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IEEE Standard for Motor Vehicle Event Data Recorder (MVEDR)

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IEEE Vehicular Technology Society

Developed by the
Intelligent Transportation Systems Committee



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IEEE Standard for Motor Vehicle Event Data Recorder (MVEDR)

Developed by the

Intelligent Transportation Systems Committee
of the
IEEE Vehicular Technology Society

Approved 23 September 2021

IEEE SA Standards Board

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Abstract: Export data related to motor vehicle pre-defined events in usage history is collected, recorded, stored, and exported by motor vehicle event data recorders (MVEDRs). A protocol for MVEDR output data compatibility and export protocols of MVEDR data elements is defined by this standard. A motor vehicle event data recorder connector lockout apparatus (MVEDRCLA) and a near field communication (NFC) protocol is defined for safeguarding access to a vehicle's event data recorder (EDR) data by securing the vehicle output diagnostic link connector (DLC) and establishing a chain of custody link. This standard is without prejudice to requirements of national or regional laws related to privacy, data protection, and personal data processing.

Keywords: communication equipment, crash data, crash data recorder (CDR), data transfer, data transmission, diagnostic link connector (DLC), diagnostic programs, diagnostic testing, EEPROM, EEPROM data, electronic control unit (ECU), electronic equipment and components, electronic scan tools, electronically erasable programmable read-only memory, event data recorder (EDR), IEEE 1616™, information exchange, litigation, nonvolatile memory, nonvolatile memory data, OBD2 or OBDII, odometer clocking, odometer fraud, odometer spun, odometer tampering, on-board diagnostic, on-board network data security, power control module (PCM) and/or electronic control unit (ECU) flashing, road vehicle components, road vehicle engineering, road vehicles, SAE J1962 connectors, vehicle components, vehicle crash data, vehicle identification number (VIN) tampering, vehicle identification number (VIN) theft.

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Introduction

This introduction is not part of IEEE Std 1616-2021, IEEE Standard for Motor Vehicle Event Data Recorder (MVEDR).

The Congressional Research Service (CRS) Report R43651 "Black Boxes" in Passenger Vehicles: Policy Issues cites that "Vehicle crashes impose an enormous expense on society and on individuals. In the United States, over 30,000 people die each year in vehicle-related crashes and around 4 million people are injured. NHTSA has estimated that these crashes impose costs of about $871 billion annually—the equivalent of 2% of GDP—in harm to individuals and costs to society from lost productivity and other factors. Analyses of crashes are important for helping to understand how crashes can be prevented or mitigated, and how vehicle occupants can be protected in the event of a crash. Crash analysis is challenging. Crashes often occur on heavily trafficked roads, where the investigator is under pressure to clear the scene quickly in order to restore traffic flow. In some cases, the investigator is at risk from passing traffic. Many crashes happen at night and in inclement weather, further hampering investigation. The investigator may not be able to interview participants or witnesses, and if they are available neither the crash vehicle occupants nor witnesses may be able to provide accurate information; in the case of the crash vehicle occupants, they may have reason to lie. EDR data are useful in analyzing crashes. They provide specific information about several factors, such as vehicle speed and brake application, which can help investigators understand the crash sequence. They also provide crash data in volumes that are not obtainable in any other way, making possible statistical analysis focused on detailed elements of crash involvement. Vehicle manufacturers, NHTSA, and other safety groups perform crash tests on vehicles, but relatively few such tests are conducted annually. By contrast, NHTSA collects crash data, including EDR data, from thousands of investigations of actual vehicle crashes each year. EDR data can help vehicle manufacturers improve the safety performance of vehicles. They also can help inform traffic safety policies and regulations intended to prevent or mitigate the effects of crashes. For example, EDR data were helpful in analyzing the high-profile unintended vehicle acceleration issue with Toyota vehicles in 2009 and 2010."

Crash information is critical to understanding causation leading up to the crash, occupant kinematics and vehicle performance during a crash, and post-crash events. Manufacturers, engineers, policy makers, researchers, and others rely on crash information to improve vehicle design, shape regulatory policy, develop injury criteria, detect vehicle defects, and resolve investigations and litigation.

Motor vehicles have markedly transitioned from mechanical machines with mechanical controls to highly technological vehicles with integrated electronic systems and sensors. Modern automobiles generate, utilize, and analyze electronic data to improve vehicle performance, safety, security, comfort, and emissions. Surrounding a crash, capture of a subset of vehicle data on an MVEDR makes important information readily available for medical responders, crash investigators, and researchers. The degree of societal benefit from MVEDRs is directly related to the number of vehicles operating with an MVEDR and the ability to retrieve and utilize these data. Having standardized data definitions and formats allows the capture of vehicle crash information.

The IEEE 1616 Working Group recognizes the value of improved crash information in improving the knowledge of what happens before, during, and after a motor vehicle crash. Such insights will provide major benefits to society and significantly improve the science of motor vehicle crashes. This standard defines a protocol for MVEDR output data compatibility and export protocols of MVEDR data elements.

The impact of improved crash data goes beyond just understanding the dynamics of a crash; it affects a myriad of important societal and business functions. With that in mind, the working group solicited input from a range of end users to help identify important data element and critical uses of motor vehicle crash data. Both individual crash events and aggregate data have value for end users, depending on the application and data used.

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Users and beneficiaries of this standard include the following:

— *Automotive industry:* Data-driven design of vehicles, using larger numbers of crashes across a continuum of severity; early evaluation of system and vehicle design performance; and international harmonization of safety standards.

— *Insurance industry:* Help to identify fraudulent claims, costing more than $20 billion annually; improve risk management; expedite claims and decrease administrative cost. Insurers require accurate crash data for subrogation of claims and recovery of expenses.

— *Government:* Promulgating and evaluating standards; identifying problem injuries and mechanisms; stipulating injury criteria and investigating of defects. State and local officials require crash information to identify problem intersections and road lengths, to determine hazard countermeasures, and to evaluate the effectiveness of safety interventions.

— *Researchers:* Human factors research, such as the man-machine interface; crash causation, the effects of aging, medical conditions, and fatigue; biomechanics research on human response to crashes, harmonized dummy development, and injury causation.

— *Medical providers:* On-scene field triage of motor vehicle crash victims; improved diagnostic and therapeutic decisions; automatic notification of emergency providers; better organization of trauma and emergency medical services (EMS) system resources.

— *The public:* Better policies, vehicle design, emergency response, roadway design, and driving habits; lowered insurance costs, decreased possibility for fraud; fewer crashes and more efficient systems.

In the United States, an estimated 80 million motor vehicles already use some type of event-recording equipment that collects not only acceleration and deceleration speed but also braking and steering data. Proponents of standard data recorders hope the crash data they collect will be a useful complement to accident information gathered from victims and eyewitnesses.

However, the implementation of event data recorders (EDRs) has not been without controversy. The United States Department of Transportation (USDOT) Docket Management System (DMS) contains over 1000 submissions reflecting the pros and cons of a decade-long debate among automakers, government regulators, safety and privacy advocates, and the public.

