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IEEE Standard for Motor Vehicle Event Data Recorders (MVEDRs)

IEEE Vehicular Technology Society

Sponsored by the
Motor Vehicle Event Data Recorder (MVEDR) Committee

IEEE

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IEEE Standard for Motor Vehicle Event Data Recorder (MVEDR)

Sponsor

Motor Vehicle Event Data Recorder (MVEDR) Committee
of the
IEEE Vehicular Technology Society

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Abstract: A performance standard for MVEDR data collection, storage, and retrieval, to ensure that comparable event data parameters are generated by all vehicles, is described.
Keywords: crash data, event data recorder, motor vehicle

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Introduction

[This introduction is not part of IEEE Std 1616-2004, IEEE Standard for Motor Vehicle Event Data Recorder (MVEDR).]

In 2000, over 16 million motor vehicle crashes occurred in the U.S., damaging over 27.6 million vehicles and injuring 5.3 million persons. With a crash occurring every two seconds, over 41,000 Americans die from fatal injuries annually. Motor vehicle crashes are the leading killers of Americans under the age of 34 and the leading cause of major brain and spinal injuries.

The impact of motor vehicle crashes on a society is enormous. For 2000, the National Highway Traffic Safety Administration (NHTSA) estimated the cost of crashes at well over 1/2 billion dollars a day, totaling $230 billion annually. These costs include property damage, medical care, insurance administration, emergency services, legal and court costs, travel delay, productivity losses, and costs to employers.

According to the European Transport Safety Council, the numbers in EU countries are quite similar—43,000 die and over 3.5 million are injured annually, with motor vehicle injuries being the leading cause of death and hospital admission for citizens under 45. Globally, vehicle crashes are the single largest cause of death of men between the ages of 15 and 44 and the ninth disease burden worldwide. Currently, worldwide, one person dies every minute of the day in a motor vehicle crash. The World Heath Organization projects that by the year 2020 road traffic injuries will be the third highest burden of disease in the world.

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 P1616 Working Group of IEEE 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.

Some users and uses 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.

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— *Insurance industry:* Help to identify fraudulent claim, 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 and 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 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.

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IEEE Standard for Motor Vehicle Event Data Recorder (MVEDR)

1. Overview

1.1 Scope

MVEDRs collect, record, store, and export data related to motor vehicle predefined events. 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. It is applicable to 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 into the vehicle.

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. 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 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

[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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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 personal identification information available, which can potentially include one, or more of the following:

1) Driver or occupant name or the equivalent
2) Event place, date, and time
3) Precise Global Positioning System (GPS) coordinates
4) Wireless telephone number or electronic serial number (ESN)
5) Complete vehicle identification number (VIN)
6) Unique MVEDR serial number

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.

1.4 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, References, gives the references 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.

Clause 6, Output, defines common interfaces that may be utilized to extract MVEDR data.

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 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.

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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, MVEDRs and implementation of ACN systems, explains the connection between the two emerging technologies.

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

1.5 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. References

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.

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.[3]

FMVSS 208, Occupant Crash Protection.[4]

FMVSS 214, Side Impact Protection.

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

[3]EIA publications are available from Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112, USA (http://global.ihs.com/).

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

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FMVSS 301, Fuel System Integrity.

IEEE/ASTM SI 10™-2002, American National Standard for Use of the International System of Units (SI): The Modern Metric System.[5]

ISO 2575:2004, Road Vehicles—Symbols for Controls, Indicators, and Telltales.[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 Signalling.

ISO 11898-2:2003, Road Vehicles—Controller Area Network (CAN)—Part 2: High-speed Medium Access Unit.

ISO 12353-2:2003, Road Vehicles—Traffic Accident Analysis—Part 2: Guidelines for the Use of Impact Severity Measures.

SAE J211/1-2003, Instrumentation for Impact Test—Part 1: Electronic Instrumentation. *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

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

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

3.1.3 capture: The process of saving recorded data.

[5]IEEE publications are available from the Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, Piscataway, NJ 08854, USA (http://standards.ieee.org/).

[6]ISO publications are available from the 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 (http://www.ansi.org/).

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

[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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3.1.4 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.

3.1.5 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.

3.1.6 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).

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

3.1.8 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.

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

3.1.10 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.

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

3.1.12 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.

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

3.1.14 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.

3.1.15 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.

3.1.16 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.

3.1.17 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.

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3.1.18 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.

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

3.1.20 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.

3.1.21 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 MVEDR.

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

3.1.23 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.

3.1.24 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.

3.1.25 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 ACN system.

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

3.1.27 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.

3.1.28 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.

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

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

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

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

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

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

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

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3.1.36 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.

3.1.37 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.

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

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

3.1.40 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.

3.1.41 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).

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

3.1.43 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.

3.1.44 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.

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

3.1.46 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.

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

3.1.48 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.

3.1.49 trigger: This initiates the capture of data.

3.1.50 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.

3.1.51 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.

3.1.52 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

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bills of sale. The coded information in the VIN describes characteristics of the vehicle, such as make, model, manufacturer, and other limited vehicle details.

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

3.1.54 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.

3.1.55 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.

3.1.56 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
APTA	American Public Transportation Association
ATA	American Trucking Association
AVL	automatic vehicle location
BI	bodily injury
CAN	controller area network
CDR	crash data retrieval tool
CFR	Code of Federal Regulations
CG	center of gravity
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

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DOT	Department of Transportation
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 Association
EMI	electromagnetic interference
EMS	emergency medical services
EPROM	electronically programmable read-only memory
FARS	Fatality Analysis Reporting System
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
GPS	Global Positioning System
IC	integrated circuit
ID	identifier
IEEE	Institute of Electrical and Electronics Engineers
I/O	input/output
IR	infrared electromagnetic spectrum
ISO	International Standards Organization

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ITE	Institute of Transportation Engineers
ITS	intelligent transportation system
IVHS	Intelligent Vehicle Highway Systems
JPL	Jet Propulsion Laboratory, California Institute of Technology
MVEDR	motor vehicle event data recorder
NAT	Network Analysis Tool
NCHRP	National Cooperative Highway Research Program
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)
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
ROM	read-only memory
RP	recommended practice
SAE	Society of Automotive Engineers
SSN	Social Security number

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TCIP	Transit Communications Interface Profiles
TMC	The Maintenance Council of the American Trucking Association
TRB	Transportation Research Board
UIM	uninsured claim for the insured against a third party
UM	uninsured motorist
USB	universal serial bus
WGS	World Geodetic System
WSB	wheel speed based

4. Applicability

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.

4.1 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:

1) Brief description of the user's overall "business"
2) Description of the user's "role" and objectives as related to automotive crashes/accidents
3) How does the user fulfill the role/objectives currently?
4) 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 an MVEDR might be used to address the current challenges and "problems" faced by the user, specifically:

1) The questions and/or decisions that the user hopes to address with information obtained from MVEDRs.
2) The analysis methodology needed to address the questions.
3) The specific data elements needed to support the analyses or to answer the questions confronting a particular end-user group.
4) How "accurate" does the data need to be?
5) What is the appropriate time period for recording the data?

