ 2703(a), 2703(b)(1)(B)(ii), 2703(d) (2001).

5.6 May police officers obtain the data without the owner's consent after obtaining a warrant for both criminal and non-criminal investigations?

The Fourth Amendment guarantees "the right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures," and further provides that "no Warrants shall issue, but upon probable cause."[148] Clearly, if police were to acquire a warrant they would be able to obtain the information contained in an EDR. Police have been able to obtain computer files, personal diaries, and video surveillance footage with a warrant.[149] As described *infra*, EDRs are comparable to such storage devices for they maintain information that may be relevant for purposes of litigation. Thus, police would be able to obtain the data contained in an EDR by securing a warrant.

5.6.1 May police officers seize EDR information without a warrant?

Perhaps the more difficult question is whether the police may obtain the data recorded by the EDRs without a warrant. It has long been the case that courts have consistently recognized exceptions to the warrant requirement. Oftentimes, those exceptions fall within certain narrow categories where the government is able to establish a legitimate need. For example, "the First, Second, and Fourth Congresses … authorized federal officers to conduct warrantless searches" of ships and vessels, to find property that owed duty.[150] Assuming *arguendo* that car owners do have a reasonable expectation of privacy in EDRs or EDR data, police officers may nonetheless seize EDRs without a warrant based on exigent circumstances or "special needs." If an individual maintains a reasonable expectation of privacy in the object to be searched, then seizure is within the scope of the Fourth Amendment, and is prohibited without a warrant or a valid exception to the warrant requirement. Exceptions to the warrant requirement, founded on the public interest requirement of flexibility in application of the general rule, arise in those cases where the societal costs of obtaining a warrant, such as danger to law officers or risk of loss or destruction of evidence, outweigh reasons for recourse to a neutral magistrate.[151]

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[148] U.S. Const. amend. IV.

[149] *U.S. v. Humphrey*, 279 F.3d 372 (2002) (Video Surveillance); *U.S. v. Lightfoot*, 6 Fed.Appx. 181 (2001) (Video Surveillance); *U.S. v. Walton*,217 F.3d 443 (2000) (Video Surveillance);. *Moyer v. Com*, 531 S.E.2d 580 (2000) (Diary); *U.S. v. Angevine*, 281 F.3d 1130 (2002) (Computer files); *U.S. v. Jewell*, 16 Fed.Appx. 295 (2001) (Computer Files).

[150] *Florida v. White*, 526 U.S. 559, 564 (1999).

[151] *United States v. Kreimes*, 649 F.2d 1185 (5th Cir. 1981) (holding that police officer was justified in stopping defendant's truck and the warrantless search of luggage found in truck was justified because officer had probable cause to believe that an armed fugitive was at large).

Courts and other commentators often point to *Carrol v. U.S* as the case that created the so-called "automobile exception" to the Fourth Amendment.[152] The "automobile exception" authorizes police officers to stop and search automobiles without a warrant, as long as the police officers have probable cause to believe that there is evidence of criminal activity within the automobile. The rationale behind the decision in *Carrol*, was that the mobile nature of cars creates an exigent circumstance making a warrant impractical and counter productive to law enforcement. *Carrol* follows earlier cases that enabled authorities to search carriages and maritime vessels as part of a system of inspections without needing to resort to a warrant.

1) Exigent Circumstances

Circumstances that justify warrantless searches include those in which officers reasonably fear for their safety, where firearms are present, where there is risk of criminal suspect's escaping, or fear of destruction of evidence.[153] The exigent circumstances doctrine bears special application where the object of the search is damaged property, as in the inspection of burnt homes or businesses. Analysis under the Supreme Court's line of cases involving "fire searches" is framed by two Supreme Court decisions: *Michigan v. Tyler*,[154] and *Michigan v. Clifford*.[155]

In *Tyler*, a furniture store fire was reduced to "smoldering embers" by the time the local Fire Chief reported to the scene.[156] The Chief concluded that the fire was possibly the result of arson, and called a police detective, who took some photographs, but "abandoned his efforts because of the smoke and steam."[157] Four hours later, the Chief returned with the Assistant Chief, whose task it was to determine the origin of all fires in the township. The fire was effectively out when they returned, and the building was empty. The investigators quickly left, returning with the police detective around 9:00 a.m. They found suspicious burn marks, not visible earlier, and took carpet and stair samples. Rejecting the premise that "the exigency justifying a warrantless entry to fight a fire ends, and the need to get a warrant begins, with the dousing of the last flame," the Court found the two searches conducted on the morning after the fire were constitutionally permitted.[158] After noting that the investigation on the night of the fire was hindered by the darkness as well as the steam and smoke, the Court found that the fire officials' morning-after entries were no more than an actual continuation of the first, valid

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[152] *Carrol v. U.S.,* 267 U.S. 132 (1925)(federal agents stopped a car they had probable cause to believe contained illegal liquor and immediately subjected it to a warrantless search).

[153] *United States v. Mendoza-Burciaga*, 981 F.2d 192 (5th Cir. 1992).

[154] *Michigan v. Tyler,* 436 U.S. 499 (1978).

[155] *Michigan v. Clifford*, 464 U.S. 287 (1984).

[156] Tyler, 436 U.S. at 501.

[157] Id. at 502.

[158] Id. at 510.

search.[159] The *Tyler* Court promulgated a yet-undisturbed rule: "a warrantless entry by criminal law enforcement officials may be legal when there is compelling need for official action and no time to secure a warrant." [160]

In *Clifford*, a fire department reported to a residential fire about 5:42 in the morning. The fire was extinguished, and the fire officials and police left the premises at 7:04 a.m. At about 1:00 p.m. that afternoon a fire investigator arrived at the scene, having been informed that the fire department suspected arson. Despite the fact that the house was being boarded up on behalf of the out-of-town owners, the Cliffords, and despite their knowledge that the Cliffords did not plan to return that day, the fire investigator and his partner searched the house. After determining that the fire had been set in the basement, and how, the investigators searched the entire house, taking photographs.[161] In finding that the challenged search by the fire investigator was not a continuation of an earlier search, as in *Tyler*, and in distinguishing between the two cases, the Court explained

> Between the time the firefighters had extinguished the blaze and left the scene and the arson investigators first arrived . . . the Cliffords had taken steps to secure the privacy interests that remained in their residence against further intrusion. These efforts separate the entry made to extinguish the blaze by that made later by different officers to investigate its origin. Second, the privacy interests in the residence--particularly after the Cliffords had acted--were significantly greater than those in the fire-damaged furniture store [in *Tyler*], making the delay between the fire and the mid-day search unreasonable absent a warrant, consent, or exigent circumstances.[162]

Thus, the *Clifford* Court laid out three factors for analyzing the constitutionality of warrantless searches of fire-damaged premises: 1) whether there are legitimate privacy interests in the fire-damaged property that are protected by the Fourth Amendment; 2) whether exigent circumstances justify the government intrusion regardless of any reasonable expectation of privacy; and 3) whether the object of the search is to determine the cause of the fire or to gather evidence of criminal activity.[163] *Clifford* thus established the principle that Fire officials need no warrant to enter and remain in a building for reasonable time to investigate the cause of a blaze after it has been extinguished.[164]

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[159] Id. at 511.
[160] Id. at 509.

[161] *Clifford*, 464 U.S. at 289-91.

[162] *Id*. at 296.

[163] *Clifford*, 464 U.S. at 291.

[164] *U.S. v. Finnigin*, 113 F.3d 1182 (10th Cir. 1997).

Should police officers charged with investigating car accidents be afforded the same authority? Perhaps so. Fire officials are charged not only with extinguishing fires, but with finding their causes. Prompt determination of the fire's origin may be necessary to prevent its recurrence...."[165] For this reason, fire officials need no warrant to enter and remain in a building for a reasonable time to investigate the cause of a blaze after it has been extinguished.[166]

Accident investigation officials are similarly charged with finding an accident's cause. EDRs provide data critical to that inquiry. In *Commonwealth of Massachusetts v. Mamacos*, a defendant, charged with two counts of homicide by negligent operation of a motor vehicle, moved to suppress results of the testing of his truck and all items removed from his truck on the ground that such evidence was obtained without a search warrant.[167] After the case was transferred from the Appeals Court, however, the Supreme Judicial Court, Essex County, O'Connor, J., held that: (1) the police department had a right to remove any truck involved in a fatal accident from the scene of the accident and to hold such truck in storage for a reasonable time, and (2) even if the owner of the truck involved in the fatal accident had a subjective expectation of privacy with respect to the truck's brakes, society would not recognize such an expectation of privacy as reasonable when the truck came into possession of the police following the death of the motorists.[168] Accordingly, the police officer's examination and testing of the brakes conducted after the owner requested that the truck be returned to him was not a "search" within the meaning of the Fourth Amendment.[169]

While prompt discovery of an accident's origin is not necessary to prevent its reoccurrence, a prompt seizure of the EDR may be required to prevent loss of the EDRs critical data. This may be especially true where vehicles are only slightly damaged, and may be driven from the scene by their owners. "[A] warrantless entry by criminal law enforcement officials may be legal when there is a compelling need for official action and no time to secure a warrant."[170] Where a driver may remove a vehicle from the accident scene there exists the possibility that critical evidence may be lost, thus creating a "compelling need for official action."[171]

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[165] *Id.* at 1185.

[166] *Id*.

[167] *Massachusetts v. Mamacos,* 409 Mass 635 (1991).

[168] *Id.*

[169] *Id.*

[170] *Michigan v. Tyler*, 436 U.S. 499, 509 (1978).

[171] *Id.*

Alternatively, police officers may seize EDRs without a warrant during accident investigations because the EDR contains critical evidence of the accident's potential causes, and may furnish other evidence used to prosecute drivers from criminal offenses. It is well settled that warrantless searches of automobiles are permitted by the Fourth Amendment if the officers have probable cause to believe that the vehicle contains contraband or other evidence of a crime.[172] Whether an officer has probable cause to search a vehicle depends on the totality of the circumstances viewed "in light of the observations, knowledge, and training of the law enforcement officers involved in the warrantless search."[173] As the Supreme Court stated in *Ross*, "If probable cause justifies the search of a lawfully stopped vehicle, it justifies the search of every part of the vehicle and its contents that may conceal the object of the search."[174]

Accident investigators, because of their training and experience, may have reason to suspect that drivers involved in accidents have committed a criminal offense or are not answering the officer's questions regarding potential crimes truthfully. In those instances, police officers may be justified in seizing EDRs because they know or have probable cause to believe that the EDR contains evidence of a crime. A police officer in that situation may seize the EDR without violating the Fourth Amendment. However, the exigent circumstance rationale has been supplemented by subsequent cases such as *South Dakota v. Opperman,* which held that in addition to the mobile nature of cars, "less rigorous warrant requirements govern because the expectation of privacy with respect to one's automobile is significantly less than that relating to one's home or office."[175] *Cady v. Dombrowski*, explained that the reduced privacy interest derived "from the pervasive regulation of vehicles capable of traveling on the public highways."[176] *Opperman*, elaborated on the "pervasive regulation" rationale stating that automobiles are subjected to "continuing governmental regulation and controls including periodic inspection and licensing requirements."[177] *Opperman* pointed out that cars are subjected to inspections for expired license plates, inspection stickers and for other violations "such as exhaust fumes or excessive noise" and "[defective] headlights or other safety equipment." [178] Explaining the boundaries of a search conducted without a warrant, *U.S. v. Ross* held that "if probable cause justifies the search of a lawfully stopped vehicle, it justifies the search of every part of the vehicle and its contents that may conceal the object of the

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[172] *See United States v. Ross*, 456 U.S. 798, 809-10 (1982); *United States v. Buchner*, 7 F.3d 1149, 1154 (5th Cir.1993), cert. denied, 510 U.S. 1207 (1994); *United States v. Kelly*, 961 F.2d 524, 527 (5th Cir.1992).

[173] *United States v. Muniz-Melchor*, 894 F.2d 1430, 1438 (5th Cir.), cert. denied, 495 U.S. 923 (1990).

[174] *Ross,* 456 U.S. at 825.

[175] *South Dakota v. Opperman*, 428 U.S. 364 (1976).