The National Highway Traffic Safety Administration (NHTSA) rule on event data recorders (49 CFR 563 [B9][1]) does not address issues generally within the realm of state law, such as the following:

— The ownership of EDR data

— How EDR data can be used/discovered in civil litigation

— How EDR data may be used in criminal proceedings

— Whether EDR data may be obtained by the police without a warrant

— Whether EDR data may be developed into a driver-monitoring tool

— The nature and extent that private parties will have or may contract for access to EDR data

These issues are being addressed by state legislatures. There are many types of recorders. Some continuously record data, overwriting the previous few minutes until a crash stops them, and others are activated by crash-like events (such as a sudden change of velocity or angular momentum) and continue to record until the crash is over. EDRs can record whether or not brakes were used, the speed at the time of impact, the steering angle, and whether seat belts were worn during the crash. While EDR information can be useful in determining the cause of a crash, a lockout gives you the reassurance of knowing that you have control of crash data. The "black box" will still work exactly as it is designed to. However, with a motor vehicle event data recorder

[1] The numbers in brackets correspond to those of the bibliography in Annex F

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connector lockout apparatus (MVEDRCLA), the vehicle owner (and only the vehicle owner) determines when and who sees the data and, thus, controls how it is used. Ownership of EDR data is a matter of state law. Generally, the owner of the vehicle is considered to be the rightful owner; however, courts can subpoena crash data. Crash data can be used in civil and criminal court cases. This amendment seeks to maintain privacy, prevent tampering, avoid odometer fraud, limit data access, and enhance safety by using a MVEDRCLA.

While many vehicle purchasers are aware these devices are in their vehicles, most are unaware of the nature and potential use of the information collected by their EDR. Data collected by EDRs, without the driver's knowledge, has been used in civil and criminal cases in several states and in Canada. At least one automotive insurance company is considering basing policy rates on EDR data. Auto manufacturers could use EDR data to void warranties. The possibilities are endless.

Several states have already passed laws requiring disclosure of the existence of an EDR in a vehicle, and protection of a driver's privacy by requiring the owner's permission or a court order before downloading the EDR data. It is generally agreed that the owner of a vehicle also owns the EDR data as they have purchased the technology when they bought their vehicle. When consumers drive off the lot with a new car, they own more than just the vehicle; they own the information their vehicle generates and stores.

A large ever-expanding market exists consisting of: Registered owners of over 243 million motor vehicles; military vehicles and federal, state, county, and local government vehicles; vehicle OEMs and new car dealerships that lease vehicles; automotive insurance companies that seek to prevent other parties from access to data; automotive rental companies that cannot permit odometer tampering; institutional fleets such as schools, colleges, and universities; business fleets include leasing, construction, plumbing, heating, food distribution, shipping, utilities; and others such as police, fire, EMS, taxi, etc.

An NHTSA report (DOT HS 809 441 [B146]) notes:

"Odometer fraud is the illegal practice of rolling back odometers to make it appear that vehicles have lower mileage than they actually do. This has historically been considered a significant problem for the American consumer. While any vehicle sold on the used car market could have been the object of odometer tampering, the problem has been considered to be most prevalent among late-model vehicles which have accumulated high mileage in a relatively short period of time. Vehicles in fleets, such as lease fleets, rental fleets, or business company fleets typically fall into this category. When sold on the used car market, vehicles whose odometers have been rolled back, or 'spun,' can obtain artificially high prices, since a vehicle's odometer reading is a key indicator of the condition, and hence the value, of the vehicle."

The Congressional Research Service (CRS) Report R43651 "Black Boxes" in Passenger Vehicles: Policy Issues cites IEEE standards. Can technology also protect privacy? While NHTSA was studying EDR technology, the IEEE issued in 2004 the first universal, voluntary standard specifying minimal performance characteristics for memory devices in autos, trucks, buses, ambulances, and fire trucks. IEEE Std 1616 is an international protocol issued to help manufacturers develop black boxes with up to 87 data elements that will survive in crash situations. IEEE and others have argued that NHTSA's pending EDR regulation does not go far enough to protect owners' privacy. In 2010, IEEE issued a new standard, IEEE Std 1616a™, which specifies a lockout system to block unauthorized access that could otherwise lead to data tampering, odometer fraud, and VIN theft. It argued that such steps are necessary to ensure that motorists embraced the EDR technology in the long run. With this lockout standard, a motorist would have a separate key which would lock access to the OBD-II connector (as well as the EDR). In a letter to the NHTSA administrator, IEEE stated:

"We believe public acceptance is crucial to the goals of this rulemaking. We agree with the findings of a National Academies study that noted '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 manufacturers to offer owners the option to turn off their EDRs or even 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.'"

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IEEE Standard for Motor Vehicle Event Data Recorder (MVEDR)

1. Overview

1.1 Scope

Motor vehicle event data recorders (MVEDRs) collect, record, store, and export data related to motor vehicle pre-defined events in usage history. This standard defines a protocol for MVEDR output data compatibility and export protocols of MVEDR data elements. This standard does not prescribe which specific data elements shall be recorded, but instead provides a data dictionary of data attributes. This standard also defines a means of maintaining data security on the vehicle via a motor vehicle diagnostic link connector lockout apparatus (MVEDRCLA) by securing the vehicle output diagnostic link connector (DLC). This standard does not prescribe data security within the vehicle electronic control units (ECUs) or within the intra-vehicle communication and/or diagnostic networks; it instead defines ways and means to permit uniform but controlled access of electronic scan tools to the DLC for legitimate vehicle emissions status, maintenance, and/or repair. This standard also defines a motor vehicle event data recorder connector lockout apparatus (MVEDRCLA) and a near field communication (NFC) protocol of safeguarding access to a vehicle's event data recorder (EDR) data by securing the vehicle output diagnostic link connector (DLC). This standard is without prejudice to requirements of national or regional laws related to privacy, data protection, and personal data processing. This standard does not directly address related issues with regard to human health or human safety. It is applicable to vehicles and their respective event data recorders for all types of motor vehicles licensed to operate on public roadways, whether offered as original or aftermarket equipment, whether stand-alone or integrated within ~~into~~ the vehicle.

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1.2 Purpose

Many light-duty motor vehicles, and increasing numbers of heavy commercial vehicles, are equipped with some form of MVEDR. These systems, which are designed and produced by individual motor vehicle manufacturers and component suppliers, are diverse in function, and proprietary in nature, however, the SAE J1962 [B118][2] (ISO 15031-3:2004 [B55]) vehicle DLC has a common design and pinout, and is thus universally used to access event data recorder information. Data access via the DLC can be accomplished by using scan tools or microcomputers and network interfaces. This same DLC and network interface is also used for re-calibrating electronic control units on a vehicle. Such ECU applications can include restraint controls, engine controls, stability controls, braking controls, etc. This standard defines a protocol to protect against misuse of electronic tools which use the DLC to erase, modify, or tamper with electronic controller or odometer readings, or to improperly download data. Implementation of MVEDRCLA provides an opportunity to voluntarily achieve DLC security by standardizing a MVEDRCLA that will act to prevent vehicle tampering, which can include odometer fraud, illegal calibrations leading to emissions violations, and theft of personal data. Adoption of this standard will therefore make the common MVEDR/DLC data more secure and credible while still permitting accessibility to legitimate end users. The continuing implementation of MVEDR systems provides an opportunity to voluntarily standardize data output and retrieval protocols to facilitate analysis and promote compatibility of MVEDR data. Adoption of the standard will therefore make MVEDR data more accessible and useful to end users.

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals is *required to*).[3, 4]

[2] This standard defines the physical connector used for the OBD-II interface.

[3] The use of the word *must* is deprecated and cannot be used when stating mandatory requirements, *must* is used only to describe unavoidable situations.

[4] The use of *will* is deprecated and cannot be used when stating mandatory requirements, *will* is only used in statements of fact.

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The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals is *recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals is *permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals is *able to*).

1.4 General

Crash information is critical to understanding causation leading up to the crash, occupant kinematics, and vehicle performance during a crash, and post-crash events. Manufacturers, engineers, policy makers, researchers, and others rely on crash information to improve vehicle design, shape regulatory policy, develop injury criteria, detect vehicle defects, and resolve investigations and litigation. Motor vehicles have markedly transitioned from mechanical machines with mechanical controls to highly technological vehicles with integrated electronic systems and sensors. Modern automobiles generate, utilize, and analyze electronic data to improve vehicle performance, safety, security, comfort, and emissions. Surrounding a crash, capture of a subset of vehicle data on an MVEDR makes important information readily available for medical responders, crash investigators, and researchers. The degree of societal benefit from MVEDRs is directly related to the number of vehicles operating with an MVEDR and the ability to retrieve and utilize these data. Having standardized data definitions and formats allows the capture of vehicle crash information. This standard recognizes the value of improved crash information in improving the knowledge of what happens before, during, and after a motor vehicle crash. Such insights will provide major benefits to society and significantly improve the science of motor vehicle crashes.