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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.

4.2 International use of MVEDR data

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

1) Global development of treaties on roads and transport
2) Reports on international road safety
3) Government transport agencies
4) International road safety databases
5) Country specific road safety issues
6) Regional road issues
7) International organizations on road safety
8) United Nations road safety initiatives
9) European Union road safety initiatives
10) Organization for Economic Co-operation and Development (OECD)
11) International non-governmental organizations
12) World Health Organization (WHO) road safety initiatives

4.3 Summary of user group perspectives

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

4.3.1 National Transportation Safety Board (NTSB)

4.3.2 General crash research and defect investigation community

4.3.3 Automotive industry

4.3.4 Emergency response community

4.3.5 Roadside/infrastructure design community

4.3.6 Insurance industry

4.3.1 National Transportation Safety Board (NTSB)

The NTSB is an independent Federal agency responsible for investigating every civil aviation accident in the 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.

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

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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.

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 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.

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 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

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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.

The 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 to 30 degree increments (based 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 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 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 to 2 min of hard braking, could be reset while the vehicle is traversing a severe downgrade to 30 s intervals over a 6 to 12 min period.

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 (VIN codes) and change operating parameters, and there can be differences between ECM data and what is on the vehicle.

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4.3.2 General crash research and defect investigation community

The scope and level of detail of crash research and defect investigations vary considerably, depending 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.

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.

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

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).

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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.

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.

4.3.3 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. This data is presented in Table 3. There may be data collected by other automotive companies, which are not represented here.

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Table 3—Summary of EDR systems, circa 1999, from NHTSA EDR WG Report

Category	GM	Ford	DCX	Honda	Toyota	Volkswagen
Application	Started MY99 w/ phases in	Internal fleet only for crash research	TBD	TBD	Started MY 01 w/ phases in	TBD
Air bag type deployed (dual-stage)	Y	Y	Y	Y	Y	Y
Ignition cycle counter	Y	Y	Y	Y	Y	Y
Seat belt	Y (driver only)	Y	Y	Y	Y	Y
Occupant sensing	No	Y	Y	Y	Y	Y
Air bag warning lamp	Y	Y	Y	Y	Y	Y
Engine r/min	Y (5 s pre-impact)	TBD	TBD	No	Some cars	Yes
Throttle position	Y (5 s pre-impact)	TBD	TBD	No	Some cars	Yes
Brake applied	Y (5 s pre-impact)	TBD	TBD	No	Some cars	Yes
Vehicle speed	Y (5 s pre-impact)	TBD	TBD	No	Some cars	Owners choice by dealer pro-gramming
Crash pulse information	Δv at 10 ms intervals	Actual decel-eration pulse at 1 ms intervals	No	Partial Δv	Δv at 10 ms intervals	Decelera-tion, rate, and duration

Specialists with the proper training and equipment may now download and analyze the data on their own. Previously, the CDRs had to be downloaded by the CDR manufacturer. There have been several generations of MVEDR systems, each recording a unique set of data variables. Table 4 and Table 5 present a list of variables typically collected by these two manufacturers. Note that these lists may not include all data collected and outputted, nor do systems installed by these manufacturers record and store all these variables in every unit. These data represent a typical set of data elements.

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Table 4—Data collected and downloadable by Ford Systems

Acceleration, *x*-axis
Acceleration, *y*-axis
Left (driver) side air bag
Right (pass) side air bag
Pass suppression switch
Air bag warning lamp
Time, wakeup to pretensioner
Time, wakeup to 1st stage, unbelted
Time, wakeup to 1st stage, belted
Time, wakeup to 2nd stage
Restraint, driver
Restraint, passenger
Driver seat forward
Pass seat weight sensor
Time, wakeup to pretensioner, driver
Time, wakeup to pretensioner, passenger
Time, wakeup to 1st stage, driver
Time, wakeup to 1st stage, passenger
Time, wakeup to 2nd stage, driver
Time, wakeup to 2nd stage, passenger

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Table 5—Data collected and downloadable by GM systems

Speed
Brake
r/min
Throttle pos
Δ*v*, long
Warning lamp
Driver belt
Ignition cycles
Ignition cycles, investigation
Max Δ*v*, long
Time, enable to 1st stage, driver
Time, enable to 2nd stage, passenger
Time, enable to 1st stage, driver
Time, enable to 2nd stage, passenger
Time between near deploy and deploy events
Frontal deployment level event counter
Event recording complete
Multiple events associated with this record
Multiple events not recorded

4.3.4 Emergency response community

Although the WG devoted significant time and attention towards understanding the technical issues of standardizing a rapid download method specific to the needs of the real-time emergency medical services (EMS) community, many issues associated with the technical specifications remain unsettled despite the best efforts of the WG. This standard provides a comprehensive EMS use-case scenario, a recommended table of suggested EMS data elements (including ACN), technical specifications for a telltale, and an informative Annex D specific to EMS.

Emergency medical response users are the medical personnel who respond to the scene of a motor vehicle crash, assess crash victims for injuries, estimate the severity of the crash, begin treating the victims, and make decisions about how to transport victims to the "right hospital, in the right way, and in the right time frame." The decision process they use is based on local, state, or national trauma triage guidelines. National and state trauma triage guidelines already use *guess-estimates* of mechanism of injury, such as crash severity, to guide EMS personnel. Crash severity data helps ensure that crash victims are transported and treated appropriately—there is evidence this reduces crash-related deaths.

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The direct "customers" being served by the MVEDR data is: the EMS personnel, the hospitals and the victims of the crash. In many cases, the owner of the vehicle will be one of the victims of the crash. The victims of the crash benefit from better triage decisions that result in better outcomes. The hospitals treating the patients benefit by receiving better information about the severity of crashes so that it is less likely that "hidden" injuries will be overlooked. It is anticipated that insurers also will benefit by improvements in matching crash victims to the right type of transport and right level of hospital.

4.3.4.1 EMS's role and objectives as related to automotive crashes

Presently, EMS personnel must guess-estimate the severity of crash from a visual assessment or "word of mouth" descriptions at the scene of a crash in order to triage patients. MVEDR data that more objectively describes the severity of the crash will help improve the triage decision process. Some serious injuries from car crashes are obvious and outwardly visible, and some are initially "hidden" (such as internal head or abdominal organ injuries). Using guess-estimates, EMS personnel are more likely to improperly estimate the severity of a crash than if they had more objective data. If the severity of a crash is underestimated, serious (e.g., internal or hidden) injuries may be overlooked at the scene of a crash, with life-threatening consequences.

Underestimates of the crash severity can lead to the "under-deployment" of the EMS system. For example, a ground ambulance may be called to transport a seriously injured patient to a community hospital instead of an air medical helicopter that would transport the patient to a Level I trauma center. If an injured person is taken to a hospital that does not have the staff or resources or operating room to treat their injuries, their risk of having complications or dying can increase. EMS may find it useful to have a flag indicating whether brake application had taken place before or after impact. Did the crash occur because the driver was unconscious (or unresponsive) or is the driver unconscious because of the crash? This can alert EMS to look for underlying medical problems as well as trauma problems during triage.