[176] *Cady v. Dombrowski,* 413 U.S.433, 440 (1974).

[177] *Opperman*, 428 U.S. at 368.

[178] *Opperman*, 428 U.S. at 368.

search."[179] *Ross* further held that the search was determined not by the nature of the containers within the car, but by the nature of the evidence searched for.[180]

When a police officer arrives at the scene of an automobile accident, he is investigating and inspecting both safety and criminal concerns. The police officer will need to assess if there are any safety issues that need to be resolved immediately such as a gas leak or an obstructed lane of traffic. Additionally, the police officer will need to determine whether the cars at the scene are safe to be driven from the scene. As a separate empowering interest, the police officer will have to determine if any of the drivers were committing traffic or other criminal offenses prior to the accident. These offenses could be as (relatively) minor as driving without a license, expired tags, defective tail light, improper or unsafe suspension (such as, but not limited to, an unsafe low-rider, or a truck that is improperly raised), speeding, failing to yield, improper lane change etc. On the other hand, the offenses could also be quite severe, warranting criminal sanctions. Such offenses include driving while intoxicated, driving under the influence, reckless driving, and reckless homicide.

The individuals involved in the car accident already have a reduced privacy interest.[181] The rationale for this reduced sense of privacy is that society objectively recognizes that cars are already subjected to multiple inspections, safety requirements, and licenses.[182] Finally, if a police officer has probable cause to believe that one of the cars involved in the accident was violating criminal laws, or in the alternative that the act of driving away from the scene would violate minimal safety statutes, the police officers can search and inspect the car to the extent necessary to resolve those issues.[183] *Ross* gives police officers the authority to search in any "container" where they have probable cause to believe they will find evidence of the crime or violation they are investigating. By downloading the EDR data, a police officer could quickly evaluate if the brakes are working properly, if the brakes were used at all, if the driver was speeding, if the driver was speeding to the point of being reckless, or if the driver was in an accident of the magnitude that would likely damage a car to the point that it would be unsafe to drive. Depending on the particular EDR, the police may be able to obtain even more information. Thus, pursuant to the Court's acknowledgment that public safety and the need to conduct prompt investigations may permit officers to conduct warrantless searches in certain narrow circumstances, it is similarly likely that the warrantless seizure of the data contained in an EDR is constitutionally permissible as well.

2) "Special Needs" Exception

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[179] *U.S. v. Ross,* 456 U.S. 798 (1982).

[180] *Id.*

[181] *Cady v. Dombrowski,* 413 U.S. 433, 440 (1974).

[182] *South Dakota v. Opperman*, 428 U.S. 364 (1976).

[183] *U.S. v. Ross*, 456 U.S. 798 (1982).

Moreover, authority derived from legislative action mandating seizure of EDRs during accident investigations may arise through the "special needs" exception to the Fourth Amendment's proscription against warrantless searches. A search unsupported by either a warrant or probable cause can be constitutional when special needs other than the normal need for law enforcement provide sufficient justification.[184] Under the "special needs doctrine," a court identifies a special need which makes adherence to the warrant and probable cause requirements impracticable, and then balances the government's interest in conducting a particular search against the individual's privacy interests upon which the search intrudes.[185] The "special needs doctrine" allows the state to dispense with the normal warrant and probable cause requirements when two conditions are satisfied. First, the state must show that it has some "special need" or governmental interest beyond normal law enforcement activities that make the search or seizure necessary. Second, the state must show that its interest cannot be achieved or would be frustrated if a court imposed normal warrant and probable cause requirements. If the state satisfies these two conditions, the court then engages in an independent analysis, balancing the state's interest against individual privacy interests. Only if the court is satisfied that the state's interest in the search or seizure outweighs the individual's privacy interest will it uphold the search and dispense with the warrant and probable cause requirements.

The Motor Vehicle Safety Act makes clear that the state has a vested interest in highway safety. If EDRs are required in automobiles, it must be that NHTSA found EDRs instrumental in promoting highway safety. Thus it seems likely that the state, in mandating seizure of EDRs during accident investigations, has a special interest beyond normal law enforcement, such as state promotion of safety on highways and the efficiency of the civil tort system.[186] Thus, it seems likely that significant state interests would not be achieved if accident investigators are subject to normal warrant and probable cause requirements.

Finally, even assuming citizens can claim some privacy interest in an EDR or its data, that interest is likely to be relatively small considering the state's interest in promoting highway safety and public welfare. Seizure of EDRs thus fulfills the "special needs"

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[184] *Ferguson v. City of Charleston*, 532 U.S. 67 (2001) (A S.C. hospital selectively tested pregnant women seeking prenatal care and turned their drug test results over to the police who then arrested a number of the women. The court held that this was a violation of the Fourth Amendment and was not within the special needs exception).

[185] *Earls ex rel. Earls v. Board of Educ. of Tecumseh Public School Dist.*, 242 F.3d 1264 (10th Cir. 2001) (Existence of drug problem at public high school constituted a "special need" for purposes of determining whether the school's suspicionless drug testing of students participating in competitive extracurricular activities was reasonable).

[186]*See Edmond v. Goldsmith*, 183 F.3d 659 (7th Cir. 1999) ("Randomized or comprehensive searches that have survived the Fourth Amendment are not concerned with catching crooks, but rather with securing the safety or efficiency of the activity in which people who are searched are engaged * * * for example, owners and proprietors (such as state as owner of public roads) have a right to take reasonable measures to protect safety and efficiency of their operations.")

exception, and accident investigators can be authorized by statute[187] to seize EDRs and the data contained therein without a warrant.

5.6.2 Additional Considerations Regarding the Use of EDR Data

Most of the forgoing discussion dealt with seizure of EDR information at the scene of an accident. Law enforcement authorities have fairly broad authority to secure information from the scene of a crash. Different rules apply when police are simply seeking information related to the prosecution of a crime. But there have been a number of cases in which EDR data was used to prosecute a crime.[188] It is clear that the information recorded by EDRs could prove crucial in future criminal prosecutions.[189] A recent Florida case highlights the various uses for EDR data. In that case, the defendant was charged with four counts of DUI manslaughter and two counts of vehicular homicide for killing two teenagers in an accident.[190] Although a blood test showed that the defendant was intoxicated at the time of the accident, the trial court found the test inadmissible because the defendant had not given voluntary consent. Absent data from the EDR, which measured the defendant's speed at 114 mph five seconds before the crash and detected that he was pressing the gas pedal at 99 percent of its maximum capacity, it might have been difficult to prosecute the case.

Prosecutors are not the only ones who potentially benefit from the use of EDR data. While prosecutors may use the data to bring charges against citizens who violate the law, defendants may also be able to use EDR data to defend themselves against prosecution. In *Colorado v. Cain*, [191] for example, the state charged the defendant with vehicular homicide, arguing that he was recklessly speeding when the accident occurred. The defendant, however, was able to take advantage of the EDR data stored in his vehicle to successfully defended himself against the charge by using the recorded evidence to show that he was not speeding when the accident occurred. Although a jury may decline to

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[187] The "special needs" exception may not apply absent a specific statute on point. The Sixth Circuit has held that the government may initiate seizure of property without prior hearing under certain very limited circumstances; in each case, seizure has been directly necessary to secure important governmental or general public interest, there must have been a special need for prompt action, and the person initiating seizure must have been a government official responsible for determining, *under standards of a narrowly drawn statute*, that it was necessary and justified in the particular instance. First Federal Sav. Bank and Trust v. Ryan, 927 F.2d 1345 (6th Cir. 1991) (emphasis added).

[188] See, e.g., *Pennsylvania v. Rhodes*. Crim. Div. Docket No. 746701 (Montgomery County, Court of Common Pleas) (2002) (defendant pleaded guilty in case where EDR data was admitted to show that when the accident occurred, he was driving in excess of 100 miles per hour); *California v. Beeler*, Case. No. SCD158974 (San Diego Sup. Ct.) (2002) (EDR data admitted to show that defendant was traveling at excessive speeds in a 45 mph zone—defendant convicted of felony and pleaded guilty to manslaughter).

[189] This is particularly true if the type of data EDRs record is expanded to include other information that may be relevant to an accident investigation (such as issues relating to vehicle maintenance or servicing) or if driving data is recorded and stored over a longer period of time.

[190] Noah Bierman, *Black box gives crash details: Broward traffic-deaths case among first of its kind*, Miami Herald, Tuesday, May 6, 2003, http://www.miami.com/mld/miamiherald/5793635.htm.

[191] Case No. 01 CR 967 (1st Judicial District Court, Div. 3, Jefferson County) (2003).

credit a defendant's self-serving protestations of innocence, when faced with objective factual evidence of the defendant's innocence, such statements take on a new light. Presumably, police officers obtained the data in these cases while at the accident scenes. If police officers seek to obtain data from an EDR *after* the event has occurred and the vehicle has been released into the owner's custody, then it is clear that they must obtain a search warrant. Of course, the practical difficulty is whether the necessary data would still exist. Unless so ordered, or if involved in litigation, the defendant vehicle owner would be under no obligation to preserve the data unless such a duty were statutorily created. Although no cases have yet addressed the issue of EDR tampering, court rulings in cases involving similar devices in trains and trucks indicate that deliberate erasure or tampering with EDR data will move courts to invoke so-called evidence spoilation remedies.[192] In other words, the deliberate destruction of such evidence may lead to sanctions against the despoiling party and judges may permit juries to draw certain negative inferences from such behavior.

Perhaps a more interesting question is whether the police could simply download the vehicle's data via a wireless connection. Under those circumstances, police would not be committing a physical trespass. It might also be argued that to obtain data through those means, police are in effect doing nothing more than that which they do when they use a radar gun to record vehicle speed. The Supreme Court's opinion in *Kyllo v. United States*[193] provides some instruction here. In that case the Court held that when the government uses a device that is not in general public use to explore details of a private home that would previously have been unknowable absent physical intrusion, a Fourth Amendment "search" has occurred and it is presumptively unreasonable without a warrant. The officers were standing on the other side of the street from the targeted home and used a thermal imaging device to record the home's heat signature. The Court's decision turned largely upon the novelty of the device used and the fact that it involved the invasion of one's privacy at home. Traditionally, the protection of vehicles from the prying eyes of law enforcement is considerably less than that afforded to private homes. Similarly, if EDRs become routinely used by manufacturers, the expectation of privacy that vehicles owners may enjoy might become diminished over time. The courts, therefore, might become more amenable to police use of EDR data as a means of monitoring criminal activity, similar to that of the accepted use of radar guns.

5.7 The Fifth Amendment and EDRs

The Constitution's Fifth Amendment provides that no person "shall be compelled in any criminal case to be a witness against himself."[194] It has been suggested that the Fifth Amendment's protection against compelled self-incrimination could be invoked as a

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[192] See, e.g., *Stanton v. Nat'l R.R. Passenger Corp*., 849 F. Supp. 1524, 1528(M.D. Ala. 1994); Dennis Donnelly, *Black Box Technology in the Courtroom*, 38 APR Trial 41 (April, 2002).

[193] 533 U.S. 27 (2001).

[194] U.S. Const. Amend. V.

means of preventing the admission of EDR data at trial. This simply represents a misunderstanding of what the amendment was designed to protect. The Fifth Amendment grants an evidentiary privilege that permits an individual to refuse to give testimony that incriminates him. Thus, the privilege applies only to testimony or statements; it does not apply to other forms of evidence.[195] In *Schmerber v. California*,[196] the Supreme Court had little difficulty in determining that the state could compel the defendant to produce a blood sample without violating the Fifth Amendment. There, the Court clarified the circumstances in which the self-incrimination protection applies:

> "[T]he privilege protects an accused only from being compelled to testify against himself, or otherwise provide the state with evidence of a testimonial or communicative nature, and that the withdrawal of blood and use of the analysis in question in this case did not involve compulsion to these ends."[197]

Thus, the protection only exists to shield *statements* from legal compulsion.[198] In other words, in a criminal proceeding, the government may not, in a criminal proceeding, move into evidence statements obtained from the defendant in violation of the Fifth Amendment. While it could certainly be argued (and was by counsel in *Schmerber*) that the withdrawal of the defendant's blood over his objection amounted to compelled testimony, the Court refused to extend the Fifth Amendment's self-incrimination protection to other forms of evidence. Even diaries, business records and journals, all of which may be written by the defendant, are admissible at trial pursuant to the Fifth Amendment.[199] The only evidence that is shielded by the privilege against self-incrimination is testimonial evidence made by the defendant to authorities or in the context of a judicial or administrative proceeding of some sort. The admission of EDR data simply does not run afoul of the Fifth Amendment.