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The past four decades have witnessed an exponential increase in the number and sophistication of electronic systems in vehicles. A vast increase in automotive electronic systems, coupled with related memory storage technologies, has created an array of new safety engineering opportunities and subsequent consumer acceptance challenges. Virtually every passenger car and light truck manufactured in or imported to the North American market since model year 1996 includes an Environmental Protection Agency (EPA) mandated DLC to allow access to engine and emissions diagnostic data. This on-board DLC (OBDII) is regulated by the Code of Federal Regulations (CFR) (40 CFR 86.094-17(h) [B8]) and revisions for subsequent model years. It is standardized by the Society of Automotive Engineers (SAE) Vehicle Electrical Engineering Systems Diagnostic Standards Committee. The physical configuration of the output plug is specified under SAE J1962-2002 [B118] and through the International Standards Organization under ISO 15031-3:2004 [B55], and is increasingly used as an access point to other in-vehicle electronics systems, subsystems, computers, sensors, actuators, and an array of control modules including the air bag control module. The on-board DLC is also used as a serial port to retrieve data elements from on-board systems, subsystems, modules, devices, and functions that collect and store data elements related to a vehicle crash, such as a restraint control module (RCM) and event data recorder (EDR). Thus, the on-board DLC provides a portal for capture of an increasing volume of sophisticated sensor data regarding the operating condition, operation and behavior of vehicles, and in particular the operation and behavior of vehicles involved in crashes. Consumers continue to be interested in safety advancements, but remain concerned about issues of privacy, tampering, and misuse of vehicle crash data. It is important to protect a variety of crash-sensing and diagnostic memory modules. Increasingly, data from these devices have been used in civil and criminal court cases nationwide, including cases dealing with vehicular homicide in which speed was an issue. Thus, this standard defines a protocol for MVEDR output data compatibility and export protocols of MVEDR data elements and a protocol for an MVEDRCLA.

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1.5 Data privacy and security ~~recommendations~~[1]

~~Privacy is a central element of consumer protection. In recent years, advances in technology have made it possible for detailed information about individuals to be compiled and shared. This has produced many benefits for society as a whole and individual consumers. At the same time, as personal information becomes more accessible, precautions must be taken to protect against the misuse of information.~~

~~MVEDR data aggregated across many events has significant scientific value. Occasional errors in data recording, communication, or retrieval will undoubtedly occur. However, uncontrolled release of any data, especially erroneous data for any specific event, has the potential to compromise the directly affected individual's need for confidentiality. Moreover, aggregate MVEDR data may contain an occasional statistical anomaly. While scientifically undesirable, minor errors are not catastrophic to the overall value of the data. However, individual or personal data containing statistically insignificant errors or omissions may wrongly attribute liability, falsely indicate fraud, or erroneously convict/exonerate a particular person.~~

~~The use of an~~ MVEDR may make use of personal identification information available, which can potentially include one~~,~~ or more of the following:

a) Driver or occupant name or the equivalent

b) Event place, date, and time

c) Precise Global Positioning System (GPS) coordinates

~~4) Wireless telephone number or electronic serial number (ESN)~~

d) Complete vehicle identification number (VIN)

e) Unique MVEDR serial number

~~[1]The recommendations contained in this subclause do not guarantee compliance with all state and local privacy requirements and are only intended to provide baseline recommendations. Individual parties collecting motor vehicle event data should consult local laws for specific privacy guidance.~~

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This standard does not make any recommendations on safeguarding data, personal or otherwise.

~~MVEDR data shall not be compiled into a public database or released to third parties without due process of law unless done in accordance with local and Federal privacy regulations. Further, personally identifiable information similar to items a) through f) shall be recognized as requiring more stringent security precautions than data aggregated over multiple events. MVEDR data in the process of being recorded, retrieved, transmitted, preserved, and/or transmitted shall be subject to reasonable means of authentication and verification of its integrity. In particular, records shall be maintained of data recording, retrieval, transcription, preservation, or transmission, by which the "chain of custody" can be retraced to original sources.~~

~~All rights in retrieved MVEDR data shall be preserved, including the right of data owners and adversaries to dispute its accuracy. Any identified individual must be afforded notification that his personally identifiable information is contained in MVEDR data, and the individual must be given reasonable opportunity to legitimately challenge or correct possible erroneous or incomplete information.~~

1.6 Standard structure

This standard is portioned into clauses that serve several distinct purposes.

Clause 1, Overview, provides background for understanding the goals and objectives for this standard.

Clause 2, Normative references, gives the references used ~~referred to~~ in this standard.

Clause 3, Definitions, acronyms, and abbreviations, provides a glossary that defines the terms used ~~by later clauses~~ within the standard.

Clause 4, Applicability, provides information about the different constituencies who will benefit from this standard and also notes use-case perspectives and applications.

Clause 5, Event description, defines the meaning of an event as it pertains to motor vehicle crashes.

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Clause 6, Output, defines common interfaces that may be utilized to extract MVEDR data and MVEDRCLA device and Near Field Communication (NFC) protocol.

Clause 7, MVEDR data attributes, describes how the crash sequence is examined in circumstances surrounding the event: prior to the crash occurring, the circumstances involved during the crash, and those involved after the crash.

Clause 8, MVEDR data dictionary, explains how the data dictionary comprises ~~is comprised as~~ a collection of entries specifying the name, source, usage, and format of each data element used in a system or set of systems.

Clause 9, Conformance, specifies levels of conformance for the data formats defined by this standard.

Annex A, Test control program, identifies the requirements necessary to establish and implement a test control program.

Annex B, In-vehicle networks, explains controller area network (CAN), a widely used vehicular network. Annex C, Government databases, explains that for the purpose of accident causation analysis, a number of accident databases have been developed and used to identify effective countermeasures to improve the safety of the surface transportation system.

Annex D, Motor vehicle event data recorders (MVEDRs) and implementation of automatic collision notification (ACN) systems, explains the connection between the two emerging technologies.

Annex E, Bibliography, lists background material for this standard.

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1.7 Data dictionary

Historically, motor vehicles were basically mechanical systems. Mechanical systems, including early restraint systems, allowed a mechanical reconstruction of system performance and no MVEDR was needed, nor was there electronic data available to record. Modern motor vehicles now include a vast array of electronic systems. The past four decades have witnessed an exponential increase in the number and sophistication of electronic systems in vehicles. The growth of electronic systems has had implications for vehicle engineering. Today, electronic systems need to record critical system inputs and outputs to know if systems performed as intended in the field. A need exists to ascertain if motor vehicle safety-related components or systems performed properly in field events, to decide if a product improvement is necessary. This standard includes a data dictionary of data elements or data attributes. These data elements will be useful for effective crash investigations, analysis of the performance of safety equipment (e.g., advanced air bags), and automatic collision notification (ACN) systems. Several of these elements are associated with crash severity and usage of the restraint system, while others are important to understanding the human response to avoiding a pending crash. The data dictionary is located in Clause 8.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

~~This standard shall be used in conjunction with the following standards. When the following standards are superseded by an approved revision, the revision shall apply. In case of a conflict between this standard and the referenced document, this standard shall take precedence. Those provisions of the referenced documents that are not in conflict with this standard shall apply as referenced.~~

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~~Canadian Motor Vehicle Safety Regulations, Standard 101-2003, Location and Identification of Controls and Displays.[2]~~

EIA 232D~~-1987~~, Interface between Data Terminal Equipment and Data.[5] [3]

FMVSS 208, Occupant Crash Protection.[6] [4]

FMVSS 214, Side Impact Protection.