EMS response is time critical. There is a short time frame, the so-called *golden hour* in trauma care, to make triage decisions. A mistake in triage decisions can result in delays in key treatments and poorer outcomes, such as higher death rates. A delay in recognizing life-threatening injuries may result in the victim being transported to a hospital that does not have the resources or specialized staff to treat the injuries. How might MVEDRs address the current challenges and problems facing the EMS community? A priority download of key and objective MVEDR data that is obtained in a quick and easy manner at the scene of a crash will replace the current guess-estimates of crash severity by EMS personnel. This information will, in the short term, help answer the following questions at the scene of a crash:

1 How severely injured is each occupant of the vehicle? Risk of injury based on: severity of crash, vital signs, anatomic injuries.

2) Is a vehicle occupant with or without outward signs of injury still at high risk of a life-threatening internal injury, based on the severity of the crash, restraint use, etc.?

3) Given the risk of serious injury, what is the right way to transport the injured person to the hospital? Ground ambulance? Basic life support or advanced life support? Air medical helicopter?

4) What level of hospital does the injured person need? Community hospital; mid-level trauma center—Level II or III trauma center; highest level trauma center—Level I trauma center?

The EDR design community would provide the technical method for accessing key standardized data in a quick and easy manner at the scene of a crash. The EMS community would derive significant benefits from being able to rapidly access key items of data, in standardized formats, at the scene of a crash. This data would be output in a "raw" manner in standardized physical units. However, the clinical algorithms for the use of the data would reside outside the vehicle. The algorithms would translate the physical units into information that is understood by the medical community. The medical community would develop algorithms for proper triage based on the severity of the crash and the clinical assessments at the scene. The data would be incorporated into the EMS patient care report and ultimately the hospital medical record. As more data becomes available, it will be possible to refine the triage algorithms over time.

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Table 6—Recommended data needs for EMS

Data element	Accuracy or sample rate	Time period	Justification
Time	Hours & minutes	At trigger	To assess EMS response time
Date	Calendar	At trigger	To assess EMS response time
VIN	17 character	Status prior to trigger	Matching of injured person with correct vehicle
Location (lat/long)	WGS1984 GPS high resolution	Status prior to trigger	Evaluate serious injury crash locations; for use by ACN systems to summon assistance.
3-axis acceleration	High resolution	During crash pulse	To determine impact direction and severity in order to assess probability of injury
Direction of force	High resolution	During crash pulse	To determine impact direction and severity in order to assess probability of injury
Restraint use, each occupied seat position	Yes/No	Status prior to trigger	Factor needed to assess possible severity of injury to each occupant
Air bag deployment(s), each occupied seat position	Yes/No/Disabled	Prior to and during crash pulse	Factor needed to assess possible severity of injury to each occupant
Number of occupants	Occupied seats	Prior to trigger	To determine number of persons in seat positions, allows a check for occupant ejection
Rollover	Flag	Prior to and during crash pulse	Might be determined from direction of force

4.3.4.2 Data accessibility and extraction

A dashboard or frontal area (i.e., rearview mirror location) mounted indicator shall be considered for a "check light" similar to those used by air bag systems, e.g., illuminating when the ignition key is turned to the ignition position. This light would indicate to the driver/owner that the system had passed its internal self-checks and that the MVEDR system is enabled for priority medical download use. It may be turned on and off by the driver if it is recognized that some vehicle owners will not want MVEDR features of any kind, including real-time medical use, activated. The system shall include a GPS circuit and offer continuous monitoring of seat belt usage, thereby providing the ability to record and store, for later retrieval and analysis, locations at which seat belt usage was detected. The visual telltale will provide a very quick and easy method that is needed for EMS personnel to access key data, such as seat belt usage, in a secure manner at the scene of a crash. This method should require minimal training. The access location should not require EMS personnel to use up valuable time hunting for it. The method should not require power from the vehicle. A priority download of the small number of data variables above is suggested for EMS personnel at the scene of a crash. For the data to be used to help treat victims of serious or fatal level crashes, the survivability of the MVEDR should be set at a level to cover a very high percent of these crashes. This requires survivability thresholds that exceed FMVSS 208 and 214.[10] See Annex D for additional information.

[10]Information on references can be found in Clause 2.

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4.3.5 Roadside/infrastructure design community

4.3.5.1 Description

This group includes researchers and engineers who focus on how the design of the roadway and roadside impacts the frequency and severity of automobile accidents. The effort to improve safety can be general and system-wide or specific to a particular site and/or design element. For instance, a system-wide effort would address the roadway and roadside rollover problem, while a more specific venture may focus on the effectiveness of a particular type of guardrail end treatment. Evolution of vehicle design and operating characteristics, changes in vehicular safety technology, and the development of additional roadside hardware prompt continual research by the roadside and infrastructure design community.

4.3.5.2 Role and objectives

The responsibility of this group is the enhancement of automotive safety through the improvement of the design of roadways and roadside safety hardware. Although the approach methodology can vary significantly depending upon the intended goals, most studies in this area include an identification and quantification of the problem, development of relationships, development and testing of possible solutions, solution implementation, and finally, field evaluation.

Currently, most problem identification and quantification is accomplished using national accident databases (e.g., FARS, NASS/GES [B56],[11] and NASS/CDS [B55]), several roadside/roadway focused databases (e.g., HSIS [B21], LBSS), and specialized objective studies (e.g., NCHRP Project 17-11 [B60], NCHRP Project 22-14(02) [B62]). The development of relationships between automotive accidents and roadway/ roadside characteristics is typically facilitated using the same means as well as computer simulations to a more limited extent. For the development of possible solutions, finite element-based simulations are utilized in conjunction with full-scale crash tests to ensure that the proposed designs will perform as required. Then, in an ideal situation, the practicing design engineers will implement the solutions as they adhere to the suggested design guidelines. As it is impossible to predict or test all permutations of the solutions that may occur in the implementation phase, the field evaluation is used to ensure that the developed solutions are functioning as intended. Typically this is accomplished using roadside/roadway focused databases or specialized objective studies.

Problems in the roadside and infrastructure research area stem from a lack of complete understanding of the problem. Typically, this is a result of the data dichotomy: either there is a significant amount of data with a less than optimal level of detail or there is sufficient detail but not a significant quantity. Another noteworthy data challenge is the time frame for data collection. As current accident data collection is based on information gathered or estimated after the incidence of an automotive collision, researchers tend to lack confidence in the collected information.

4.3.5.3 Pertinence of MVEDR data

The success of roadside and infrastructure-related research is critically dependent upon the validity and consistency of collected crash data. To date, a majority of the data elements are collected or inferred after the occurrence of a vehicular crash and stored in state or nationally maintained databases. Analysis has historically been hindered by errors in the accuracy of the collected data as well as the lack of consistency between the information captured from database to database. MVEDR technology has the potential to augment the collection of these data elements as well as initiate the collection of elements previously not feasible to collect.