Moreover, it is well-established that the protection against self-incrimination applies only to criminal, not civil cases.[200] Thus, whether in pre-trial discovery or cross-examination at trial, the Fifth Amendment cannot be used to shield testimony or evidence to be used in a civil proceeding. The only caveat is that the defendant may not be forced to make statements in a civil trial that might incriminate him in a future criminal proceeding. For

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[195] *See generally*, Allen, Kuhns & Stuntz, Constitutional Criminal Procedure (3rd Ed. 1995); LaFave, Israel & King, Criminal Procedure (3rd Ed. 2000).

[196] 384 U.S. 757 (1966).

[197] Id., at 761.

[198] *Malloy v. Hogan*, 378 U.S. 1 (1964).

[199] See *Fisher v. United States*, 425 U.S. 391 (1970) (reasserting that the Fifth Amendment does not protect written documents).

[200] See, e.g., *Hoffman v. United States*, 341 U.S. 479 (1951) (articulating the standards under which the privilege may be invoked).

example, in the celebrated O.J. Simpson civil trial, the plaintiffs were able to put Simpson on the stand and cross-examine him because he had already been acquitted of murder and thus could no longer be subject to criminal prosecution.[201] In any event, EDR data would not constitute "testimony" for Fifth Amendment purposes.

5.8 The Federal Rules of Evidence and the Use of EDR Data at Trial

The Federal Rules of Evidence ("FRE") are the rules by which courts control information presented to the fact-finder (normally, the jury).[202] These rules determine, among other things, what information is relevant for the jury to hear and to consider. Courts would almost certainly treat information recorded by EDRs no differently than information recorded by other reliable means used for discovery and admission of evidence. Although it is true that discovery criteria and admissibility thresholds vary from jurisdiction to jurisdiction, there appears to be a general consensus that electronically recorded data should be treated no differently from so-called hard copy documents.[203]

The Federal Rules of Civil Procedure ("FRCP"), which govern the admissibility of evidence in federal court and serve as a model for many of the states, are quite liberal in permitting the introduction of evidence at trial. Pursuant to those rules, "[p]arties may obtain discovery regarding any matter, not privileged, which is relevant to the subject matter involved in the pending action."[204] Ordinarily, a Rule 34 Request for Production of Documents is the way in which electronically recorded evidence is discovered. It provides:

> [a]ny party may serve on any other party a request (1) to produce and permit the party making the request . . . to inspect and copy, any designated documents, (including writings . . . and other data compilations from which information can be obtained, translated, if necessary, by the respondent through detection devices into reasonably usable form)… [205]

[201] *Rufo v. Simpson*, 103 Cal.Rptr.2d 492 (Cal. App. Ct., 2001).

[202] This applies strictly to federal courts. State courts, of course, have their own rules of evidence; although, as a practical matter the state rules are generally quite similar to those used in federal courts.

[203] Donald C. Massey, Proposed On-Board Recorders for Motor Carriers: Fostering Safer Highways or Unfairly Tilting the Litigation Playing Field?, 24 S. Ill. U. L. J. 453 (2000).

[204] Fed. R. Civ. P. 26(b)(1).

[205] Fed. R. Civ. P. 34. The Advisory Committee on Federal Rule 34 specifically considered evolving technology, and particularly, computer generated documents. It stated: [t]he inclusive description of documents is revised to accord with changing technology. It makes clear that Rule 34 applies to electronic data compilations from which information can be obtained only with the use of detection devices, and that when the data can as a practical matter be made usable by the discovering party only through respondent's devices, respondent may be required to use his devices to translate the devices to translate the data into usable form. In many instances this means that respondent will have to supply a print-out of computer data. Fed. R. Civ. P. 34, *1970* Advisory Committee Note.

As part of routine trial preparation, courts will impose a duty on litigants to produce electronic data that is otherwise subject to discovery.[206] Indeed, Federal Rule of Evidence (FRE) 1001, expressly observes that written documents may be electronically stored. [207]

Whether EDR data would be discoverable and ultimately admissible in a civil proceeding would be governed by the boundaries of what is discoverable and the parameters of admissibility in a given jurisdiction. However, as a general rule, anything that is not privileged and relevant to the subject matter involved in the pending action may be discovered in a civil proceeding.[208] It is obvious that such data is not privileged, nor would it be reasonable to argue that the data would be irrelevant. Standards for relevancy are broad. Relevant evidence is simply that which tends to prove or disprove any fact at issue in a case.[209] EDR data, generated immediately prior to and contemporaneous with an accident, would plainly be probative of any facts at issue in a trial of this sort. Nevertheless, there are several issues that must be considered. Special rules apply to testimony presented by so-called experts—individuals who were not themselves fact-witnesses, but because of special training and/or experience may be able to assist the jury in its deliberations. A defining feature of *expert* testimony is that the personal knowledge requirement is suspended. A qualified expert may testify to matters not within the expert's personal sensory experience, and to opinions not ultimately based on personal knowledge.[210] Therefore, not only may experts testify based on hearsay reports of sensory observations made by others but, in principle, experts may also testify to propositions not based on anyone in particular's sensory observations.

The theories that experts may bring to bear are not confined to their particular expertise. Indeed, they may testify *as experts* only if they can claim *scientific, technical,* or other *specialized* knowledge that will help the jury to understand the evidence or determine a fact in issue. Under Fed. R. Evid. 702, this specialized knowledge may be derived from experience, training, or education. The issue of whether the expert possesses specialized knowledge thus derived—i.e., whether the expert is *qualified*—is decided, in the first instance, by the trial court in its sound discretion. Once qualified, Rule 702 says that experts may offer testimony concerning their expert knowledge "in the form of an opinion or otherwise."[211] The rules permit an expert to testify to general scientific or technical principles, leaving their application to the jury.

5.8.1 The Daubert Test

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[206] Fed. R. Evid. 1001(1). Rule 1001 provides that a "writing consists of letters, words or numbers, or their equivalent, set down by . . . magnetic impulse, mechanical or electrical recording, or other form of data compilation." Id. Moreover, an original of a writing "is the writing or recording itself or any counterpart intended to have the same effect by a person executing or issuing it . . . ." Id.

[207] Id.
[208] See Fed. R. Civ. P. 26(b)(1).
[209] *See generally* Fed. R. Evid. 401.
[210] See Fed. R. Evid. 702.
[211] Fed. R. Evid. 702

For many years, the admissibility of expert scientific evidence was governed by a common law rule of thumb known as the *Frye* test, after a 1923 decision by the United States Court of Appeals for the District of Columbia in which it was first articulated.[212] Under the *Frye* test, expert scientific evidence was admissible only if the principles on which it was based had gained "general acceptance" in the scientific community.[213] Despite its widespread adoption by the courts, many viewed this "general acceptance" standard as unduly restrictive because it sometimes operated to bar testimony based on intellectually credible but somewhat novel scientific approaches. In *Daubert*, the Supreme Court was asked to decide whether the *Frye* test had been superceded by the adoption, in 1973, of the Federal Rules of Evidence.[214] In particular, Fed. R. Evid. 702 broadly governs the admissibility of expert testimony and it simply provides that: "If scientific, technical, or other specialized knowledge will assist the trier of fact to understand the evidence or to determine a fact in issue, a witness qualified as an expert by knowledge, skill, experience, training, or education, may testify thereto in the form of an opinion or otherwise."

The majority opinion in *Daubert*, authored by Justice Blackmun, held that Rule 702 did supersede *Frye*.[215] This did not mean, however, that all expert testimony purporting to be scientific was now admissible. Rather, Rule 702 required that the testimony must be founded on "scientific knowledge." This implied, according to the Court, that the testimony must be grounded in the methods and procedures of science and would possess the requisite scientific validity to establish evidentiary reliability.[216] Furthermore, the Court held that the testimony must be sufficiently tied to the facts of the case.[217]

5.8.2 EDRs and the Daubert Evidence Admissibility Test

Although the data itself recorded by EDRs would be treated no differently than any other document for purposes of discovery, there might be an issue with respect to the data's accuracy and reliability. In assessing the reliability of scientific expert testimony, the *Daubert* Court gave future trial courts a number of factors to consider.[218] Those factors

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[212] *Frye v. United States,* 54 App.D.C. 46, 47 (1923).

[213] *Id.* It is important to note that some states continue to use variations of the *Frye* test. In *Bachman v. Gen. Motors Corp.*, 332 Ill. App.3d 760 (Ill. 2002), the Appellate Court of Illinois applied the Frye test in permitting the admission at trial of evidence gathered from an air bag sensor. The appellate court concluded that the process of recording and downloading the air-bag sensor data proved no bar to admissibility under Frye.

[214] *Daubert v. Merrell Dow Pharmaceuticals, Inc.*, 509 U.S. 579 (1993).

[215] *Id.*

[216] *Daubert*, 509 U.S. 579 (1993).

[217] *Id.* It is important to note that many states still use *Frye*-type tests.

[218] *See* Fed. R. Evid. 702 (Advisory Committee's Note to 2000 Amendment).

included (1) whether the expert's technique or theory can be or has been tested-that is, whether the expert's theory can be challenged in some objective sense, or whether it is instead simply a subjective, conclusory approach that cannot reasonably be assessed for reliability; (2) whether the technique or theory has been subject to peer review and publication; (3) the known or potential rate of error of the technique or theory when applied; (4) the existence and maintenance of standards and controls; and (5) whether the technique or theory has been generally accepted in the scientific community.[219] This final factor is essentially a restatement of the *Frye* rule; although *Daubert* makes clear that it is only *one* factor to be subjectively considered by the judge.[220]

An important element that trial judges must use to determine the admissibility of expert testimony is whether the expert's theory can be challenged in some objective sense.[221] Thus, it will be important for EDR manufacturers to make information available concerning the reliability of their devices. If third parties may test the device itself, and if the relevant scientific community accepts the accuracy and reliability of such devices, there should be no legal constraints on the admissibility of EDR data.[222] In fact, Rule 702 is sufficiently broad that it may allow contradictory expert testimony that is the product of competing principles or methods in the same field of expertise.[223] Thus, while an automobile manufacturer might call an expert to testify to the precision of its data, opposing counsel can attempt to impeach the testimony by offering its own analysis. Rule 702 allows all of this evidence to be adduced at trial, and then permits the trier of fact to determine its legitimacy.

In *Harris v. General Motors Corporation*,[224] for example, the United States Court of Appeals for the Sixth Circuit reversed a decision of summary judgment for the defendant because it had been based solely on a GM engineer's interpretation of crash data collected from an EDR. GM filed a motion for summary judgment relying on the engineer's testimony that, based upon his interpretation of the EDR data, the air bag had properly deployed. The engineer's interpretation of the data contradicted both the driver's and the passenger's testimony, that the driver was injured because the air bag deployed late. The trial court not only admitted the testimony based on the EDR data, but

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[219] *Daubert, 509 U.S. at 593-94.*

[220] *See generally* Daubert, 509 U.S. 579 (1993).

[221] *See* Fed. R. Evid. 702.

[222] *See Daubert,* 509 U.S. at 594 (describing how the varying factors applied by judges were neither exclusive nor dispositive).

[223] *See generally* Fed. R. Evid. 702 (The 2000 Amendment provides that an expert may testify when such testimony is derived from sufficient data.). See, e.g., *Heller v. Shaw Indus., Inc.,* 167 F.3d 146, 160 (3d Cir. 1999) (describing how expert testimony cannot be excluded simply because the expert uses one test rather than another, when both tests are accepted in the field and both reach reliable results); *Ruiz-Troche v. Pepsi Cola,* 161 F.3d 77, 85 (1st Cir. 1988) (holding that "Daubert neither requires nor empowers trial courts to determine which of several competing scientific theories has the best provenance").