FMVSS 301, Fuel System Integrity.

ISO 2575~~:2004~~, Road Vehicles—Symbols for Controls, Indicators, and Telltales.[7] [6]

~~ISO 4040:2001, Passenger Cars—Location of Hand Controls, Indicators, and Telltales.~~

ISO 11898-1~~:2003~~, Road Vehicles—Controller Area Network (CAN)—Part 1: Data Link Layer and Physical Signaling ~~Signalling~~.

ISO 11898-2~~:2003~~, Road Vehicles—Controller Area Network (CAN)—Part 2: High-speed Medium Access Unit. NFC Forum, Analog Technical Specification.

NFC Forum, Digital Protocol Technical Specification.

NFC Forum, NFC Data Exchange Format (NDEF) Technical Specification. NFC Forum, Record Type Definition (RTD) Technical Specification.

NFC Forum, URI RTD Technical Specification.

~~[2]This publication is available from http://www.tc.gc.ca/acts-regulations/GENERAL/M/mvsa/regulations/mvsrg/100/mvsr101.html.~~

[5] [3]EIA publications are available from the U.S. Energy Information Administration (https://www.eia.gov~~Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112, USA (http://global.ihs.com~~/).

[6] [4]FMVSS publications are available from http://www.nhtsa.dot.gov/cars/rules/import/FMVSS/.

[7] [6] ISO publications are available from the International Organization for Standardization (https://www.iso.org/) and the American National Standards Institute ~~ISO Central Secretariat, Case Postale 56, 1 rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse (http://www.iso.ch/). ISO publications are also available in the United States from the Sales Department, American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA~~ (https ~~http~~://www.ansi.org/).

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NFC Forum, Type 2 Tag Technical Specification.

NFC Forum, Type 3 Tag Technical Specification.

NFC Forum, Type 4 Tag Technical Specification.

NFC Forum, Type 5 Tag Technical Specification.

SAE J211/1 ~~2003~~, Instrumentation for Impact Test—Part 1—~~:~~ Electronic Instrumentation.[8] ~~*See also* SAE Paper 2002-01-0796: Digital Filtering for J211 Requirements Using a Fast Fourier Transform-Based Filter.[7]~~

SAE J1455 ~~1994~~, Joint SAE/TMC Recommended Environmental Practices for Electronic Equipment Design (Heavy-Duty Trucks).

~~Universal Serial Bus Revision 2.0 (USB 2.0) specification.[8]~~

~~U.S. Code of Federal Regulations (CFR) Title 49: Transportation; Part 571.101: Controls and displays (revised as of 2002).[9]~~

3. Definitions, acronyms, and abbreviations

3.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.[9]

[8] [7] SAE publications are available from the Society of Automotive Engineers~~, 400 Commonwealth Drive, Warrendale, PA 15096, USA~~ (https ~~http~~://www.sae.org/).

[9] *IEEE Standards Dictionary Online* is available at: http://dictionary.ieee.org. An IEEE Account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

~~[8]This publication is available from http://www.usb.org/developers/docs/.~~

~~[9]CFR publications are available from the Superintendent of Documents, U.S. Government Printing Office, P.O. Box 37082, Washington, DC 20013-7082, USA (http://www.access.gpo.gov/).~~

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ABS activity: This indicates that the anti-lock brake system (ABS) is actively controlling the vehicle's brakes.

advanced driver assistance system (ADAS): Electronically controlled vehicle system aimed at assisting a human driver in performing part of the dynamic driving task (DDT) through information support (e.g., warnings in safety-critical situations) and influencing the lateral and/or longitudinal control of the vehicle. Influence of lateral and/or longitudinal control may be temporary or on a sustained basis, but can always be overridden by the human driver. The driver is in particular required to monitor the environment and system performance, and shall not perform other activities that would hamper the driver's immediate intervention when required by the system or the environment.

anti-lock brake system (ABS): A means to maintain directional stability and control during braking of a vehicle.

automatic emergency braking (AEB) system: A system that is able to detect potential collision and automatically initiate the breaking.

autonomous driving (AD) mode: The vehicle is self-driving without control from human driver.

capture: The process of saving recorded data.

card emulator: Role of an NFC Forum Device, reached when an NFC Forum Device in Listen Mode has gone through a number of States. In this mode, the NFC Forum Device behaves as one of the Technology Subsets.

connection: Two mated connectors or contacts.

connector: Assembly of contact and housing that terminates conductors for the purpose of providing connection and disconnection to a suitable mating connector.

connector lockout apparatus (CLA): Device or mechanism to secure a connector.

contact: Conductive element in a connector (including means for cable attachment) that mates with a corresponding element to provide an electrical path.

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crash: An unusual or unstable event or an occurrence in a sequence of events that produces injury, death, and/or damage to one or more vehicles involving a motor vehicle in transport.

crash pulse: The acceleration-time history of the occupant compartment of a vehicle during a crash. This is represented typically in terms of acceleration as multiples of the standard calculational value for the acceleration due to gravity, g_n (= 9.806 65 m/s^2, exactly), plotted against time in milliseconds (1 ms = 0.001 s). The crash pulse determines the test's severity of the crash: an occupant will undergo greater forces if the crash pulse accelerations are higher at the peak or if the duration of the crash pulse is shorter. Local values for the acceleration due to gravity, g, may differ from g_n significantly and vary from one locale to the next and in some areas with tidal conditions; hence g_n is the international standard calculational basis.

crash severity: The most severe injury sustained in the crash as recorded on the police accident report (PAR) and consists of: property damage only (no injuries); minor or moderate (evident, but not incapacitating; complaint of injury; or injured, severity unknown); severe or fatal (killed or incapacitating).

cybersecurity: The condition in which road vehicles and their functions are protected from cyber threats to electrical or electronic components.

data BUS: An electrical system installed in a vehicle that allows vehicle subsystems to communicate with each other

data definition: A description of the format, structure, and properties of a data element.

data dictionary: A collection of entries specifying the name, source, usage, and format of each data element used in a motor vehicle system or set of systems.

data element: A uniquely named and defined component of a data definition; a data "type" in which data items (actual values) can be placed.

decrypt: To change electronic information or signals that were stored, written, or sent in the form of a secret code (a system of letters, numbers, or symbols) back into an understandable form that can be used normally. Messages encrypted using the public key can be decrypted only by someone with the private key.

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delta-v (Δv): For vehicles with only longitudinal acceleration measurement capability, the change in velocity of the vehicle along the longitudinal axis, and for vehicles with both longitudinal and lateral acceleration measurement capability, the change in velocity of the resultant of the longitudinal and lateral vehicle velocity time histories, within the time interval starting from the time zero and ending 5000 ms after time zero.

deployment level: The highest level inflator ignited in an air bag deployment.

diagnostic link connector: The diagnostic link connector (DLC) on OBD II-equipped vehicles is a standardized 16-pin diagnostic connector used to interface an OBD II-compliant scan tool with the power control model (PCM) allowing access to on-board diagnostics and live data streams.

disposal: The deployment of the second (or higher, if present) stage of a frontal air bag for the purpose of disposing the propellant from the air bag device.

dual-stage event: An event that is a sequence of two single-stage events within a period of time.

encrypt: The method by which information is converted into secret code that hides the information's true meaning. The science of encrypting and decrypting information is called *cryptography*.

engine RPM: For vehicles powered by internal combustion engines, the number of revolutions per minute of the main crankshaft of the vehicle's engine, and for vehicles not powered by internal combustion engines, the number of revolutions per minute of the motor shaft at the point at which it enters the vehicle transmission gearbox. The universal unit symbol for RPM is r/min.

engine throttle, percent full: For vehicles powered by internal combustion engines, the percent of the engine throttle opening compared to the full open position of the engine throttle opening., ~~and~~ For vehicles not powered by internal combustion engines, the percent of vehicle accelerator depression compared to the fully depressed position.

event: A change in the condition or performance of interest at a specific time that causes the trigger threshold to be met or exceeded after the end of the 500 ms period for recording data regarding the immediately previous event.