Although MVEDR technology will not replace all aspects of accident investigation, it has the potential to shift the accident data collection time frame closer to the interval in which the event occurs. Information

[11]The numbers in brackets correspond to those of the bibliography in Annex E.

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such as the initial vehicle speed, total change in velocity, and seat belt status may be obtained from these devices as it occurs during the event. This will aid researchers in obtaining a more accurate representation of the impact conditions and vehicular characteristics during an event. With a better understanding of the problem and the involved mechanisms, researchers will be better equipped to develop cost-effective solutions.

4.3.5.4 Data elements

An in-depth study regarding MVEDR data elements that could be utilized to support roadside safety research is being conducted under NCHRP Project 17-24 [B61]. By methodically examining existing accident database elements, conducting a literature review and consulting an expert advisory panel, the team assembled and prioritized a catalogue of candidate MVEDR data elements that could improve roadside safety research. The top 15 prioritized elements from this study are presented in Table 7, with an indication of whether the current state of the art supports collection.

Table 7—Roadside/infrastructure community prioritized potential MVEDR data elements

Priority	Variable description	Current technology	Technology does not exist now
1	Vehicle speed	X	
2	Vehicle yaw rate	X	
3	Location of the crash (GPS—includes latitude, longitude, state, county, and city or municipality)	X	
4	Longitudinal component of Δv	X	
5	Lateral component of Δv	X	
6	Vehicle roll rate	X	
7	Brake position		X
8	Crash pulse—lateral	X	
9	Crash pulse—longitudinal	X	
10	Acceleration—lateral (pre-crash)	X	
11	Acceleration—longitudinal (pre-crash)	X	
12	VIN	X	
13	Steering wheel angle		X
14	Manual belt status	X	
15	Compass heading	X	

4.3.6 Insurance Industry

4.3.6.1 Description

Insurance companies provide financial protection for their policyholders when an event occurs that damages property or injures people covered under the insurance policy. Policies may include payment of costs related to repairing the vehicle(s) in the subject accident, paying for injuries to the insured (personal injury

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protection or PIP), to a third party (bodily injury or BI), or to cover costs related to an under insured (UM) or uninsured claim for the insured (UIM) against a third party. Some states have contributory negligence or comparative liability laws which can affect the ultimate financial settlement of the claim (e.g., the "amount" a party contributed to the accident's occurrence affects their ability to recover for damages).

Insurance companies provide services to the businesses (commercial lines) and individuals (property and casualty or P&C). In general, the insurance companies want to understand what their legitimate financial exposure will be for the collision, and they want to quickly and efficiently resolve the claim for the parties involved. They want to provide good service to their insured at a reasonable cost and are contractually obligated to return the insured's vehicle to its pre-accident condition.

The insurance companies may want to know some or all of the following related to an auto collision to manage and/or investigate the claim(s):

1) What is the condition of the vehicle occupant(s) and what is the condition of the vehicle(s), to determine what services to provide (e.g., tow truck, rental car, medical services, etc.) for the insured and others immediately or shortly after the accident?
2) How did the accident happen and which party (or parties) contributed to the accident's occurrence?
3) Who was injured and what is the extent and prognosis of their injuries? Was the claimed injury likely to have been caused by the accident?
4) What is the level of damage to the vehicle(s) and can the vehicle(s) be repaired?
5) What other contributory factors were present, such as restraint usage, vehicle speeds prior to impact, driver visibility, distractions, etc.?

Insurance companies have claims professionals who handle claims. They will typically investigate, evaluate and negotiate the claim to its resolution. Often times, one person will review and resolve the property damage claims, and another person will evaluate and resolve any injury claims. As part of the claims resolution process, they may retain the services of other industry stakeholders, such as attorneys, engineering experts, etc., to help them review and resolve the claim. They historically have not had access to MVEDR data and are beginning to use the data as part of their claim investigation process.

4.3.6.2 Insurance company's role

Insurance companies have historically relied on the training and experience of their claims professionals to evaluate the claims presented to them. The claims professionals frequently review repair estimates, photos, and a description of the impact (from police reports, statements of the parties involved, etc.) to evaluate property damage, liability, and/or injury issues. MVEDR data is relatively new to the insurance industry and has not been used on a wide scale to evaluate collision severity, accident causation, and/or injury causation. Technologies have become available which make the use of the MVEDR data more viable for the insurance industry, and companies are learning how to use the information to better investigate auto collisions.

The industry has used various technologies to help in the claims evaluation process, and the Insurance Institute for Highway Safety has done testing to understand vehicle performance in terms of property damage and factors contributing to injuries for select models each year. The use of outside expertise (e.g., accident reconstructionists, biomechanics, etc.) to help understand and evaluate claims is frequently made on financial considerations on a claim-by-claim basis. Such expertise is generally expensive, particularly in relationship to the cost of settling the claim, so it is not used on a widespread basis.

Some of the challenges facing the insurance industry include the following:

1) Evolving auto technology, which makes vehicles more robust in terms of their ability to withstand impact forces with reduced damage from low velocity impacts, "crumple zone" technology to improve occupant injury outcomes at higher velocities, new headrest designs to reduce "whiplash" injury, etc.

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2) An increasing number of injury claims (33% increase) despite a decrease in the number of property damage claims (17% decrease) in auto insurance
3) An increased sophistication by those making injury and/or property damage claims
4) Pressure on financial results to manage claim costs and write better policies to manage their risks more effectively

MVEDR data can help the insurance companies to understand vehicle and occupant performance on a broader scale than is currently available today. On individual claims, MVEDR data can provide more information in understanding what happened to cause the accident and/or injury or if the injury was caused by a collision. Ultimately, MVEDR data can provide information to better understand and define collision events and allow the companies to have a better understanding of their risk in insuring a vehicle and/or driver.

4.3.6.3 Examples

The advent of availability of MVEDR data to the insurance companies allows them to address several issues by the use of the data. At the time of the crash, the insurance companies are one of the first to be notified of the accident. This early notification gives them the opportunity to better serve their insureds and provide cost-effective services quickly. For example, with a telematic MVEDR solution, the insurance companies could decide appropriate services to provide immediately post collision. From these data, the insurance company could understand the damage to the vehicle to determine if the vehicle needs to be towed, and possibly, the extent of repairs. From an occupant perspective, they could determine the possibility of injury and the need for medical services. A non-injured occupant with a damaged vehicle may need a rental car until their vehicle is repaired or declared a total loss.

The next questions that may need to be resolved in the evaluation of the claim are: Which party contributed to the occurrence of the accident? Could the accident have been avoided?