[224] 201 F.3d. 800 (2001).

granted GM summary judgment on that basis. The lower court applied the "physical facts" rule[225] to conclude that the plaintiff's *could not* have been correct based upon the indisputable physical facts of the case. Explaining that it had failed to unearth any cases dealing with the interpretation of EDR data, the Court of Appeals held that "the [EDR] data suggests that the air bag deployed properly; it does not establish beyond factual dispute that the airbag could not have deployed belatedly in the manner" the plaintiff contended.[226] Because the court found the record devoid of any demonstration that GM had proved the reliability of its engineer's testimony beyond factual doubt, the court remanded the case to the trial court for a hearing on admissibility.

The admissibility of information gathered from EDRs in the courtroom would almost certainly be admissible under the *Daubert* test. As the Court held in *Daubert*, any information grounded in the methods and procedures of science that possesses the requisite scientific validity to establish evidentiary reliability pertaining to the case at hand was admissible.[227] By way of offering further guidance, the Court noted the availability of other mechanisms of judicial control, including summary judgment and the ability to exclude confusing or prejudicial evidence under Fed. R. Evid. 403, were adequate means to ensure that only relevant, credible evidence would be presented to the jury.

5.9 Conclusion

In our opinion, the USDOT may have the authority to require installation of EDRs if it is demonstrated that they improve highway safety or advance other significant public policy interests. Although the legal authority may exist, that does not mean that the public will necessarily accept the implementation of such devices—particularly if it is felt that EDRs trench upon legitimate privacy interests.

Although the privacy concerns are doubtless serious, they are not insurmountable. First, police may properly seize EDRs without a warrant during post-accident investigations, either because seizure of a required safety device does not constitute a "search" implicating the Fourth Amendment or, in the alternative, because seizure of a safety device qualifies under one of the exemptions for conducting warrantless searches. In other, non-emergency situations, however, police may need to obtain a warrant before seizing the data—at least insofar as the data is intended to be used in a criminal investigation and a privacy interest in the data continues to be recognized. It is possible, as the *Kyllo* Court appears to suggest, that if the downloading and use of EDR data becomes sufficiently widespread and routine, individuals may no longer have a reasonable privacy interest in the data.

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[225] The so-called physical facts rule disallows testimony "which is opposed to the laws of nature, or which is clearly in conflict with principles of science, [and] is of no probative value . . . ." *Lovas v. Gen. Motors Corp*., 212 F.2d 805, 808 (6th Cir. 1954). Such testimony, "which is positively contradicted by the physical facts cannot be given probative value by the court." *Ibid*.
[226] Id., at 804.

[227] *Daubert*, 509 U.S. 579 (1993).

Second, although the data (and the recorder itself) is in all likelihood "owned" by the automobile's owner, it may almost certainly be used as evidence against the owner (or other driver) in either a civil or a criminal case. The Fifth Amendment's privilege against compelled self-incrimination will not shield the data from being introduced at trial. Nor will it be possible to prevent adverse civil litigants from obtaining the data as a matter of routine pre-trial discovery. Of course, depending upon the nature of the data collected, Congress (or the individual states) could choose to privilege the use of the data, but that seems quite unlikely. In reality, the only real obstacle to the use of EDR data in court would either be a demonstration that the devices themselves, or the decoders used to download the data, were consistently inaccurate and unreliable, or if shown that automobile owners could tamper with the devices, thereby rendering the data unusable. However, courts have a long history of creating remedies for the spoiling of data, and similarly, laws could be created that criminalize the willful destruction or alteration of EDR data.

Finally, it is worth noting that some concerns may be mollified if insurance companies or the car manufacturers themselves take active steps to provide individual purchasers / insurers with incentives to waive any interests they may have in the EDR data. For example, insurers could premise policy decisions on whether a consumer agreed to allow the company unimpeded access to the data. Similarly, insurers could provide discounts to such consumers in exchange for their waivers. Automobile manufacturers could require purchasers to agree to permit them to review data in the event of an accident, either for safety engineering purposes or to protect the company from potential lawsuits. Private solutions to these potential problems no doubt exist; these are only a few of the possible avenues that could be taken to ensure that EDR collected data are easily recovered.

6. Public Acceptability of Event Data Recorders

6.1 Background

Paralleling the legal issues of Event Data Recorders (EDRs) are concerns over consumer acceptability. For example, a recent class action suit, filed in New Jersey, alleged that General Motors never told owners of their vehicles that EDRs were installed [USA Today, 2000]. A consumer revolt against the installation of EDRs could negatively impact sales and/or lead many manufacturers to offer owners the option to turn off their EDRs or even to stop installation of them altogether. These options would seriously limit the amount of EDR data collected for research by personnel in law enforcement, insurance, government, manufacturing, and education.

The objective of this portion of the research project was to determine the public awareness and level of acceptance of Event Data Recorders. The consumer acceptability study was conducted in two phases. In the first phase, a survey was mailed to a large sample of licensed drivers. In the second phase, focus groups were conducted, with a smaller sample of licensed drivers, to follow-up on the survey. The survey was mailed in the spring of 2003 to 10,000 persons. The focus groups, held in February 2004, were comprised of 18 persons.

6.2 Consumer Survey

A survey was designed to measure the attitude of the public toward Event Data Recorders and mailed to 10,000 licensed drivers. A copy of the questionnaire and cover letter is provided in the appendices. As a means of simplifying this issue for a non-technical public, the term 'Event Data Recorder' (EDR) was replaced with the term 'Crash Data Recorder' (CDR). The results, which follow, will use the term CDR rather than EDR. The survey focused on the following major areas:

- Awareness of CDRs
- Thoughts on CDR Installation
- Legal Issues Regarding CDRs
- Access to CDR Data
- Impact of CDRs on Driving Habits
- Impact of CDRs on Purchasing Decisions

The survey also provided the opportunity to examine how opinions in these critical areas varied with age, gender, ethnicity, and safety record of the respondents.

6.2.1 Research Method

The questionnaire was designed based on the findings of a pilot study conducted in spring 2001 by Dr. Berhe Habte-Giorgis of the Department of Marketing in the College of Business Administration at Rowan University in Glassboro, New Jersey. The pilot study identified the factors that should be investigated in the study. The survey sent to the public was designed after extensive consultation with the Project Panel and the Expert Advisory Group. In addition, the opinion of stakeholders in the study, primarily automakers, government agencies, and other associations and interested organizations, was obtained by circulating a draft of the questionnaire.

A sample of 10,000 licensed drivers was selected from a mailing list maintained by a commercial supplier. A mail survey was the preferred method of collecting data because of the need to get the data from a large number of subjects located all over the country at reasonable cost and within a limited time. Mailing of the questionnaire was preceded by a postcard informing the subjects of the upcoming questionnaire. The questionnaire was mailed to the selected sample members with a self addressed and stamped return envelope. Twenty questionnaires were returned for non-delivery and ten questionnaires were discarded because they were not correctly completed. In the end, there were 790 usable questionnaires. Each returned questionnaire was edited for error and deliberate bias. Data were entered into a standard statistical package for analysis.

6.2.2 Analysis of the Data

Demographics: The most typical type of respondent to this survey was an older, wealthier, white male. The male respondents outnumbered the female respondents by two to one as shown in Figure 6-1. Almost half of the respondents were middle-aged, 40 to 59, as seen in Figure 6-2. The average household income level of the respondents was somewhat higher than national averages with the mean, median, and mode all in the $30,000 to $69,999 range. Figure 6-3 shows the distribution of household incomes. Most respondents were Caucasian (86%) followed by 5% Black/African American, 3% Hispanic/Latino, and 2% each Native American/Alaska Native, Asian/Pacific Islander, and other as shown in Figure 6-4. All fifty states and Washington, D.C., were represented. Just over half of the respondents lived in a suburban or rural area. Almost one-third of the respondents had children at home who were not of driving age and one in five respondents had children of driving age living with them.

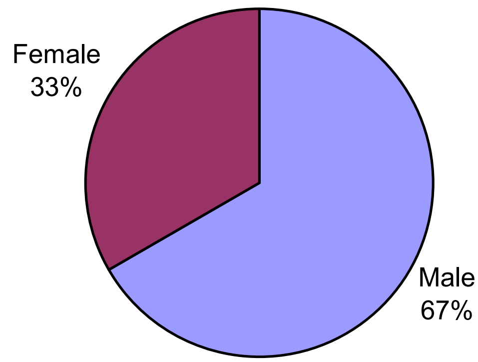

Figure 6-1. Gender Differences

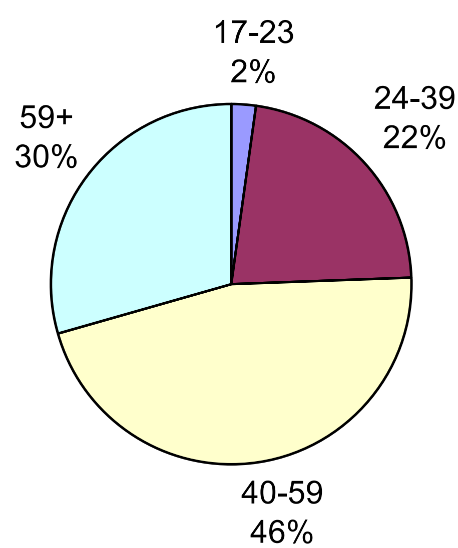

Figure 6-2. Age Distribution

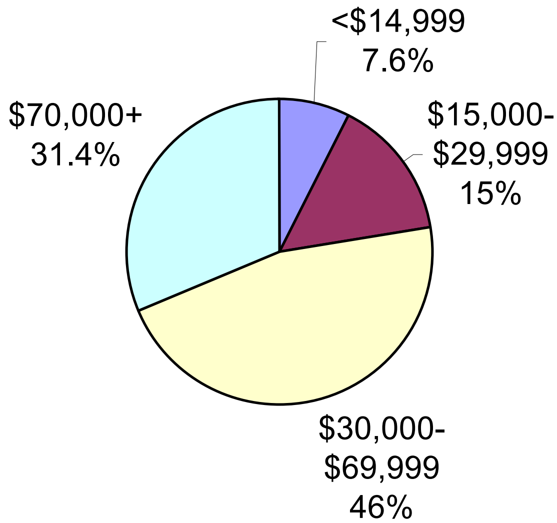

Figure 6-3. Distribution of Household Annual Income

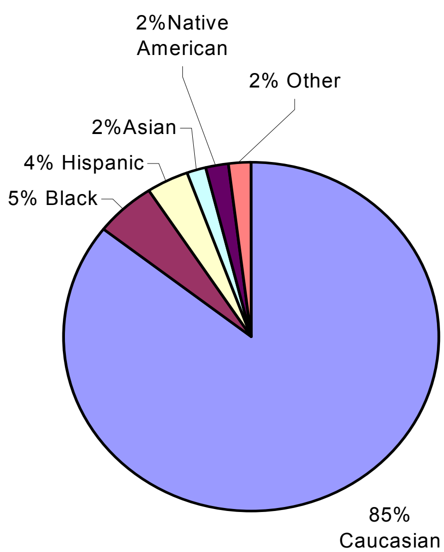

Figure 6-4. Ethnicity Distribution

General Motors, Ford, and Chrysler were, by far, the most popular makes of the vehicles driven most frequently by the respondents. The model years of their cars ranged from

1952 to 2003 with 1999 being the most common year cited and the 1996-1997 era vehicles as typical. Only one in five respondents indicated they planned to purchase a car within the next two years. Although the characteristics of our sample are not necessarily representative of the national population, they do tend to represent persons most likely to be primarily in charge of buying cars for the household.

Driving Habits: Seventeen percent indicated they never or only sometimes wear a seatbelt when riding in a car. Men were disproportionately more likely to say they did not always wear seatbelts. Most respondents, 85%, had no non-parking traffic citations/tickets in the last three years and the same percentage had not been in any traffic accidents resulting in vehicle damage of more than $500 during the last three years. Most respondents, 79%, indicated they drive their own car to work. Three percent primarily use public transportation and less than one percent car pool. Presumably, the other 18% either are unemployed, walk to work, or work at home.