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event data recorder (EDR): A device or function in a vehicle that records any vehicle or occupant-based data just prior to or during a crash, such that the data can be retrieved after the crash, including vehicle or occupant-based data included in any of the data elements of this standard~~, IEEE Std 1616-2004~~.

Federal Motor Vehicle Safety Standard (FMVSS): U.S. federal vehicle regulations specifying design, construction, performance, and durability requirements for motor vehicles and regulated automobile safety-related components, systems, and design features.

forward collision warning system (FCW): A system that is able to detect potential collision and warn the driver about it.

forward seat position: A seat position that is in the forward-most third of the measured distance between the full forward and the mid-track positions of the seat.

frontal air bag: The primary inflatable occupant restraint device that is designed to deploy in a frontal crash to protect the front seat occupants.

government-grade cryptography: Traditionally, military-grade encryption uses a key size equal to or greater than 128 bits. The U.S. government specifies the use of FIPS 140-2.

high-security non-reproducible lock: A lock/key blank coded with serial numbers that is self-certified by the original equipment manufacturer (OEM) as "unpickable" by professional locksmith tools and not available to the public, meaning that any duplication is by the original manufacturer.

ignition cycle, crash: The number (count) of the ignition key applications sufficient to start the engine and/or the power vehicle accessories, from the date of manufacture to, and including, the time of the event.

ignition cycle download: The number (count) of the ignition key applications sufficient to start the engine and/or the power vehicle accessories, from the date of manufacture to, and including, the time when the data is downloaded from the motor vehicle event data recorder (MVEDR).

incident: An event in which the safety of the vehicle or any person is threatened.

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lane departure warning (LDW) system: The system that is able to detect the unintentional crossing out of lane and warn the driver about it.

lane keeping support (LKS) system: The system that is able to detect the unintentional crossing out of lane and automatically steer the vehicle back into its lane.

lateral acceleration: The component of the acceleration vector of a point in the vehicle in the y-direction. The lateral acceleration is positive from left to right, from the perspective of the driver when seated in the vehicle facing the direction of forward vehicle travel.

Listen Mode: The mode of an NFC Forum Device where it receives Commands and sends Responses.

lock: Device or mechanism to secure an area.

longitudinal acceleration: The component of the acceleration vector of a point in the vehicle in the x-direction. The longitudinal acceleration is positive in the direction of forward vehicle travel.

mobile cell phone app: A mobile application, also referred to as a mobile app or simply an app, is a computer program or software application designed to run on a mobile device such as a phone, tablet, or watch.

motor vehicle event data recorder (MVEDR): A device that is installed in a motor vehicle to record technical vehicle- and occupant-based information for a period of time before, during, and after a crash. MVEDRs may record (1) pre-crash vehicle dynamics and system status, (2) driver inputs, (3) vehicle crash signature, (4) restraint usage/deployment status, and (5) certain post-crash data, such as the activation of an automatic collision notification (ACN) system.

motor vehicle event data recorder connector lockout apparatus (MVEDRCLA): A device to secure a connector from tampering.

multi-event crash: The occurrence of two or more events, the first and last of which begin not more than 5 s apart.

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NDEF Message: The basic message construct defined by the NFC Data Exchange Format Technical Specification. An NDEF Message contains one or more NDEF Record(s).

NDEF Record: An NDEF Record contains a payload described by a type, a length, and an optional identifier.

NFC Forum Device: A device that supports at least one communication protocol for at least one communication mode defined by the NFC Forum specifications.

NFC Forum Tag: A contactless tag or (smart) card supporting NDEF.

near field communication: A set of communication protocols for communication between two electronic devices over a distance of 4 cm (1½ in) or less. NFC offers a low-speed connection with simple setup that can be used to bootstrap more-capable wireless connections.

NFC Data Exchange Format (NDEF): The NFC Data Exchange Format (NDEF) is a standardized data format that can be used to exchange information between any compatible NFC device and another NFC device or tag. The data format consists of NDEF Messages and NDEF Records.

NFC Tag Device: An NFC Forum Device that supports at least one communication protocol for card emulator and NFC Data Exchange Format (NDEF).

NFC tag: A near field communication (NFC) tag is a sticker or wristband with small microchips that can be read by mobile devices in range. Information is stored in these microchips.

normal acceleration: The component of the acceleration vector of a point in the vehicle in the z-direction. The normal acceleration is positive in a downward direction.

occupant size classification: The right front passenger, the classification of an occupant as an adult or a child occupant, and for the driver, the classification of the driver as being or not being a small female.

odometer: An instrument for measuring the distance traveled by a vehicle.

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odometer fraud: The illegal practice of rolling back an odometer to make it appear that a vehicle has lower mileage than its actual mileage.

post-crash: Condition inside/outside a vehicle following a crash.

pre-crash: Condition inside/outside a vehicle prior to a crash.

pretensioner: A device that is activated by a vehicle's crash sensing system and removes slack from a vehicle belt system.

record: The process of storing data into volatile memory for later use.

recorder: A device or method to detail action and/or reaction. *See:* **motor vehicle event data recorder (MVEDR)**.

safety belt status: This indicates if an occupant's safety belt is buckled or not buckled.

seat position: The position of a seat along the track for moving the seat in a forward or rearward direction.

side air bag: Any inflatable occupant restraint device that is mounted to the seat or side structure of the vehicle interior at or below the window sill, and that is designed to deploy and protect the occupants in a side impact crash.

side curtain/tube air bag: Any inflatable occupant restraint device that is mounted to the side structure of the vehicle interior above the window sill, and that is designed to deploy and protect the occupants in a side impact crash or rollover.

single-stage event: An event that is caused by a single trigger or the logical result of two or more triggers.

speed, vehicle indicated: The speed indicated on the vehicle's speedometer.

stability control: Any device that is not directly controlled by the operator (e.g., steering or brakes) and is intended to prevent loss of vehicle control by sensing, interpreting, and adjusting a vehicle's driving and handling characteristics.

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steering wheel angle: The angular displacement of the steering wheel measured from the straight-ahead position (position corresponding to zero average steer angle of a pair of steered wheels).

suppression switch status: The status of the switch indicating whether an air bag suppression system is on or off.

tampering: Means to modify, remove, render inoperative, cause to be removed, or to make less operative any device or element on a motor vehicle or motor vehicle power train, chassis, or body components that results in altering Federal Vehicle Motor Safety Standards (FMVSSs). Tampering involves the deliberate altering or adulteration of information, a product, or system.

telltale: A display that indicates the activation of a device, a correct or defective functioning or condition, or a failure to function. Telltales are considered visible when activated.

time to deploy: The elapsed time between time zero and the time when the inflator of a side air bag or side curtain/tube air bag is fired.

time to first stage: The status of the switch indicating whether an air bag suppression system is on or off.

time to n^{th} stage: The elapsed time between time zero and the time when the second stage of a frontal air bag is fired.

time zero: The beginning of the first 20-ms interval in which the trigger threshold is met during an event.

triage: At the time of a motor vehicle crash, the method or means of classification by which patients are directed to services by medical professionals based on the severity of their injuries.

trigger: This initiates the capture of data.

trigger threshold: A change in vehicle velocity—~~,~~ in the longitudinal direction for vehicles with only longitudinal acceleration measurements or in the horizontal plane for vehicles with both longitudinal and lateral measurements—~~,~~ that equals or exceeds 0.8 km/h with a 20 ms interval.