The insurance companies can use MVEDR data to understand how the accident happened. This is particularly important when there are issues of contributory negligence or comparative liability. They can combine the MVEDR data with the damage profile for the vehicle to determine the point and angle of impact, the pre-impact speeds of both vehicles, etc., to understand how the accident happened. Today, they rely on statements, vehicle damage, police reports, etc., which are often subjective and may be inaccurate, to make a determination of how the accident happened. MVEDR data allows a more accurate and consistent evaluation of accident causation by using the vehicle(s) to provide information about what happened.

They can also gain insight into the contributing factors to the accident. Understanding the braking and vehicle speed prior to the impact can determine how much time and/or distance the vehicle had to stop to avoid the collision. Was the turn signal on for the turn? Could the driver see or be seen with the vehicle's lights off/on? Were they steering to avoid the collision? All of these currently depend on scene and/or witness information that may be unreliable and/or biased.

The next question might be: Did the accident cause the injuries that are being claimed as a result of the impact? As with the accident causation, knowing information about the impact severity to one vehicle can lead to an understanding of the impact severity to the other vehicle when the MVEDR data is combined with the damage information. Direction of impact, restraint usage, and air bag deployment can provide insight into occupant(s) movement and stresses on their bodies, possible vehicle interior interactions, and the resulting injury potential.

4.3.6.4 Data elements

The data elements that would be helpful for insurance users are listed in Table 8. Most of the information is collected "forensically" and does not have to be "real-time" with the exception of possible crash notification

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as discussed previously. Recording at least two events would be helpful. Standardized and fast collection of data is a positive although not an absolute requirement.

Table 8—Insurance industry prioritization of potential data elements

Data element	Units	Sample rate	Sample range	Data range	Rationale
Longitudinal change in velocity	km/h (mi/h)	10 Hz	300 s	0 to 97 km/h (0 to 60 mi/h)	Determine impact severity and estimate injury potential
Lateral change in velocity	km/h (mi/h)	10 Hz	300 s	0 to 97 km/h (0 to 60 mi/h)	Determine impact severity, principle direction of force, and estimate injury potential
Vehicle pre-crash speed	km/h (mi/h)	200 Hz	5 s	0 to 240 km/h (0 to 150 mi/h)	Determine accident causation
Braking activity	On/off	200 Hz	5 s	On/off	Determine accident causation
Driver restraint usage	On/off	At time of impact		On/off	Determine injury causation
Passenger restrain usage	On/off	At time of impact		On/off	Determine injury causation
Date	mm-dd-yy	At time of impact	—	—	Identify event and reduce opportunity of fraud
Time	hh-mm-ss	At time of impact	—	—	Identify event and reduce opportunity of fraud
VIN	17 characters	—	—	—	Identify vehicle and reduce opportunity of fraud
Front drivers air bag deployment	On/off	At time of impact	—	On/off	Determine injury causation
Front passengers air bag deployment	On/off	At time of impact	—	On/off	Determine injury causation
Side drivers air bag deployment	On/off	At time of impact	—	On/off	Determine injury causation
Side passengers air bag deployment	On/off	At time of impact	—	On/off	Determine injury causation
Steering input	—	200 Hz	5 s	—	Determine accident causation
Percent throttle	Percent	200 Hz	5 s	0% to 100%	Determine accident causation
Turn signal	On/off	200 Hz	5 s	On/off	Determine accident causation
Windshield wipers	On/off	At time of impact	—	On/off	Determine accident causation
Lights	On/off	At time of impact	—	On/off	Determine accident causation

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Table 8—Insurance industry prioritization of potential data elements *(continued)*

Data element	Units	Sample rate	Sample range	Data range	Rationale
EDR warning lamp	On/off	At time of impact	—	On/off	Understand pre-crash vehicle status
Passenger air bag suppression	On/off	At time of impact	—	On/off	Understand pre-crash vehicle status
Number of occupants	Count	At time of impact	—	1 to 99	Determine occupants in vehicle during crash

4.4 Summary of recommended data elements from use-case scenarios

Table 9—Summary of data elements selected by case reports

Data element	Freq (Hz)	Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB R & E	NTSB Rec	Insurance	Roadside
Acceleration, angular	1					X			
Acceleration, pre-crash, x-axis	1								X
Acceleration, pre-crash, y-axis	1								X
Acceleration, *x*-axis	5	X		X	X	X	X		
Acceleration, *y*-axis	5	X		X	X	X	X		
Acceleration, *z*-axis	3			X		X	X		
Air bag suppression, passenger air bag	4	X			X		X	X	
Air bag, deployment level, driver	2	X			X				
Air bag, deployment level, pass	2	X			X				
Air bag, driver deployment	4	X		X	X			X	
Air bag, driver's side air bag deployment	3	X		X				X	
Air bag, passenger deployment	4	X		X	X			X	
Air bag, passenger's side air bag deployment	3	X		X				X	
Air bag, time from enable to first/single-stage deploy, driver	3	X			X		X		
Air bag, time from enable to first/single-stage deploy, pass	3	X			X		X		
Air bag, time from enable to pretensioner fire, driver	2	X			X				

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Table 9—Summary of data elements selected by case reports *(continued)*

Data element	Freq (Hz)	Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB R & E	NTSB Rec	Insurance	Roadside
Air bag, time from enable to pretensioner fire, pass	2	X			X				
Air bag, time from enable to second-stage deploy, driver	3	X			X		X		
Air bag, time from enable to second-stage deploy, pass	3	X			X		X		
Battery voltage	1						X		
Braking activity, ABS	4		X		X	X	X		
Braking activity, service	1	X	X		X	X	X	X	X
Braking, fault codes	1					X			
Braking, line pressure	1					X			
Braking, pulses	1					X			
Braking, retarder	2					X	X		
Braking, stability control	1					X			
Braking, temperature	1					X			
Braking, timing	1					X			
Braking, traction control	1						X		
Braking, truck parking	1						X		
Braking, truck trailer	1						X		
Change in velocity, x-axis	4	X				X		X	X
Change in velocity, y-axis	3					X		X	X
Change in velocity, z-axis	1					X			
Clutch	1		X						
Cruise control	1						X		
Date	3			X			X	X	
Direction of force	1			X					
Engine data, manifold pressure	1		X						
Engine data, as a function of speed in r/min	4	X	X		X		X		
Engine data, temperature	1		X						
Engine data, throttle (percent open)	5	X			X	X	X	X	
Hazard	1						X		
Heading, direction of vehicle	3					X	X		X
Ignition cycle, crash	2	X			X				
Ignition cycle, investigation	2	X			X				

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Table 9—Summary of data elements selected by case reports *(continued)*