CDR Awareness: The survey results indicated that level of awareness about the CDR and its application is fairly low. One third of the respondents indicated they had heard about CDRs in vehicles prior to receiving this survey as shown in Figure 6-5. This matches data obtained by the Insurance Research Council in 2002 in which two-thirds of car buyers were unaware of these devices [Oldenburg, 2003]. Less than 1% reported having a CDR in their vehicle. However, only eight percent indicated they knew how to determine if there was a CDR in their vehicle. Three percent knew of an automobile crash in which CDR data were used to determine the cause of the accident.

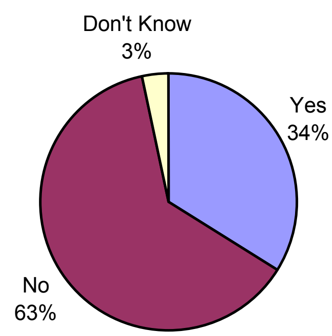

Figure 6-5. Response to “I have heard about CDRs in vehicles prior to receiving this survey”.

When developing the survey, we suspected that many vehicle owners would not know that their car already contained a CDR. In addition to asking participants whether their car had a CDR, the survey also asked the participants what car they drove. We knew from earlier work on this project that all GMC vehicles (GMC, Pontiac, Chevrolet, Oldsmobile, Buick, and Saturn) manufactured since the 1996 model year have a CDR already installed. As shown in Table 6-1 below, our suspicion was confirmed. Nearly two-thirds of all GMC vehicle owners with CDRs already installed told us that their vehicle did not contain a CDR.

Table 6-1. Response to "I have a CDR in my vehicle" from owners of 1996-2003 GMC vehicles known to have CDRs installed

Response to "I have a CDR in my Vehicle"	Number	%
Yes	3	2
No	93	65
Don't Know	47	33
Total	143	100

Installation of CDRs: A substantial number of respondents thought that installation of CDRs should be an option left to the prospective vehicle owner, not vehicle manufacturers as shown in Figure 6-6. Caucasian respondents, who made up most of the total respondents, thought that it is not acceptable for their vehicles to be equipped with a CDR without their knowledge. However, among ethnic minority groups, a majority of respondents, 52%, reported it would be acceptable for CDRs to be installed without their knowledge. Two-thirds of respondents thought CDR installation should be optional equipment. Only 47% thought they should be standard equipment. Five types of respondents held different views from the majority of respondents: women, minorities, lower income, seat belt wearers, and those who had not heard of CDRs.

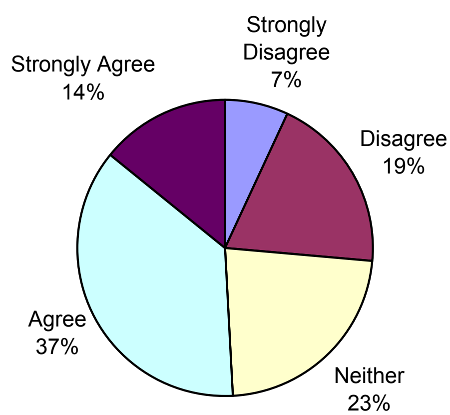

Figure 6-6. Response to the statement "The installation of a CDR should be an option left to the prospective vehicle owner"

Legal Aspects of CDRs: A slim majority of respondents, 51%, tended to think that there should be a law requiring all new cars to be equipped with CDRs. However, certain groups of respondents indicated significant differences in opinion. Those individuals who were more likely to support such a law included those who were unaware of CDRs before this survey, seatbelt wearers, of lower income, women, and/or minorities. This finding perfectly supports the finding regarding installation that these same groups thought CDRs should be standard equipment. A slim majority of respondents overall, 57%, think use of CDRs is not an invasion of their privacy. Although those who had not heard previously about CDRs and those who do not always wear seatbelts were much more likely to think CDRs are an invasion of privacy. All groups of respondents tended to report (77%) that, if vehicles have CDRs, use of data should be regulated by law.

Access to CDR Data: One of the biggest concerns about CDRs was access to the data. The questionnaire included a series of questions pertaining to various groups who could conceivably want access. More than half of respondents agreed or strongly agreed that each of the six groups in question should have access. The range was highest with owner at 87.1%, law enforcement with 70.5%, vehicle manufacturers with 65.2%, government researchers with 63.3%, and just 53.8% saying rescue and medical personnel should have access. Following this pattern, 56.4% of respondents thought that CDR information belongs to the vehicle owner. However, even though a majority of respondents thought the information belonged to them, only 44% thought vehicle owners should be able to remove a CDR on their car if already installed and only about one third thought vehicle owners should be able to turn a CDR on or off. In fact, 17% of respondents said the data belong to them, but they should not be allowed to turn off the CDR. Eleven percent who said the data belonged to them, said they should not be allowed to remove the CDR altogether.

Acceptability of CDRs by Vehicle Owners: Drivers were asked what kinds of factors regarding CDRs and data would make CDRs more acceptable to vehicle owners. A two-thirds majority of respondents thought that if vehicle owners were permitted to view CDR data, CDRs will be more acceptable. Almost half thought that allowing researchers but not law enforcement officials to access the data will make CDRs more acceptable. Finally, just under half thought that allowing vehicle owners to turn off some CDR elements such as vehicle speed or allowing vehicle owners to delete recorded data altogether will make CDRs acceptable. A notable minority of around one-quarter each was neutral on these four items.

Perceived Benefits of CDRs: In general, respondents tended to perceive that CDRs could be beneficial. For example, CDRs could help in crash investigation such as in determining who was at fault in the event of a collision. Many respondents thought insurance fraud could be reduced by use of CDR data (77%) and that CDR information could lead to improved road and vehicle safety (78%) and reduced insurance costs (55%). However, most drivers (70%) indicated that they, themselves, would not be more cautious while driving with a CDR in their own car. Finally, a small majority of respondents, 60%, thought that CDR information could also help emergency medical response teams.

Again, some groups of people held slightly different views than the majority. For example, the only group to report that they would drive more cautiously as a result of CDRs was the lowest income category. Persons of higher income status were much more likely than the lower income groups to report that CDRs would not make them more cautious in their driving. Income again was a factor in whether respondents thought CDRs would reduce insurance costs such that the highest income group were the only ones who thought CDRs would not reduce costs. Respondents with children of driving age in their household also did not think CDRs would lower insurance rates. As far as whether CDRs would help emergency medical response teams, only those who had not previously heard about CDRs tended to think the teams would benefit.

6.2.3 Summary of Survey Results

- Most respondents were unaware of CDRs and their use.
- Most respondents saw considerable benefits of CDRs such as in crash investigation, lowered insurance rates, encouraging safer drivers.
- Most respondents would prefer CDRs and their use to be optional.
- Most respondents had some concern about access to CDR data (i.e., who has access and how data are used).
- Opinions were reasonably consistent across demographics, but older, wealthier, Caucasian men were more concerned about control issues.

6.3 Focus Groups

The survey analysis led to a desire to meet with drivers face-to-face (i.e., in a focus group) to conduct qualitative analysis on the public perception of crash data recorders. As a follow-up to the survey, eighteen licensed drivers with a demographic breakdown similar to that of the United States were gathered together in a focus group format to discuss their perceptions of crash data recorders.

6.3.1 Focus Group Study Leader

Dr. Heidi L. Newell, who analyzed the survey results, served as the coordinator for the focus groups. Ms. Alana DeSimone, mechanical engineering student at Rowan University, served as an assistant to the coordinator. She was a research assistant working with the Principal Investigator, Dr. Hampton C. Gabler, on the technical aspects of this research program.

6.3.2 Subjects

A stratified representative sample of twenty licensed drivers with at least one vehicle being used in their household and who live within a twenty minute drive from the campus of Rowan University in Glassboro, New Jersey, were selected. The invitation list included an equal number of men and women. Five participants were African American, Hispanic, or Asian. In terms of the four age group categories used in the survey, the invitation list included four persons ages 17 to 23, four persons ages 24 to 39, eight persons ages 40 to 59 and four persons ages 60 and older. Fifteen persons of the invited sample had children, either living at home or adult children outside the home; five had no children. Persons from a variety of occupational backgrounds participated in the focus groups including, for example, a librarian, a homemaker, a contractor, a physical therapist, a computer technician, a construction worker, a businessman, and a student. The sample was asked to participate in the study, via telephone. A cover letter describing the project and directions/maps to campus were sent to participants. A copy of the cover letter is contained in the appendices. Some persons included in the original sample were unable to participate and substitutions were made in all but two cases in which the researcher did not have sufficient notice to substitute. Therefore, there was a total of 18 participants, 9 in each session. The demographic breakdown of actual participants was as follows:

Table 6-2. Demographic Breakdown of Focus Group Participants

Age	N	Ethnicity	N	Gender	N	Children	N
17 to 23	3	Caucasian	13	Women	9	With	14
24 to 39	3	African American	2	Men	9	None	4
40 to 59	8	Hispanic	3				
60+	4						

Each subject was given an honorarium to participate payable upon full completion of the focus group session.

6.3.3 Format

The focus groups were held in a conference room in Rowan Hall on the campus of Rowan University in Glassboro, New Jersey. Participants were asked to sit around a large, square table designed to seat twelve comfortably. The first focus group was held on Wednesday, February 11, 2004, and the second on Thursday, February 12, 2004. Both sessions began at 7:00 p.m. and ended by 8:30 p.m. The first fifteen minutes were designated for getting nametags and dessert as well as becoming acquainted with one another. Then, focus group participants were given a few minutes of instruction about how the focus group would be run. The session itself lasted about an hour.

The session was recorded on audiotape for subsequent transcription. Also, the leader's assistant typed key thoughts on her lap top computer.

6.3.4 Questions

The questions were piloted with a select group of Rowan University engineering faculty and members of the general public prior to the actual focus group sessions to make sure they were clear, sufficient, and would fit within the time allotted.

The subjects were told that the leader would ask questions and record the answers, but would not participate in the answer dialogue so as not to influence the discussion. Subjects were asked to freely express their thoughts and opinions. They were told that it was acceptable to disagree with someone else, but that they had to be respectful of others' ideas. They were told that they did not have to answer any given question if they felt uncomfortable doing so. They were encouraged to express a level of agreement to disagreement with another's ideas even if they did not have anything more to add. They were not given any other information about CDRs other than what appeared in the cover letter.

Listed below are the basic questions asked:

- What is your initial reaction to Crash Data Recorders?
- Had you heard of Crash Data Recorders for personal vehicles before you learned about this study?
- Which vehicles do you know currently have CDRs installed?
- Have you ever been in a car accident? Were data from CDRs of any of the cars involved used? How did you feel about that usage?
- What is your reaction to each of the pieces of data they can now record? For example, vehicle speed, seatbelt status, braking, seat position, air bag deployment…
- Would you buy a vehicle with a CDR already installed? Why or why not?
- If a CDR were already installed in a vehicle you were considering purchasing, would you go to another dealer to buy a vehicle without a CDR? Why or why not?
- Would you prefer a vehicle with a CDR already installed? Why or why not?
- Who should have access to your vehicle's CDR data?
- On the scale "personal privacy vs. public safety", which way do you lean?

- How would your driving habits change if there were a CDR in your car or wouldn't you change?
- How would you react if the federal Department of Transportation (USDOT) passed a law requiring that CDRs must be installed in all new vehicles?
- How would you feel if the police (or other governmental accident investigators) had the right to collect data without a warrant during post-accident investigations? During traffic violation stops?
- How would you feel about usage of CDRs in vehicles like busses, taxis, and rental cars?
- Whom do you think would benefit the most from CDRs?
- Some of our survey respondents responded that emergency medical response teams would not benefit from those data. Do you think they would or would not and why?
- Would use of CDRs be detrimental to anyone?
- How do you think CDR data could help design safer cars?
- In what ways could/should CDR data be used in a legal proceeding?
- How would you feel about CDRs being used with teenage or other new drivers?
- How do you think CDRs and their data would impact cost in terms of vehicle manufacturing and insurance rates?
- Our survey asked respondents what kinds of things car manufacturers could do to make CDRs more acceptable to vehicle owners such as giving drivers the option to remove it or turn some of it off. What are some other things that could be done?
- A small number (between 11 and 17%) of our survey respondents said that CDR data belonged to vehicle owners, but owners should not be allowed to turn off the CDR or remove it altogether. What are your thoughts on this position?
- If you could talk to auto manufacturers about CDRs what would you tell them?
- If you could talk to lawmakers about CDRs what would you tell them?
- What other opinions do you have about CDRs that were not mentioned in this focus group? That is, what didn't I ask you?