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vehicle class: A term that includes sedans, station wagons, ambulances, buses and trucks, or different categories of vehicles such as light vehicles, medium vehicles, and heavy vehicles.

vehicle identification number (VIN): As defined in 49 CFR 567, a set of about 17 alphanumeric characters, assigned to a vehicle at the factory and inscribed on a small metal label attached to the dashboard and visible through the windshield. VIN is a unique identifier for the vehicle and therefore is often found on insurance cards, vehicle registrations, vehicle titles, safety or emission certificates, insurance policies, and bills of sale. The coded information in the VIN describes characteristics of the vehicle, such as make, model, manufacturer, and other limited vehicle details.

vehicle identification number (VIN) modification: Use of an electronic device connected to the vehicle diagnostic link connector to modify the VIN to a value other than the number provided by the original manufacturer of the vehicle.

vehicle roll angle: The angle between the vehicle *y*-axis and the ground plane.

x-direction: In the direction of the vehicle *x*-axis, which is horizontal and parallel to the vehicle's longitudinal centerline. The positive direction is forward.

y-direction: ~~means in~~ The direction of the *y*-axis, which is horizontal and perpendicular to its *x*- and *z*-axes. The positive direction is to the right, as seen from driver's perspective.

z-direction: ~~In~~ The direction of the vehicle *z*-axis, which is vertical and perpendicular to its *x*- and *y*-axes. The positive direction is down.

3.2 Acronyms and abbreviations

ABS	anti-lock braking system
ACN	automatic collision notification
ADAS	advanced driver assistance system
AEB	automatic emergency braking

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ANSI	American National Standards Institute
APTA	American Public Transportation Association
ATA	American Trucking Association
AVL	automatic vehicle location
BI	bodily injury
CAN	controller area network
CDR	crash data recorder ~~retrieval tool~~
CFR	Code of Federal Regulations
CG	center of gravity
CLA	connector lockout apparatus
CMV	commercial motor vehicle
ComCARE	Communications for Coordinated Assistance and Response to Emergencies
CSS	child safety system
~~data BUS~~	~~electrical system installed in a vehicle that allows vehicle subsystems to communicate with each other~~
DC	direct current
delta-V	delta (change in) velocity, Δv
DGPS	Differential Global Positioning System
DOB	date of birth
DOT	Department of Transportation

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DRL	daytime running lights
~~ESN~~	~~electronic serial number~~
EBV	equivalency barrier velocity
ECM	electronic control module
ECU	electronic control unit
EDR	event data recorder
EEPROM	electronically erasable programmable read-only memory
EIA	Electronic Industries Alliance ~~Association~~
EMI	electromagnetic interference
EMS	emergency medical services
EPROM	electronically programmable read-only memory
FARS	Fatality Analysis Reporting System
FCW	forward collision warning
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FMVSS	Federal Motor Vehicle Safety Standard
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
GIS	Geographic Information System
GNSS	Global Navigation Satellite System

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GPS	Global Positioning System
HDOP	horizontal dilution of precision
IC	integrated circuit
ID	identifier
~~IEEE~~	~~Institute of Electrical and Electronics Engineers~~
I/O	input/output
IR	infrared electromagnetic spectrum
ISO	International Standards Organization
ITE	Institute of Transportation Engineers
ITS	intelligent transportation system
IVHS	Intelligent Vehicle Highway Systems
IVN	in-vehicle network
JPL	Jet Propulsion Laboratory, California Institute of Technology
LDW	lane departure warning
LKS	lane keeping support
MVEDR	motor vehicle event data recorder
MVEDRCLA	motor vehicle event data recorder connector lockout apparatus
NAT	Network Analysis Tool
NCHRP	National Cooperative Highway Research Program
NDEF	NFC Data Exchange Format

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NFC	near field communication
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
NTCIP	National Transportation Communications for ITS Protocols
OBD	on-board diagnostic
OEM	original equipment manufacturer
OSI	Open Systems Interconnection
PCMCIA	Personal Computer Memory Card Industry Association
PDOF	principal direction of force
PRNDL	~~transmission gear position (P =~~ park, ~~R =~~ reverse, ~~N =~~ neutral, ~~D =~~ drive, ~~L =~~ low (transmission gear position)
PIP	personal injury protection
~~R & D~~	~~research and development~~
RAM	random access memory
RCM	restraint control module
~~RF~~	~~radio frequency~~
RFCSS	rear-facing child safety system
RFI	radio frequency interference
RTD	Record Type Definition
~~ROM~~	~~read-only memory~~

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~~RP~~	~~recommended practice~~
SAE	Society of Automotive Engineers
~~SSN~~	~~Social Security number~~
TCIP	Transit Communications Interface Profiles
TMC	The Maintenance Council of the American Trucking Association
TPMS	tire pressure monitoring system
TRB	Transportation Research Board
UIM	underinsured motorist
UM	uninsured motorist
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
USB	universal serial bus
UUID	Universally Unique Identifier
WGS	World Geodetic System
WSB	wheel speed base~~based~~

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4. Applicability

4.1 Background

This standard shall benefit many different constituencies and applications including: automakers, automotive suppliers, academia, state and local department of transportation agencies, highway operations, transportation operators, vehicle safety regulators, accident investigators, law enforcement agencies, insurance companies, human factors researchers, emergency medical services, motorcycle manufacturers, school bus manufacturers, motor-coach manufacturers, transit agencies, fleet owners, and transit manufacturers.

4.2 Rationale for the development of this standard via use cases

The purpose of developing use-case scenarios is to establish a basis for making better, more informed decisions about the need for recording specific data elements and attributes, requirements for data accessibility, and overall (or high-level) design requirements. Essentially, the more that is known about how crash data can and will be used by various ~~"~~users,~~"~~ the more intelligently the recording requirements can be assembled. The use-case scenarios endeavor to provide the following:

a) Brief description of the user's overall "business."

b) Description of the user's "role" and objectives as related to automotive crashes/accidents.

c) How does the user fulfill the role/objectives currently?

d) What are the current challenges, problems, and issues facing users as they try to fulfill their role and meet their objectives?

The use-case scenario provides examples of how a motor vehicle event data recorder (~~an~~ MVEDR) might be used to address the current challenges and ~~"~~problems~~"~~ faced by the user, specifically:

— The questions and/or decisions that the user hopes to address with information obtained from MVEDRs.

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— The analysis methodology needed to address the questions.

— The specific data elements needed to support the analyses or to answer the questions confronting a particular end-user group.

— How "accurate" does the data need to be?

— What is the appropriate time period for recording the data?

The output of use-case scenarios are used to help identify and prioritize the data elements to be defined and included in this standard, as well as help to establish overall design requirements including data extraction standards.

4.3 International use of MVEDR data

Users of MVEDR data include, but are not limited to, the following:

a) Global development of treaties on roads and transport

b) Reports on international road safety

c) Government transport agencies

d) International road safety databases

e) Country-specific road safety issues

f) Regional road issues

g) International organizations on road safety

h) United Nations road safety initiatives

i) European Union road safety initiatives

j) Organization for Economic Co-operation and Development (OECD)

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k) International non-governmental organizations

l) World Health Organization (WHO) road safety initiatives

4.4 Summary of user group perspectives

4.4.1 Overview

This subclause presents use-case summaries for the following groups:

— 4.4.2 ~~4.3.1~~ National Transportation Safety Board (NTSB)

— 4.4.3 ~~4.3.2~~ General crash research and defect investigation community

— 4.4.4 ~~4.3.3~~ Automotive industry

— 4.4.5 ~~4.3.4~~ Emergency response community

— 4.4.6 ~~4.3.5~~ Roadside/infrastructure design community

— 4.4.7 ~~4.3.6~~ Insurance industry

4.4.2 National Transportation Safety Board (NTSB)

The NTSB is an independent federal agency responsible for investigating every civil aviation accident in the United States ~~U.S.~~ and significant accidents in the other modes of transportation: railroad, highway, marine, and pipeline. The Safety Board determines the probable cause of these accidents and issues safety recommendations aimed at preventing future accidents. The Safety Board's work in this discussion is limited to its highway crash investigation activities, and specifically, to the collection of data by the Vehicle Factors/On-Board Recorder Group Chairman and the analysis of the data by its Office of Research and Engineering. Through its investigations, the Safety Board's objective is to obtain quantitative data of high quality and fidelity in order to improve transportation safety for the general public. The depth and breadth of the Safety Board's investigations are of the highest technical and analytical levels possible.