Data element	Freq (Hz)	Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB R & E	NTSB Rec	Insurance	Roadside
Load, truck	1						X		
Location of impact on vehicle	2					X			X
Location, lat/long	2			X		X			
MVEDR ID	2	X					X		
Number of occupants	2			X				X	
PRNDL	3		X			X	X		
PRNDL codes	1					X			
Restraint usage, driver	6	X		X	X		X	X	X
Restraint usage, other positions	1			X					
Restraint usage, pass	5	X		X	X			X	X
Roll rate	1								X
Rollover	1			X					
School bus warning lamps	1						X		
Seat position, driver	2	X			X				
Seat position, pass	2	X			X				
Seat, passenger, occupant classification	2	X			X				
Speed, vehicle pre-crash speed	6	X	X		X		X	X	X
Steering input	4					X	X	X	X
Steering input, rear axle	1					X			
Time between two events, if recorded	2	X			X				
Time of day	3			X			X	X	
Tire pressure	1					X			
Tire failure, time	1					X			
Turn signal	3		X				X	X	
Vehicle lighting	2						X	X	
Vehicle maneuver	1					X			
Video	1						X		
VIN	4			X			X	X	X
Warning lamp, air bag	2				X		X		
Warning lamp, MVEDR	1							X	
Wheel speeds (each wheel end)	1						X		
Windshield wipers	2						X	X	
Yaw rate	1								X

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4.5 Additional use-case group perspectives

Additional use-case perspectives are deferred to the maintenance activity of this standard. IEEE P1616a permits follow-up standards activities to address motorcycles, school bus manufacturers, transit agencies, fleet owners, transit manufacturers of heavy commercial and public safety vehicles, and EMS first responders.

4.6 MVEDR operational requirements

4.6.1 Electronic equipment operating environment

As appropriate, either SAE J1211-1978 [B73] or SAE J1455-1994 shall be used to address the following environmental factors in the design of the MVEDR:

1) Electrical operational requirements
2) Temperature
3) Humidity
4) Salt spray atmosphere
5) Immersion and splash (water, chemicals, and oils)
6) Dust, sand, and gravel bombardment
7) Altitude
8) Mechanical vibration
9) Mechanical shock
10) Factors affecting the automotive or heavy-duty truck electrical environment
11) Steady-state electrical characteristics
12) Transient, noise, and electrostatic characteristics
13) Fungus (SAE J1455-1994)
14) Steam cleaning and pressure washing (SAE J1455-1994)
15) Electromagnetic compatibility/electromagnetic interference (SAE J1455-1994)

4.6.2 Battery/reserve power

The MVEDR shall have enough reserve power to complete all data acquisition after a trigger event has been detected and an indicator to provide notification if there is a battery disconnect.

4.7 Crashworthiness

The MVEDR memory shall be capable of meeting the crashworthiness requirements outlined in Table 10. Judicious placement of the MVEDR within the vehicle may also help to minimize the likelihood of damage as a result of a crash. Survivability requirements should be considered when selecting and installing connectors to the nonvolatile memory and other MVEDR components. Although protection of the MVEDR as a whole is important, the priority for crashworthiness is protection of the nonvolatile memory. The manufacturer should document, and make available to whomever requests it, the reliability, confidence level, and minimum lifetime information for a particular MVEDR. The MVEDR processor should continually operate when subjected to the vehicle environment where it is located. During a crash, at a minimum, the processor should operate long enough to attempt capturing the buffered memory within the nonvolatile memory. After an event, the processor should operate for at least the minimum duration specified by the data elements being recorded. The manufacturer shall specify what crashworthiness requirements were used for the following conditions: *impact shock, penetration, static crush, fire,* and *fluid immersion*. The requirements may be met by the design of the storage device within the vehicle body

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envelope (e.g., to take advantage of the crashworthiness and fire-barriers properties of the vehicle body), or by a combination of these approaches. The MVEDRs of light vehicles are part of the air bag module that is located in the occupant compartment of vehicles, providing protection against crush in all but the most severe cases. Moreover, because MVEDRs are part of the air bag module, their electronics are designed to operate in a shock environment; however they lack protection from fire and immersion in water and motor vehicle fluids. MVEDRs shall meet the requirements for applicable data elements and format in crash tests specified in FMVSS 208, 214, and 301. To provide both a check on MVEDR performance and ensure a basic level of survivability, data shall be required to be retrievable by the method specified by the vehicle manufacturer after the crash test.

Table 10—Crashworthiness requirements

Condition	Requirement
Impact shock	Equal to or greater than that provided by an impulse of 50 ms duration, with a peak force of 1.5 N, and shaped like the first half of a sine curvatures pulse, applied to the most damage-vulnerable axis in the most damage-vulnerable direction.[a]
Penetration	45 kg mass (100 lb) with a protruding 6 mm (0.25 in) diameter steel pin dropped from a height of 1.5 m (5 ft) onto the most damage-vulnerable face of the recorder at the most critical point.[b]
Static crush	2.3 kN (500 lbf) for 5 min, applied to at least four points on the crash protected module, irrespective of its shape and including, where applicable, each of the main diagonals and each of the main faces.
Fire	1000 °C for 10 min, followed by 260 °C for 30 min.
Fluid immersion	Immersion in any of the following individually for 6 hours: gasoline, diesel fuel, lubricating oil, regular water.

[a]Where necessary, tests shall be performed on a separate test specimen to determine the axis and direction that are most damage-vulnerable.
[b]Where necessary, tests shall be performed on a separate test specimen to determine the point that is the most damage-vulnerable.

5. Event description

This standard defines the meaning of an *event* as it pertains to motor vehicle crashes. Generally, there is agreement that the overall type of event is a crash, but MVEDRs may also collect data for different types of events, such as high brake force applications and large magnitude accelerations. An *event* may also be defined as a roadway departure.

Crash-related events have been the typical triggering functions used by light vehicle original equipment manufacturers (OEMs). Many OEMs use the air bag sensor to make a determination to initiate the MVEDR function. Some systems are incorporated into the sensing and diagnostic module (SDM), also known as the air bag sensor. In a typical scenario, the processor starts to collect data after the accelerometer reads a 2 g_n deceleration. The initiation of data collection is often referred to as *algorithm enable.* After the event is over, the data is stored into a permanent memory storage area. For events where the air bag does not deploy, the data is stored in the “near-deploy” file. These data can be overwritten by the next event if it has a total Δv which exceeds that of the event in storage. If it is less, the file is not stored. For events that result in air bag deployment, the data is stored in the “deployment” memory storage area. Thus several OEM vehicles will typically have a file stored in the “near-deploy” file and a second file stored in the “deploy” file, in the case when the crash resulted in an air bag deployment. Other OEMs store the data in the restraint control module (RCM) which uses a similar threshold for algorithm enable. The RCM stores one file, which is updated

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when the Δv exceeds the Δv of the stored file. An air bag deployment will always be recorded, no matter what the Δv.

Aftermarket systems may use various trigger levels to determine an event. An acceleration threshold can be used to automatically record data. Aftermarket MVEDRs may be triggered automatically, using predetermined acceleration thresholds or using other data channels and appropriate thresholds, or manually. The exact threshold may be user specific, and can be set high to limit the collection to crash-related events or lower to collect both crash-related events and driving-related events, such as hard braking.

There are several characteristics of a collision that can be used to detect its occurrence. These include deceleration of the vehicle and chassis deformation.