- Now that you've participated in this focus group, how has your initial reaction to CDRs changed?

6.3.5 Qualitative Analysis

Preconceptions: About one-third of the participants had heard of crash data recorders (CDRs) before they were invited to participate in the focus group. Most of those who were familiar with CDRs were men. The participants' initial reactions to CDRs tended to fall into one of two categories and correlated roughly with gender: the men were most interested in what CDRs were going to cost them in terms of increased vehicle purchase price and car insurance whereas the women were most interested in how CDRs would improve vehicle safety for them and their loved ones. The men were also more curious about what specific data are currently being recorded by CDRs and what is planned for the future. Most respondents were initially very excited and had positive feelings before the discussion got going. When asked if they knew which vehicles currently had installed CDRs, subjects tended to report public transportation vehicles, commercial vehicles, and "high-end" personal cars such as SUV's (by type) and Lexus, Cadillac, and Mercedes (by name). Although several participants had recently been involved in car accidents, none knew of involvement of CDR data in their post-accident investigations.

Reaction to Types of Data Recorded by CDRs: In general, subjects tended to accept recording of driving-related factors that they felt they were executing properly anyway, but were a little bit skeptical of things that they might be "caught" not doing properly at least some of the time.

- *Vehicle Speed* – most subjects would not object to vehicle speed being recorded and some thought that this might help the perceived speeding problem in this geographical area. One senior citizen woman was focused on safety and said that CDRs could help monitor driving habits. Another younger woman thought it could help monitor vehicle speed, in particular. However, a few subjects were concerned that they could be cited for speeding even if they were "only going a few miles over the limit" whereas a police officer "probably would not issue a ticket without the CDR data." One young, Hispanic man was very concerned that CDRs would "take away his right to make decisions" and that he "would not have the same freedom as before," indicating that he thought the "freedom" to drive a few miles over the limit was important to him.

- *Seatbelt Usage* – Recording whether the driver and passenger(s) were wearing seatbelts was not of concern to these drivers, but they reported that they generally wear seat-belts. Those who did not wear seatbelts all the time admitted that they knew they should being doing so and that knowing CDRs were recording their status might encourage them to buckle up. A middle-aged woman worried that she might suffer negative consequences if her car's CDR data showed that she had unbuckled her seatbelt only temporarily to retrieve an item and, then, rebuckled.

- *Braking* – Subjects did not object to the CDRs recording their braking behavior and reported that they believed they tended to brake properly.

- *Seat Position* - As with braking, subjects believed their seats were properly positioned so this would be a non-issue to them. A middle-aged man thought that perhaps some drivers and/or passengers position their seats too far forward and the CDR data might show them that.

- *Airbag Deployment* – Subjects were most accepting of this piece of data being recorded because they viewed that this was not under their control as a driver. Following up on a comment about seat position, the middle-aged man thought that if airbags are injuring people because they are sitting too close to the airbag storage area when the airbag deploys, this type of CDR data would be a major positive use.

<u>CDR Impact on Vehicle Purchasing</u>: Most subjects reported that they would buy a vehicle with a CDR already installed as long as it did not increase the purchase price. Some of the men expressed a desire to first learn what their CDR is recording and how these data would be used. One woman said that she would buy a car with a CDR installed if the extra cost were reasonable. None of the subjects said they would avoid buying a vehicle with a CDR installed, again unless that meant a higher cost. Although these drivers would not avoid cars with CDRs and would buy vehicles with CDRs, no one seemed to want to seek out a car with a CDR installed. One participant said CDRs would not be a "selling-point" as are some other features available in vehicles because he saw it as a tool for the auto manufacturers and not vehicle buyers. Some of these drivers, mostly the men, said they did not see the benefit in having a CDR installed.

<u>CDR Data Access</u>: Most respondents tended to think that it was acceptable for car insurance companies to have access to CDR data and some thought the police investigating an accident could have access. One woman mentioned personal attorneys representing car accident victims as deserving of data access and a man mentioned car repair personnel. One notable factor with the issue of data access is that these drivers did not seem to think that auto manufacturers should have access to their data. The other notable factor is that these drivers were more in favor of access in accident cases and, generally not much in favor in the case of police stops for traffic violations.

<u>CDR Impact on Driving Habits</u>: These drivers tended to think they were already safe drivers so they thought CDRs in their vehicles would have little impact on their driving habits. They did tend to say they would probably "think twice" about their driving habits, at least initially, but may tend to forget about the presence of CDRs after awhile. These drivers were wholly in favor of CDRs being installed in all public transportation vehicles and commercial vehicles because they believed that this would lead to safer driving habits on the part of those transporting the public or the public's goods. School busses were cited first by both groups. Even though they would be driving rental vehicles, these drivers thought that rental car owners had the right to have CDRs installed to improve driver habits. The only concern expressed was to question to what extent recorded driving

habits in rental cars would be connected to individual drivers' records and possibly held against them.

Legal Aspects of CDRs: These drivers seemed to think that if a law were passed requiring CDRs be installed in new vehicles, they would have to accept it, but said that it would feel too much like "Big Brother is watching over them." Some, mostly men, thought it was an invasion of their privacy whereas the women tended to think having a CDR in their vehicles was not overly invasive. Some said that CDR data should be admissible in a court of law only if all vehicles involved in the crash had installed CDRs. The subjects said CDR data should not be the only piece of evidence submitted in a trial situation. Instead, CDR data should be treated somewhat like a human witness – just one perspective, the value of which could be weighed against other pieces of evidence. Participants were very concerned about the idea of being able to put CDR data into the context of the entire accident evidence situation and its evidence such that CDRs should not take away from the value of the human explanation. They were concerned that CDR data would be perceived by those weighing the evidence as "black or white" and they wanted the right to present evidence and explain what was happening outside of the CDR's parameters. However, if a case involved two or more parties who each had a plausible explanation, the CDR might "tip the scale" in favor of whose case had more weight. Another perceived benefit mentioned was in cases in which one or more of the parties was killed in the car accident and was, therefore, unable to testify on their own behalf such that the CDR data could "testify" as to what happened with their vehicle. Finally, one subject mentioned that CDRs could be valuable in cases involving a vehicle owner or his/her estate filing suit against the vehicle's manufacturer because it would be a so-called "neutral third-party." As with data access, these drivers thought that CDR data should be accessed only if they were being charged with a traffic violation or the post-accident investigators were assigning fault. A man said that "it was his vehicle and it would be unacceptable for the police to collect any CDR data without a warrant."

CDRs and Demographic Groups of Drivers: At first, most participants, especially those with their offspring driving vehicles on participants' insurance, thought that CDRs would be a terrific way to monitor those driving their vehicles. Some parents somewhat gleefully said it would allow them to find out what their teenage drivers were doing with the vehicle. A woman in the youngest demographic group said that she and her teenaged brother would have been more responsible drivers if they knew a CDR were installed in their parents' cars that they drove. A man in the oldest demographic group thought that although it sounded like a good idea, it would strain the level of trust between parents and their teenaged driver children. However, the older participants expressed concern that if CDRs could be used to monitor driving habits of groups like the very young drivers, then what would stop police from using CDRs to monitor driving habits of them as older drivers. One of the Caucasian men referred to the minorities in the room and worried that police might target them in a discriminatory fashion. Once this idea was expressed, the group became more serious and agreed that, perhaps, it would not be a good idea to start allowing authorities or others to track drivers based on demographic group. One person said it might actually help if it could be shown that certain groups of drivers are not any more likely to be at fault or violate traffic laws than any other group.

Perceived Beneficiaries of CDRs: Both focus groups listed auto manufacturers first as the primary beneficiary of CDR data followed by insurance companies. One group listed the "not-at-fault drivers" in accidents or traffic stops and the other group listed the manufacturers of the CDR devices themselves. Safety researchers and the general public were listed last and almost as an afterthought. If the CDR data could rightfully eliminate gray areas in court, all relevant parties would benefit by the decision being fair.

Perceived Detrimented Parties of CDRs: One group reported that poor drivers who were at fault would be negatively, but justly, impacted by CDRs. The other group said that the drivers in the right would be negatively impacted in cases in which another driver tampered with their own CDR and or its data, or in cases in which the device malfunctioned.

CDRs and Cost Benefit Analysis: It seemed that these participants were all in favor of safer cars, but they were not necessarily willing to pay for them. Some thought that CDRs would increase the purchase price of vehicles at least until CDRs became more common and/or required by law. Some thought that insurance costs would go down because blame would be assigned correctly more often, drivers would drive more safely, and CDR data might lead to safer cars and, thus, a lower rate/degree of injury and lower rate of deaths might occur. One woman thought that insurance companies might decide to raise the cost of insurance to policies with vehicles that did not have CDRs installed and lower them for vehicles with CDRs. Those in the lower socioeconomic status group worried that wealthier drivers would be able to better afford vehicles with CDRs and, therefore, persons of lower socioeconomic status would be discriminated against in terms of not being able to afford to buy safer vehicles.

CDRs and Designing Safer Cars: Participants were very supportive of the stated purpose of CDRs, that is, to design safer cars. The NHTSA also found that the public would be more accepting of CDRs if "the data are used to … improve the general cause of public safety" [NHTSA, 2002]. Participants reported that data recorded by CDRs might show something wrong with a vehicle such as evidence of structural failure, electrical problems, or braking problems – improving or correcting all of which could lead to safer cars. One woman thought that CDRs could "idiot-proof" the vehicles. A man thought that CDRs might help determine the vehicle's response and help drivers to become better drivers in conjunction with their vehicles' responses.

CDR Data and Usage Emergency Medical Personnel: The limited amount of pre-existing information and the complexity of this device led to failure to determine how Emergency Medical Personnel would benefit from usage of CDR data. One woman who is involved in administering physical therapy proposed that these data might provide insight into preventing injuries that were caused by problems with the vehicle and how it responded in an accident situation. One man said that EMTs are not in direct contact with the engineers who design cars so he did not see why EMTs should have the data.

Increasing the Acceptance of CDRs: The higher educated participants felt very strongly that they needed more information about CDRs so they recommended safety researchers launching an educational campaign targeted at car-buying and driver consumers to explain the benefits of CDRs. The NHTSA reported that General Motors believed that they could alleviate consumer fears "through honest and open communications to customers by means of statements in owners' manuals informing them that such data are recorded" [NHTSA, 2002]. All participants wanted to know specifically how vehicle owners would benefit. The mailed survey proposed giving consumers the option to remove the CDR or turn some of it off, but the focus group participants in both groups said that did not make any sense to them. They stated that the CDR should either be in the vehicle, fully functional, and recording, or not installed in the vehicle in the first place. The women participants suggested that if every vehicle had a CDR installed, CDRs would become more acceptable. The men participants suggested that car manufacturers should absorb the cost of installing CDRs if they want access to the data for their research. Insurance companies should use CDR data to lower rates for cars with them and for drivers whose CDR data show safe driving habits. One person suggested that CDRs could be used to establish a pattern of safe driving and this record could be used to subtract "points" against a driver. CDRs should record only data that are needed to make safer cars.

What Focus Group Participants Want Auto Manufacturers to Know: These drivers were asked what they thought they and other consumers might think about CDRs and would want auto manufacturers to answer about CDRs:

- Why do auto manufacturers want these data and what will happen to the data?
- How have CDRs already benefited manufacturers, vehicles, and the general public?
- What is legal for CDRs to record?
- What is the potential for additional cost if/when CDRs are installed in vehicles?
- How will manufacturers pay for this added expense without passing on the cost to consumers?
- What are CDRs recording and for how long are the data stored?
- How will CDR data benefit the general public?
- What steps would be taken to prevent CDR tampering?
- Consumers want all cars, not just high-end cars, to be as safe as they can be.