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During the initial portion of a Safety Board highway crash investigation, the Vehicle Factors/On-Board Recorder Group Chairman identifies sources of recorded information ([such as engine electronic control modules [(ECMs])] on the vehicle(s) involved. Currently, data extraction is usually not performed by Safety Board personnel, but by a party to the investigation with the Safety Board's participation. The Vehicle Factors/On-Board Recorder Group Chairman prefers to have the data extracted while the device remains in the vehicle and connected to its data sources. In the event that data from an ECM is extracted by the manufacturer, the ECM may be connected to a vehicle "simulator."

The recovered data is then used to corroborate physical and other evidence with vehicle performance data, to diagnose and troubleshoot vehicle and systems defects, and as a data source when a driver is not available to be interviewed. The data is also supplied to performance engineers from the Office of Research and Engineering to use in software simulations of vehicle and, possibly, occupant kinematics during a crash sequence. The process of simulation consists of matching physical evidence from scene and vehicle recorder data, starting with known data, and then using engineering calculations and physics to determine other critical parameters. The simulation process begins by building a three-dimensional scene, including the roadway (which itself is surveyed and drawn with AutoCAD). The performance engineers build the vehicle next, starting with the physical dimensions ([size, weight(s), center of gravity location, passenger or freight loading)] and its engine (from design and performance curves as a function of engine speed in r/min). They assign stiffness parameters and solve equations of motion as a function of time. One of the products of the simulation is the crash pulse—the acceleration-time history of the vehicle.

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The software can then be used to simulate the occupants. This begins with a definition of planar or ellipsoid contact surfaces defining the space surrounding the occupant. The occupant, defined as a fully jointed human model, must start at equilibrium within the vehicle. Interactions with contact surfaces are defined for each occupant. The crash pulse is used to "drive" the vehicle through the accident. As the vehicle accelerates or decelerates, the occupant has a speed differential with the vehicle that defines the impact forces and thus the predicted injury levels. Parametric analyses can then take place based on assumptions of differential stiffness of seats, occupant restraints, etc. Unfortunately, many assumptions are necessary for both the vehicle and occupant model. More specific information concerning the vehicle dynamics, accelerations, and motions would enable a more thorough evaluation of the occupant motion and, in the long run, enable designers to develop a safer vehicle. MVEDRs may provide much of this information.

The Safety Board has had success with the recovery of recorded data in a number of accidents. In one investigation, the data recorded in an air bag electronic control unit (ECU) was critical in understanding a crash involving a passenger car and commercial motor vehicle. In that case, the data indicated the truck underride device caused the passenger car to decelerate at a rate lower than that required to activate the air bag. The Safety Board also had success extracting data from multiple sources in the Canon City, Colorado, motor-coach accident. In this accident, the motor coach lost control on slippery pavement on a steep downgrade. Recorded data was recovered from the ECM as well as the ECU from the anti-lock braking system (ABS). The recorded data highlighted factors related to the initial loss of control, that the motor coach was placed in neutral, braking was used infrequently, and the motor coach accelerated to about 70 mi/h before losing control in a curve. Nonetheless, more data on steering inputs, force of brake applications, and time stamping of fault codes would have further helped investigators and more focused safety recommendations may have resulted.

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Despite the Safety Board's successes, investigations such as the Bourbonnais, Illinois, railroad grade crossing accident illustrate accidents that would have greatly benefited from EDR data. In that particular case, steering data would have made a significant difference in determining whether a truck driver had gone around the gate at the grade crossing. Corroboration of other evidence would be a key advantage to the use of EDR data. Although recorded data is never used in isolation, information from an EDR could affect the focus of an investigation. Use of EDR data for diagnoses and troubleshooting is an emerging technology. As vehicle systems become more complex and interconnected, there is an increasing concern that unanticipated conditions or combinations of events could have unintended consequences. Examples include an ECM fault preventing the engine from being powered properly or a fuel pressure-related shutdown.

Further, analyses are time and resource intensive. Typically, simulation modeling usually takes 3 months to 6 months, but some complex simulations can take more than a year. If additional data were recorded, the Safety Board would be able to perform more thorough and cost-effective investigations. The analyses would be more accurate and could be accomplished in a shorter period of time. As a result, safety improvements could be identified and implemented sooner, thus benefiting the transportation community and the general public.

In general, the use of MVEDRs outweighs the cost of crashing $500,000 motor coaches or other expensive vehicles to obtain crash information and product performance. Further, currently, much of the occupant protection system is designed based on the results of crash tests. Some research is being focused at determining real-world accident scenarios and resulting injury patterns, but the dynamics of the vehicle are often not fully known. Crash pulse data would allow designers and engineers to develop safety improvements based on the real-world crash environment rather than only on a laboratory setting.

For the purposes of heavy vehicle crash investigations, the Vehicle Factors/On-Board Recorder Group concurs with the recommendations of the National Highway Traffic Safety Administration (NHTSA) Truck and Bus Working Group report. However, in some instances, a lower resolution (i.e., fewer samples per second) could work for some data elements.

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The Office of Research and Engineering ~~users~~ provided a general list of data elements that would have to be tailored depending on vehicle type. For vehicle performance: steering in 20 degree to 30 degree increments (based on ~~upon~~ the steering ratio for heavy vehicles), hard maneuvers, data on rear steerable axles on motor coaches; braking (time of application, pulses, pressure, temperature, ABS activity, and time-stamped fault codes; stability control timing and force; retarder on/off and settings); transmission gear (from design and performance data as a function of speed in r/min, also fault codes and time stamps); throttle (from the driver's point of view); tire pressure, failure (pressure, time); crash pulse recording time at high sampling rates (passenger car: at least 100 ms; commercial motor vehicle: could be 100 ms to 300 ms; rollover: could last up to 4 s); linear and angular accelerations to determine how many times a vehicle rolled (Δv in x, y, z; the z-axis data is needed for rollover; and to obtain occupant position and protection information). Acceleration sensors should be measured at "known" positions, at a rigid location, and preferably at the vehicle's center of gravity. Aside from the vehicle data, Δv data is also useful when considering highway design issues ([~~(~~correct super-elevation, design versus ~~vs.~~ as-built, proper signs and appropriate posted speed limit [~~(~~several recent accident sites have had speed limits raised above the initial design speeds])~~]~~. Additional useful data elements would be: location of impact (usually measured in field, Δv data would help); the direction of vehicle (with respect to magnetic north); and the geographic location (where the initiating event occurred).

The Office of Research and Engineering ~~users~~ believe it would be desirable for data sampling rates to be targeted for the system (i.e., type of vehicle), and to be able to "bracket" the events of interest. The data collection rate should be at least 50 Hz, preferably >1000 Hz after crash initiated. The MVEDR should trigger "above what a vehicle is physically capable of on its own." It should also sample at rates higher than human input and provide for multiple events and time overlap. Finally, the recording period could vary according to various preset conditions: brake temperature could be saved (buffered), and the data would be saved for a longer period if a threshold were exceeded; brake application, nominally set at 1 s intervals within 1 min to 2 min of hard braking, could be reset while the vehicle is traversing a severe downgrade to 30-s intervals over a 6-min to 12-min period.