Figure 1 illustrates the deceleration forces experienced during a crash test in which the vehicle struck a solid barrier at a speed of 50 km/h (30 mi/h). The deceleration peaks at 40 g_n and has a magnitude greater than 20 g_n for more than 50 ms. Since normal accelerations and decelerations of an automobile due to braking and poor road conditions rarely exceed $\pm g_n$ for more than a few milliseconds, it is expected that vehicle deceleration can be used to distinguish between a serious collision and normal driving. Furthermore, the magnitude of the crash test data implies that deceleration measurements do not have to be highly accurate; an accuracy of 5% to 10% would suffice. Other constraints associated with a deceleration measuring device include a ± 50 g_n operating range and an over-range protection ceiling that exceeds 100 g_n. Frequency response should be adequate to completely characterize the deceleration over the entire collision, typically 100 ms to 200 ms in duration. This calls for a frequency response of 200 Hz or greater. An important advantage of measuring deceleration is that it can be directly linked to a standard measure of crash severity called equivalent barrier velocity (EBV). EBV is estimated by integrating the deceleration profile over a time period corresponding to the duration of a crash (e.g., 100 ms to 200 ms). It is possible to relate EBV to expected occupant injuries.

Chassis deformation occurs in almost every vehicle collision, and therefore could be used to detect the occurrence of a crash. However, it is also necessary to estimate the severity of that crash so that the processor can distinguish between a “fender bender” and a serious collision. This could be accomplished by measuring the amount of chassis deformation and correlating the deformation with expected occupant injury. It is also technically feasible to detect a crash by listening for a characteristic audible signature generated by chassis deformation and processing the required audio signal.

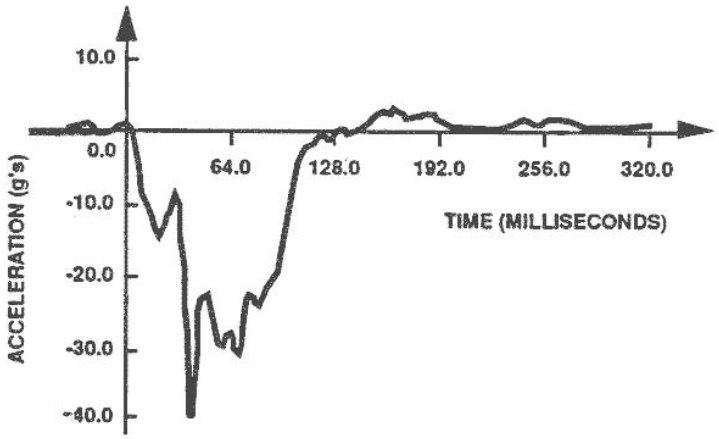

Figure 1—Acceleration data from crash test

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5.1 Vehicle crash modes

This standard covers all international types and classes of motor vehicles involved in, but not limited to, any of the following types of crashes: *pole, underride, run-off road, swideswipe, frontal, offset angle, rollover, multiple, animal impact, human impact, side impact,* and *rear impact.*

5.2 Methods for determining an event

This standard covers methods of determining an event: automatic and driver controlled. Thresholds are set to predetermined levels, which are dependent on two major considerations: the data parameter that is being monitored (brake application, deceleration, etc.), and the class of events that are being recorded (crash, driver actions, etc.).

5.3 Crash mode and crash severity algorithms

This standard covers all crash modes and all crash severities cited in Table 11 by requiring that an MVEDR incorporate an algorithm that is capable of continuously determining the crash severity of collision events in real-time. The enabling of the algorithm and calculations performed in the processing module shall result in common data element parameters.

5.4 Crash timing and crash triggers

This device shall record crash timing from –8 s to +5 s of a motor vehicle crash. This requirement would ensure that MVEDRs capture information about crashes of interest to crash investigators and researchers. The MVEDR operates in two modes. One is steady-state monitoring of pre-crash data. MVEDRs operate continually in this mode whenever the vehicle is operating. This process allows momentary recording of the pre-crash data. MVEDRs operate in the second mode when the vehicle is involved in a crash. In this mode, two decisions are made. The first is the determination of the occurrence of a crash and is accomplished by the use of a trigger threshold. The second is the decision to capture the recorded data and accomplished using a comparative process. Based on the outcome of the process, the recorded data associated with a crash are captured or deleted. In current light-duty vehicle applications, the trigger threshold is associated with the air bag crash severity analyzer. The circumstances that caused the threshold to be met are called an *event.* The beginning of the event that causes current MVEDRs to start capturing data in its permanent memory is sometimes defined as the vehicle's exceeding a specified deceleration threshold, typically around 2 g_n. After the event is over and the air bags are deployed, the data is stored in the MVEDR, if appropriate. This standard requires that an MVEDR shall start recording data when the vehicle's change in velocity during any 20 ms time interval equals or exceeds 0.8 km/h. That is equivalent to slightly more than 1 g_n of steady-state deceleration. The vehicle's change in velocity is determined in one of two ways, depending on the data collected by the MVEDR. In the case of a vehicle that does not record and capture lateral acceleration, the Δv is based on the longitudinal acceleration only. In the more complex case of a vehicle whose MVEDR records and captures both longitudinal and lateral acceleration, the Δv is calculated based on both sets of data, or simply stated, change in velocity of the vehicle in the horizontal plane. Crash triggers may be determined by the manufacturer in order to capture the data element parameters in Clause 8. A trigger is one or more events that causes the MVEDR to start recording. Triggered data may be collected from a single source sensor or through a network. Network triggered-data may use protocol based on CAN (controller area network) data link layer as specified in ISO 11898-1:2003. Triggered data may use standardized CAN physical layers as specified in ISO 11898-2:2003 or ISO 11898-3:2000 [B40].

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5.4.1 Single-stage event

A single-stage event is an event that is caused by a single trigger or the logical result of two or more triggers. Each event shall be described by an alphanumeric string used to identify the event. This event name must be a valid name and not contain any spaces. An event description is an optional description of the event.

5.4.2 Dual-stage event

A dual-stage event is an event that is a sequence of two single-stage events within a period of time. Either or both of the component events may capture data. The two single-stage events are logically entered over time.

5.4.3 Stage event sequence

A Stage 1 event is single-stage event that occurred first. A Stage 2 event is the event that occurred second. A crash may encompass several events. For example, a vehicle may swideswipe a guardrail and then hit a car, or a vehicle may hit one vehicle, then another, and finally a tree. In fact, analysis of crash data from NHTSA's NASS/CDS database guide [B55] shows that while 54% of the crashes involve a single event, 28% involve 2 events, and 18% involve 3 or more events. Thus, if an MVEDR captures only a single event as the depiction of a multi-event crash, in nearly one-half of the cases, it could be difficult to determine the event of the crash with which the MVEDR was associated. Thus, MVEDRs shall be capable of capturing up to 3 events in a multi-event crash. For any given event that generates a change in velocity that equals or exceeds the trigger threshold, the MVEDR would be required to record and capture that event and any subsequent events, up to a total of three, that begin within a 5 s window from time zero of the first event. Subsequent events are events that meet the trigger threshold more than 500 ms after time zero of the immediately preceding event. To prevent unassociated events from being captured in the multi-event MVEDR, the maximum time from the beginning of the first event to the beginning of the third event shall be limited to 5 s. Furthermore, to understand the timing between the associated events, the number of associated events shall be included as a data element, and at the time from the first to the second event and the time from the first to the third event, also be included as a data element.