What Focus Group Participants Want Lawmakers to Know: When lawmakers are writing new laws about CDRs and their data, consumers want them to understand:

- The vehicle owner has a right to access these data.
- CDR data should be protected and steps must be taken to ensure privacy is respected.
- CDR data should not be used to discriminate against a particular demographic group.
- The level of authorized access should be limited to issues of safety.
- Auto manufacturers must inform the consumer whether a CDR has been installed in a vehicle and what it is recording.
- Lawmakers should decide what is legal for CDRs to record and hold auto manufacturers to just those pieces of data.

- Tampering with CDRs and their data should be illegal and punishable by law.
- CDR data should be treated as one would treat any other piece of evidence and require a search warrant to obtain access.

Additional Concerns About CDRs: Our focus group had many questions and concerns which mirrors data collected in other studies. In short, it is apparent that consumers believe there are many questions about data usage and access to be answered and guidelines to be set. Subjects expressed concern about CDR data usage in traffic stops or post accident investigations if not all vehicles have them. In addition, they worried about the potential for malfunctioning or tampering. They were concerned that CDRs could record and store data over a long period of time and establish a record of driving habits that could be used against them just like other types of personal behaviors. Some worried that CDR data usage would show bad driving habits and make it harder to get car insurance. They wondered if CDRs would be included as part of state inspections and held against them if it were not working properly. They wondered whether it is legal to require used vehicles to become equipped with CDRs and, if so, what is being planned. A woman wondered if another driver could withhold CDR data in an accident case.

6.3.6 Discussion of Focus Group Results

As stated earlier, the subjects were generally positive about CDRs at the beginning of the session, but became more concerned as the session went on about ethical and legal issues. What was seen as an exciting new idea as potentially helpful in accidents as flight data recorders in airplanes came to be viewed with suspicion as participants began to ask questions. The link between CDR data and safety research and safer driving was not clear to most participants. The men, in particular, seemed to be very suspicious as to why CDRs are in the vehicles in the first place and how the data would be used. Some of them stressed that more consumer education is needed. There were differences in opinion between the men and the women. If the men are to be appealed to on this issue, the cost factor must be addressed favorably toward the consumer. If the women are to be appealed to on this issue, the safety factor must be addressed. The focus group participants seemed to apply a “double-standard” at times such that their perspective was different depending on if they were using themselves in the argument or referring to “other” drivers. These drivers seemed unable to see that they were the other drivers to everyone else. For example, they said they would not drive differently, but CDRs would likely affect how other drivers drove.

In general, the discussion focused on these questions that must be answered for consumers: How will CDRs affect cost, safety, and driver rights? If the auto industry and law makers are able to satisfy consumers that CDRs will not raise costs, will improve safety, and protect their rights, then, consumers will probably accept the widespread use of CDRs. All agreed that this focus group discussion gave them a lot to think about and they planned to find out more about CDRs. They hoped that, perhaps, if today’s teenaged drivers learn to drive vehicles with the understanding that the CDR is storing data about their driving habits, future generations of drivers will drive more safely.

The most substantive difference between the focus group and survey participants was the increasing suspicion and doubt that permeated the focus groups. Like the survey participants, the group was initially positive about the potential benefits of CDR usage, but expressed concerns about the use of the data and the potential invasion of privacy. Initially, the males were the most concerned about these issues, but as the conversation continued, their concerns spread throughout the room.

6.3.7 Summary of Focus Group Results

Eighteen licensed drivers with a demographic breakdown similar to that of the United States were gathered together in a focus group format to discuss perceptions of crash data recorders. The results from the focus group matched well with those obtained through the survey and from other related studies in the literature. Many of the participants were unaware of CDRs until contacted about participating in the focus groups. This matched the results of the survey and the trend discussed in [Fischetti, 2004], that indicated that most Americans remain unaware of CDRs and many who are aware only recently learned about them from the media coverage of the trial of Congressman Bill Janklow, who struck and killed a motorcyclist in South Dakota [Schmidt and Williams, 2003]. Both survey and focus group participants felt that the devices could prove useful in accident investigations, much like the results from a CDR were used to convict a driver of vehicular manslaughter when the results proved that he was driving at 114 mph at the time of a fatal crash [Oldenburg, 2003]. Survey and focus group opinions mirrored what GM found in a recent survey, that self-labeled safer drivers are more accepting of CDRs than those who admitted to some minor traffic “transgressions” [Fischetti, 2004].

At first, participants were excited about the idea of a device designed to lead to increased vehicle and passenger safety, but, as the discussion progressed, participants began to become more concerned about specific types of data being recorded by CDRs and other possible uses of the data. They were also concerned that CDRs might be in their vehicles without their knowledge. There was a notable difference between men and women in this study: men were much more focused on the associated costs of such a device and women were much more focused on issues of safety. Participants provided many suggestions for automakers and lawmakers on this topic. Finally, it is abundantly apparent that our survey and focus group opinions reflect the general population’s opinions, some of which are based in misconceptions. Once again, it appears that those wanting CDR data should promote education about what CDRs can actually do.

6.4 Conclusions

The purpose of this special study was to determine the public awareness and level of acceptance of Event Data Recorders. The consumer acceptability study was conducted in two phases. In the first phase, a questionnaire, designed for this study, was mailed to 10,000 licensed drivers. In the second phase, focus groups were conducted, with a smaller sample of licensed drivers, to follow-up on the survey results.

The survey results provided several key findings. A significant majority of all respondents were unaware of CDRs and their use. Most felt that CDRs would be beneficial in accident investigations, lowering insurance rates for safe drivers, and encouraging monitored drivers to behave more safely. Respondents expressed a preference for the use of CDRs to be optional and to maintain control of the data. The opinions expressed were reasonably consistent across demographic groups, but older, more affluent, Caucasian males were more likely to report concerns about control of CDR data and their use.

The results from the focus group matched well with those obtained through the survey and from other related studies in the literature. Many of the participants were unaware of CDRs until contacted about participating in the focus groups. This matched the results of the survey that indicated that most Americans are unaware of CDRs. Both survey and focus group participants felt that the devices could prove useful in accident investigations. Survey and focus group opinions mirrored what GM found in a recent survey, that self-labeled safer drivers are more accepting of CDRs than those who admitted to some minor traffic "transgressions". Finally, it is abundantly apparent that our survey and focus group opinions reflect the general population's opinions, some of which are based in misconceptions. Once again, it appears that those wanting CDR data should promote education about what CDRs can actually do.

6.5 References

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7. Conclusions and Recommendations

Event Data Recorders offer a remarkable new data source for improvements in highway crash data analysis and research. There are however several difficult issues which may impede the use of EDR data for highway crash data analysis. These impediments include technological, legal, and consumer acceptability concerns. This chapter summarizes the benefits as well as the obstacles which must be overcome to use EDR data. Finally, this chapter presents recommended actions which will permit transportation agencies and safety researchers to capitalize on the full potential of EDRs for highway crash data analysis.

7.1 Benefits of Collecting EDR Data

Widespread deployment of EDRs promises a new and unique glimpse of the events that occur during a highway traffic collision. The EDR in a colliding vehicle can provide a comprehensive snapshot of the entire crash event –pre-crash, crash, and post-crash. By carefully collecting and analyzing the details provided by the growing number of EDR-equipped vehicles, the roadside / traffic safety research community has an unprecedented opportunity to understand the interaction of the vehicle-roadside-driver system as experienced in thousands of U.S. highway accidents each year. State and federal transportation agencies which collect EDR data can expect several benefits:

- The initial benefit of EDR data for state transportation agencies will be improved investigation of individual accidents. EDR data is increasingly being used in the courtroom as another means of reconstructing aspects of the crash such as vehicle speed. Many state and local law enforcement organizations already collect EDR data on a regular basis for fatal accident investigations. State transportation agencies will find EDR data to be a powerful new form of evidence in legal proceedings involving collisions with roadside hardware – either to defend against lawsuits or to seek damages to recover costs of repairing roadside hardware. State transportation agencies are cautioned however that the use of EDR data to assign blame for a crash is precisely what the public finds least acceptable about EDR use.

- State and federal transportation agencies which use EDR data can significantly improve the efficiency of database collection for accident statistic databases. The use of EDR data can improve the accuracy of these databases and may, in the long term, reduce the costs of data collection. Based upon the methodical examination of eight existing crash databases and three recommended database formats, we conclude that a significant fraction of data elements currently being collected could be provided by either existing or future EDR data elements. For example, 56 of the 175 Fatality Analysis Reporting System (FARS) data elements could be provided by EDRs. For state accident databases designed to meet Model Minimum Uniform Crash Criteria (MMUCC) format, 24 of the 75 recommended data elements could be provided by EDRs.

- One of the crucial long-term benefits of EDRs will be their influence on highway crash safety research. The ready availability of EDR data in an accident statistics database will enable vehicle and roadside safety researchers to address a number of elusive, and often technically controversial, research questions including:

  - How relevant are the impact conditions used in NCHRP 350?
  - For roadside crashes, is there a linkage between vehicle acceleration and occupant injury? How realistic is the flail space model when evaluated against actual EDR crash pulses and hospital injury records?
  - Are current vehicle designs compatible with current roadside safety hardware designs?
  - Do impacts with soft roadside safety devices, e.g. crash cushions, lead to late airbag deployments?
  - Are advanced occupant restraint systems, e.g., dual stage inflator systems, performing as designed?
  - How accurate are the delta-V estimates in U.S. national accident databases?
  - What is the distribution of impact speeds as a function of roadside object struck?
  - Coupling EDR pre-impact data with highway design data, what are the relationships between highway geometric design and the probability of a runoff road event?

  This research program has conducted an extensive review of the roadside safety literature which suggests that many of the data elements recommended for collection by previous research studies could either be obtained with current EDR devices or in future EDR designs. Examples of critical research data needs which could be met by either existing or near term EDRs are pre-crash vehicle trajectory, post-crash vehicle trajectory, and the orientation of the vehicle (yaw, pitch, and roll) at the time of impact.

7.2 Costs of Collecting EDR Data

There are both startup and operational costs associated with EDR data collection. Startup costs include both the purchase of EDR data retrieval units, e.g. as those manufactured by Vetronix, and training for the accident investigators or law enforcement personnel who will be performing the actual EDR downloads. In addition, EDR data collection will add somewhat to the time required for accident investigation. These costs are summarized below:

- **Purchase of EDR Retrieval Equipment**. To download EDR data from crashed vehicles, state DOTs will need to purchase an EDR data retrieval unit. Currently, the only publicly available EDR download device is the Vetronix Crash Data Retrieval (CDR) system. At the time of this report, the list price of the Vetronix CDR system was $2500. In addition, use of the Vetronix system requires data download to a portable computer or laptop; some jurisdictions may need to purchase this as well for their investigators.

- **Need for Training.** State and federal transportation agencies who wish to extract EDR data, for applications such as accident databases, should anticipate the need for specialized training in EDR data retrieval. NHTSA found that a key component of a successful EDR download program is specialized EDR training for its accident investigators. In 2002, approximately half of NHTSA's unsuccessful EDR downloads were attributed to "Technical / Training Problems". In 2003, after conducting specialized EDR training for accident investigators, "Technical / Training Problems" was noted as the reason for an unsuccessful download in only 10% of the cases.

- **Implementation Cost**. State accident databases and many federal accident databases, e.g. FARS and NASS/GES, are based on data extracted from police accident reports. The exceptions are in-depth crash databases, e.g. NASS/CDS and LBSS, which are based upon data collection by accident investigators. In the near term, the collection and use of EDR data is unlikely to be a widespread practice in police-level accident data collection. The initial costs associated with the required equipment and training may present a formidable obstacle to collection of EDR data by police departments. In addition, the increased time required at the scene would likely render EDR data collection unacceptable to many law enforcement agencies for routine data collection.

  These startup costs however are only expected to be a barrier to EDR data collection in the near term. As EDR data becomes more widely used in the courts and as EDRs become more widespread in the passenger vehicle fleet, there will be growing legal incentives to collect EDR data. It should be pointed out that in many severe crashes EDR data collection is already commonplace. Many state police fatal accident investigation divisions collect EDR data, whenever possible, to aid in their accident reconstructions. Our understanding of severe accidents would be greatly improved if EDR data collected in fatal crashes by state police and other law enforcement agencies were included with case submissions to the FARS database. NHTSA is encouraged to retrieve EDR data from state accident investigators when available for storage with and enhancement of the FARS database.