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In terms of data accessibility and extraction, the Vehicle Factors/On-Board Recorder Group would like the ability to download through a database, using standard data collection, transmission, acquisition, and preservation protocols. Additional concerns of the Vehicle Factors/On-Board Recorder Group include MVEDR physical integrity. In particular, the current location of recording devices (i.e., ECMs) is generally acceptable, but the fire-resistance qualities should be improved. Further, there are some limitations of the current sources of recorded data. For example, vehicle ECMs are not foolproof; they can be reprogrammed to alter basic data (vehicle identification number [VIN] codes) and change operating parameters, and there can be differences between ECM data and what is on the vehicle.

4.4.3 General crash research and defect investigation community

The scope and level of detail of crash research and defect investigations vary considerably, depending on ~~upon~~ the type of research or investigations being conducted. For example, manufacturers may conduct research to determine the performance of prototypes or new vehicles. On the other hand, crash investigators are more likely to focus on determining the sequence of events leading to a crash, possibly including the factors leading to the crash and an assignment of proximate cause. An organization investigating an allegation of a vehicle defect would be very detailed in its quest for information, but would typically only address the specific component or its relationship to a safety-impacting situation. The role of these users is to improve the safety of the motoring public through the continuous improvement of motor vehicles. This is accomplished by observing the safety performance of the vehicle when it is in operation. These users' responsibilities could involve assessing a new car's safety performance, investigating a crash, or investigating an alleged design or manufacturing defect.

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MVEDR role in addressing needs: The role of the MVEDR is to capture and store data that cannot be determined readily or accurately using other means. For example, MVEDR data can/could be used to determine specific elements critical to an investigation, such as air bag deployment level, which cannot be assessed quantitatively from the crash evidence. It can/could also be used to improve analysts' ability to assess crash severity and the impacts on vehicle occupants, adding to the value of crash reconstruction software. MVEDR data could also be invaluable to determine information on the use and deployment of safety devices and other vehicle systems, such as safety belt status, information that is often lost due to immediate attendance to an individual's needs directly after the crash.

Specific data elements: Data needs vary by the type and purpose of the crash investigation. An investigator assessing an alleged vehicle defect would need data associated with the allegation. A researcher developing an improved air bag system would need data related to its operation. The list of potentially useful data elements is as long and varied as the uses for the data. In 2001, NHTSA's Special Crash Investigation office published an enhanced safety of vehicles (ESV) paper detailing MVEDR data it thought would be of interest for investigating vehicle crashes. A list of those recommendations, including data elements, is found in Table 1. In an effort to assess the needs of defect investigators, informal interviews were conducted. While these interviews are the opinions of the investigators and not the agencies they work for, they give some insight into the needs. Table 2 provides a list of data elements.

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Table 1 —Research recommendations for MVEDRs data collection ~~[B6]~~

(Chidester, Hinch, and Reston [B7])

Data collection
•Lock the deployment record data in electronically erasable programmable read-only memory (EEPROM) such that the data cannot be erased, altered, or cleared by service or crash investigation personnel. • Use SAE J211/1 protocol for collecting data. • Locate the MVEDR in a crash-survivable location while still providing post-crash inspection accessibility. • Ensure sufficient auxiliary power is available to record the entire crash sequence even when the vehicle's electrical system is damaged. • Employ a single universal crash data retrieval tool for downloading data. • The universal crash data retrieval tool should be able to be connected directly to the MVEDR for downloads. • Record data for at least two events.
Pre-crash data graph
• Record vehicle speed for 10 s before algorithm enable (km/h or m/min). • Record engine speed for 10 s before algorithm enable (r/min). • Record throttle position for 10 s before algorithm enable. • Record the brake switch circuit status for 10 s before algorithm enable (on/off). • Record the actuation of ABS for 10 s before algorithm enable (on/off).
At crash data
• Record the status of the warning lamp (on/off). • Record the driver and passenger belt switch status (buckled/unbuckled). The seat belt usage data should be recorded and stored in random access memory (RAM) at algorithm enable. • Record the driver and passenger air bag suppression switch status (on/off). • Record the ignition cycle at deployment. • Record the ignition cycle at investigation. • Record the air bag deployment level: first-stage or second-stage deployment. • Record the time from algorithm enable to air bag first-stage or single-stage deployment. • Record the time from algorithm enable to air bag second-stage deployment. • Record the time from algorithm enable to driver and passenger pretensioner deployment. • Record the time between the two event files if they are in the same ignition cycle. • Record the driver and passenger seat position. • Record the data from the passenger seat weight/position sensor.
Crash pulse graph
• Record at least 300 ms of crash pulse deceleration data recorded as multiples of g_n in 1-ms intervals for at least two events. • Record both the longitudinal and lateral axes data.

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Data collection
• Lock the deployment record data in EEPROM such that the data cannot be erased, altered, or cleared by service or crash investigation personnel. • Use SAE J211 protocol for collecting data. • Locate the MVEDR in a crash survivable location while still providing post-crash inspection accessibilty. • Ensure sufficient auxiliary power is available to record the entire crash sequence even when the vehicle's electrical system is damaged. • Employ a single universal crash data retrieval tool for downloading data. • The universal crash data retrieval tool should be able to be connected directly to the MVEDR for downloads. • Record data for at least two events.
Pre-crash data graph
• Record vehicle speed for 10 s before algorithm enable (km/h or m/min). • Record engine speed for 10 s before algorithm enable (r/min). • Record throttle position for 10 s before algorithm enable. • Record the brake switch circuit status for 10 s before algorithm enable (on/off). • Record the actuation of ABS for 10 s before algorithm enable (on/off).

(Deleted)

Table 1—Research recommendations for MVEDRs data collection [B6]

(continued)

At crash data
• Record the status of the warning lamp (on/off). • Record the driver and passenger belt switch status (buckled/unbuckled). The seat belt usage data should be recorded and stored in RAM at algorithm enable. • Record the driver and passenger air bag suppression switch status (on/off). • Record the ignition cycle at deployment. • Record the ignition cycle at investigation. • Record the air bag deployment level: first-stage or second-stage deployment. • Record the time from algorithm enable to air bag first-stage or single-stage deployment. • Record the time from algorithm enable to air bag second-stage deployment. • Record the time from algorithm enable to driver and passenger pretensioner deployment. • Record the time between the two event files if they are in the same ignition cycle. • Record the driver and passenger seat position. • Record the data from the passenger seat weight/position sensor.
Crash pulse graph
• Record at least 300 ms of crash pulse deceleration data recorded as multiples of g_n in 1 ms intervals for at least two events. • Record both the longitudinal and lateral axes data.

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Table 2 —Defect investigation data elements

Speed: Engine speed, vehicle speed from differential; final drive (ring and pinion—transfer case).
Brake use: Pedal (brake light switch—"circuit closed") and ABS sensors (for wheel lock/slippage), also ABS operating threshold (ABS does not work at very low speeds, below about 8 km/h to 13 km/h (5 mi/h to 8 mi/h).
Engine data: Engine temperature and manifold pressure data.
Transmission gear: Depends on the system whether to sense speed sensor or engine speed in r/min. Also want to see clutch in/out (clutch switch), deceleration curve (deceleration values over time).
Turn signals: On-line diagnostic cable to OBD II; also ECM.

4.4.4 Automotive industry perspective

One way to assess the data needed by the auto industry is to review the data currently being collected by several automotive companies. During the NHTSA-sponsored EDR Working Group, a list of automotive company data collection was developed. These ~~This~~ data are ~~is~~ presented in Table 3. There may be data collected by other automotive companies that~~, which~~ are not represented here.

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