7.3 Recommendations for EDR Enhancement

Event data recorders are a rapidly evolving and, in many ways, still immature technology. Although the first research studies using EDR data are confirming their potential, there are still numerous technological issues which must be resolved to promote the widespread use of EDR data. Following are our recommendations for needed enhancements to EDRs:

- **Actively Support the NHTSA NPRM on Event Data Recorders**. State transportation agencies are encouraged to actively support the NHTSA proposed rule on EDRs. Until recently, there have been no standards which govern EDR format.

This lack of standardization has been a significant impediment to national-level studies of vehicle and roadside crash safety. Recently, SAE J1698 and IEEE 1616 were issued which prescribe industry standards or recommended practices for EDRs. To date however, no automaker has installed, or announced plans to install, production EDRs which comply with these standards. Federal regulation appears to be the only alternative action which will result in standardization of EDR data elements.

The proposed NHTSA rule requires that EDRs voluntarily installed in light vehicles record a minimum set of specified data elements useful for accident investigation, analysis of occupant restraint systems, and automatic crash notification systems. As noted below, we also recommend that NHTSA extend the proposed rule to include data elements which will assist roadside safety research in general. Should this not be possible in the near-term however, simple adoption of the NHTSA rule in its current form would greatly advance state and federal efforts to collect EDR data to improve highway crash research.

- **Recommended Data Elements.** NHTSA is encouraged to extend their proposed rule on EDRs to include data elements which will assist roadside safety research in general. Based on a comparison of EDR capabilities and highway crash data analysis needs, this program has developed a catalog of 66 data elements recommended for highway crash analysis. Nearly half of these data elements are already being stored in production vehicle EDRs. Thirty-eight (38) of these elements are defined in the NHTSA NPRM on Event Data Recorders. In the near-term, we recommend adopting the data elements proposed in the NHTSA NPRM and adding the following four priority roadside safety data elements: (1) crash location, (2) Vehicle Identification Number, (3) yaw rate, and (4) roll rate. In the longer term, NHTSA should require that the entire list of recommended data elements be stored in future EDRs.

- **Recording Duration**. To capture roadside feature crash performance, automakers should enhance future EDRs to record for a greater length of time than is the current practice. Roadside safety analyses require knowledge of not only the pre-crash trajectory, but also the post-crash trajectory. Currently, this data could be obtained if EDRs, such as the GM SDM, stored 'pre-crash' parameters such as vehicle velocity for 5 seconds before <u>and</u> after a crash. Likewise, the recording duration of the crash pulse should be increased. Impacts with roadside features such as a guardrail are relatively long events in comparison with vehicle-to-vehicle crashes. To capture the entire vehicle-to-roadside event, the crash pulse should be recorded for a minimum duration of 300 milliseconds. This recommendation is consistent with the NHTSA NPRM on EDRs.

- **Number of Events Recorded.** Automakers should enhance EDRs to record a minimum of three crash events. EDRs which record only a single event, e.g. the current Ford design, lose approximately one-half of the events. EDRS which record only two events, e.g. the current GM design, lose approximately 17% of the events.

An EDR which records 3 events, on the other hand, would capture 94% of the crash events. This recommendation is consistent with the NHTSA NPRM on EDRs.

- **Expand the Definition of an Event.** Automakers are encouraged to extend the definition of an 'event' to include roadway departures. Currently, an event is a crash. In addition to this type of event, roadway departure, with or without an impact, is also an important event. Lane-keeping and roadway departure warning systems are now entering the market which could be adapted for this purpose. Accurate recording and retrieval of roadway departure events would be invaluable for encroachment studies.

7.4 Recommendations for Improved EDR Data Retrieval and Archival Methods

Currently, there is no standardized method to download data from EDRs. Similarly, there is no standardized format for storing EDR data in an accident statistics database. The following actions are recommended to alleviate these obstacles to implementation:

- **Standardize the EDR retrieval method**. The state DOTs should actively support the proposed NHTSA EDR requirement which mandates that automakers make the contents of their EDRs accessible with publicly available tools. Currently, there is no standardized method to download data from EDRs. Two automakers have awarded an exclusive license to the Vetronix Corporation to market an EDR retrieval tool for their EDRs. The remaining automakers use proprietary tools for EDR data retrieval – effectively preventing EDR access by either state or federal transportation agencies.

- **Require a Crashworthy, Universal EDR Download Connector.** NHTSA is encouraged to modify or extend their proposed rule on EDRs to require a uniform connection point for EDR download. NHTSA has found that in a significant fraction of crashes, accident investigators were unable to use the OBD-II port, the primary Vetronix access point, to access the EDR data. Investigators have the option to directly connect to the EDR. Direct connection however is plagued by the need to partially dismantle the crashed vehicle. Furthermore, direct connection requires the purchase of large numbers of different EDR connection cables as there is no universal EDR connector. We recommend that NHTSA either require a crashworthy OBD-II connection to the EDR, or that NHTSA mandate a universal connector for direct connection to the EDR.

- **Automated Method to Export EDR Data.** Vetronix, producer of the only publicly available EDR download tool, is strongly encouraged to modify their Crash Data Retrieval software to allow electronic export of EDR data to accident databases such as NASS/CDS. Currently, all EDR data must be manually transcribed from Vetronix CDR screens into a database – a tedious and error-prone process. Vetronix is however developing a CDR-to-XML conversion program which has promise for federal and state DOTs with existing or planned EDR databases. Vetronix is encouraged to release a production version of this program to improve data entry efficiency and accuracy for mass users of EDR data, e.g., federal and state transportation agencies.

- **Recommended EDR Database Format.** State and federal transportation agencies seeking to create an EDR database are encouraged to use the recommended EDR database format developed by this program. The standardized EDR database was designed to: (1) accommodate data from diverse existing EDR download formats including all publicly released GM and Ford formats, (2) store the future EDR data elements needed to comply with the NHTSA NRPM on EDRs, and (3) store the recommended list of data elements for Highway Crash Data analysis developed by this research program.

7.5 Legal Acceptability of Event Data Recorders

While the preceding technological issues are challenging, they are solvable. More uncertain are the concerns which have been raised about the legal acceptability of the widespread collection of EDR data. A special study was conducted as part of this research program to explore the legal issues surrounding the implementation and use of Event Data Recorders. The special study addressed several specific issues: (1) whether the Fourth Amendment to the United States Constitution in any way bars the collection of data recorded by Event Data Recorders, (2) whether the United States Department of Transportation's (USDOT) has the authority to mandate the installation of EDRs in all new vehicles, (3) the admissibility of the data recorded by EDRs in court, and (4) whether the collection of such data violates privacy rights.

The report's conclusions were as follows: First, it is clear that the USDOT may require the installation of devices that demonstrably improve highway safety or advance some other significant public policy interest. The public policy interest in installing EDRs seems beyond peradventure. As a consequence, the USDOT presumably enjoys the authority to mandate the installation of such devices on new automobiles.

Second, with respect to Fourth Amendment concerns, it appears that the police (or other government accident investigators) may properly seize such devices (or otherwise collect the data therefrom) without a warrant during post-accident investigations. This authority is premised upon two legal issues: either because seizure of a required safety device does not constitute a search implicating the Fourth Amendment, or in the alternative, because seizure of a safety device qualifies under the exemptions for conducting a warrantless search. The police's authority to conduct warrantless searches may be affected by how soon after the accident the search occurs. The more immediate the search occurs following the accident, the greater the officers' authority to conduct a warrantless search. Absent an accident, however, unless there are changing expectations with respect to an individual's reasonable expectation of privacy regarding EDR data, police may not be able routinely to seize such data either without a warrant or express legislative authorization. Of course, police should have little trouble in obtaining a warrant to seize EDR data (or even the device itself).

Third, although the data (and the recorder itself) may be "owned" by the automobile's owner or lessee, that data may almost certainly be used as evidence against that owner (or other driver) in either a civil or a criminal case. Certainly nothing within the Federal Rules of Evidence ("FRE") or the Fifth Amendment's protection against compelled self-incrimination would exclude the use of data recorded by the EDRs. Similarly, owners might be prohibited from tampering with the data if litigation is pending.

At bottom, the issue here is not one so much of legal authority to use EDR data in court, but instead what the public will accept. While the statutory authority to require EDRs may exist, the public may not want a device installed in their automobiles that appears to encroach upon their personal privacy interests. Understood in this way, the problem is less a legal concern than it is a battle to mold public perception. Not every life-saving device that is deployed with the best of intentions will be accepted by the public. Personal privacy and public safety must exist within the same sphere. Occasionally, respecting privacy rights will mean that harmful things may come about, but this is the cost of living in a free society.

7.6 Public Acceptability of Event Data Recorders

Paralleling the concerns over legal acceptability of EDRs are concerns over public acceptability. A consumer revolt against the installation of EDRs could negatively impact sales and/or lead many manufacturers to offer owners the option to turn off their EDRs or even to stop installation of them altogether. These options would seriously limit the amount of EDR data collected for research by personnel in law enforcement, insurance, government, manufacturing, and education.

A special study was conducted as part of this research program to determine the public awareness and level of acceptance of Event Data Recorders. The consumer acceptability study was conducted in two phases. In the first phase, a questionnaire, designed for this study, was mailed to 10,000 licensed drivers. In the second phase, focus groups were conducted, with a smaller sample of licensed drivers, to follow-up on the survey results.

The survey results provided several key findings. A significant majority of all respondents were unaware of EDRs and their use. Most felt that EDRs would be beneficial in accident investigations, lowering insurance rates for safe drivers, and encouraging monitored drivers to behave more safely. Respondents expressed a preference for the use of EDRs to be optional and to maintain control of the data. The opinions expressed were reasonably consistent across demographic groups, but older, more affluent, Caucasian males were more likely to report concerns about control of EDR data and their use.

The results from the focus groups matched well with those obtained through the survey and from other related studies in the literature. Many of the participants were unaware of EDRs until contacted about participating in the focus groups. This matched the results of the survey that indicated that most Americans are unaware of EDRs. Both survey and focus group participants felt that the devices could prove useful in accident investigations. Survey and focus group opinions mirrored what GM found in a recent survey, that self-labeled safer drivers are more accepting of EDRs than those who admitted to some minor traffic “transgressions”. Finally, it is abundantly apparent that our survey and focus group opinions reflect the general population’s opinions, some of which are based in misconceptions.

To alleviate public concerns about EDRs, those organizations or agencies wanting to use EDR data should promote education about what EDRs can actually do. The automotive manufacturers, USDOT, and state transportation agencies are encouraged to conduct a more thorough public education campaign to inform the public about the presence of EDRs in passenger vehicles and about the safety and research benefits for the motoring public.

7.7 Summary

The widespread deployment of Event Data Recorders offers a new and unique glimpse of the events that occur during a highway traffic collision. This report has examined the benefits and the costs of using EDR data in highway crash data analysis and research. Although EDRs hold tremendous promise for improving highway crash data analysis, this report has identified several issues which may impede the use of EDR data for this purpose. These impediments include technological, legal, and consumer acceptability concerns. The report has investigated these issues in depth and developed recommendations for resolution of these potential barriers to the use of EDR data.

Appendix A. Consumer Acceptability Study: Survey and Focus Group Questionnaire and Cover Letters

Appendix A is not published herein. However, it is available upon request from the NCHRP.

Appendix B. Annotated Bibliography of EDR Data Needs for Roadside Safety Analyses

Appendix B is not published herein. However, it is available upon request from the NCHRP.

Appendix C. CDR-to-XML Converter

Appendix C is not published herein. However, it is available upon request from the NCHRP.

Appendix D. Format of the NASS/CDS EDR Tables

Appendix D is not published herein. However, it is available upon request from the NCHRP.

Appendix E. Rowan University EDR Database

Appendix E is not published herein. However, it is available upon request from the NCHRP.

Appendix F. Classification of Existing Accident Databases Using the Modified Haddon Matrix Approach

Appendix F is not published herein. However, it is available upon request from the NCHRP.