6. Output

This clause defines common interfaces that may be utilized to extract MVEDR data. These interfaces consist of hardware, communication protocol, data format, and security. The common interface will utilize standardized commercially available technologies. The purpose for one common standard interface is to allow multiple vendors or OEMs the ability to extract the desired information in the same manner with the least amount of complexity. Current MVEDR designs were developed independently by each automaker or aftermarket manufacturer to meet their own vehicle-specific needs. Consequently, the design of MVEDRs varies quite widely between automakers and units designed by the same automaker. This lack of standardization impedes common usage of MVEDR data.

6.1 Minimum outputs

An MVEDR shall have the following minimum outputs:

a) Event recorder health status:

   1) A "go" or status "OK" green illuminated visual indication confirms that the recorder has passed a self-test. Faults detected during operation extinguish the green indicator and illuminate a red light. If the MVEDR is not readily accessible or viewable within the vehicle, the "go" or "OK" indication shall be displayed inside the vehicle in a location clearly visible to the operator of the driver's seating position (i.e., dash area, front windshield area, or rearview mirror area). The readiness indicator at the time of event is blue in color so as not to confuse it with colors

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internationally designated for identification of controls, telltales, and indicators in accordance with ISO 2575:2004. A blue light indicates event data was captured (i.e., seat belt usage) at trigger.

b) Data download:
   1) EIA 232D, USB, or Firewire portable test unit/laptop PC or desktop diagnostic tester
   2) Removable memory flashcard, RFID
   3) Remote extraction by wireless communication

6.2 Concept of operations (connectors) for common output

The output method and connections are directly related to the type of output provided. Output could be

1) A physical connection that could sustain major damage but is still "probe-able" after the event once the MVEDR is extracted from the vehicle.
2) A physical connection that could sustain major damage but is still capable of being "plugged to" by some diagnostic device while still connected to the vehicle.
3) A wireless device that could transmit data at the scene to first responders.
4) A wireless device that could transmit the data automatically at the time of the event.
5) An "IR port," and/or a wireless device connected to the tamper-proof electronic storage.
6) A combination of communication and connection technology to permit the stored data to be accessed, including removal and taking to a shop for "reconstruction."

6.3 Primary connections

The primary connections shall be

1) Between the MVEDR and the vehicle.
2) Between the MVEDR and data upload devices/components/systems.

6.4 Primary components—Concept of operations

The core components of an MVEDR vary according to the needs of manufacturers and end users. The basic operations of an MVEDR are a set of discrete tasks including collecting data with appropriate details and attributes, saving the data, and permitting later retrieval of this data. This subclause describes how an MVEDR is derived from relevant technology and the likely tangible components that make up an MVEDR either as a stand-alone device or a distributed system, or a hybrid thereof. While there are many technical ways to make an MVEDR, this standard does not determine specific technology; however, it is important to cite likely primary components, as follows:

— *Processor*, for managing or assisting data organization, retrieval, retention, or delivery of collected data
— *Nonvolatile memory*, for retaining key data that occurred immediately prior and after an event. This holds critical data relevant to an event, in a media that does not require a power source, to retain its contents
— *Memory buffer*, for collecting data just prior to an event, which can be refreshed, and to dump its content into a nonvolatile memory shortly after an "event" or "crash"
— *Internal or external clock*, for keeping relative or real-time when an event occurs and to determine when each data element occurred relative to the event
— *Rugged design*, for greater assurance that critical data will survive; at least one survivability container, or additional rugged design aspects, can be added to the nonvolatile memory, processor, or memory buffer.

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6.5 Secondary components—Concept of operations

Secondary components of an MVEDR include wireless connections for data transfer, automatic alerting devices for emergency first responders, additional memory components to collect multiple events, and software or circuity permitting collection of data sets beyond the scope of this standard, IEEE Std 1616-2004.

6.6 Ability to access nonvolatile memory

The main concern for addressing connectors is the interest in retrieving data after a severe event or crash and allowing for enough capability in the connector to collect the data. For example, if the connector or the overall MVEDR is damaged so much that normal downloading of data cannot occur, then the memory should be accessible to some extent and in turn read by special equipment or reconstructed at a lab.

6.7 Type of connectors

Connector(s) internal to the MVEDR for the nonvolatile memory shall be anything the manufacturer deems appropriate as being sufficient to comply with the other clauses within the standard. However, by using a connector with an existing standard, such as USB v 2.0, IEEE Std 1394-1995 [B35], EIA 232D-1987, and so on, the manufacturer shall meet its minimum standard.

6.8 Use of proprietary connectors

In the event the manufacturer uses a proprietary connector, the manufacturer must also make an MVEDR reader for it or universal adapter for it that would allow other MVEDR readers to connect, or it must provide a license or agreement for its manufacture by other companies. Also, if a manufacturer uses a propriety connector, there must be a well-documented way to access the nonvolatile memory in the event the connector or MVEDR is damaged, and this information shall be made available to anyone doing crisis/crash resolution on an MVEDR.

6.9 Data retrieval information

6.9.1 Information filing requirements

a) Each manufacturer of a motor vehicle equipped with an MVEDR shall furnish non-proprietary technical specifications at a level of detail sufficient to permit companies that manufacture diagnostic tools to develop and build a device capable of the following:
   1) Accessing
   2) Retrieving
   3) Interpreting
   4) Converting

   the data stored in the MVEDR that are required by this part.

b) The technical information provided under item a1) must identify the following:
   1) Make
   2) Model
   3) Model year

   of each vehicle equipped with an MVEDR.

c) Further, the technical information provided under item a1) must

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1) Specify the interface locations
2) Permit the access, retrieval, interpretation, and conversion of the data in an identifiable manner,
3) Be consistent with the requirements of this part for each vehicle of every identified make, model, and model year.

If the information differs for different vehicles of same make, model, and model year, the information provided must explain how the VINs for the vehicles of that make, model, and model year can be used to determine which aspects of the information apply to a particular vehicle.

6.10 Distinguishing the recorded memory within the container

An MVEDR shall visually distinguish the recorded memory and provide a clear indication as to which side of the container has the connector by the following:

1) A distinguishing visual identification color or combination of colors different from other devices in the vehicle to assist those who are searching for the device
2) A diagram included within the documentation specifying the location of the installation and the exterior color of the device should be available in the vehicle
3) Clearly marking the port containing the nonvolatile memory

6.11 Location of an MVEDR within a vehicle

This standard does not prescribe the location of an MVEDR within a vehicle. Manufacturers of the vehicle and aftermarket installers will choose alternate locations. However, it is important that the location of the device and the operating health of the device are clearly and quickly determined by first alert responders. The operating health status of an MVEDR shall conform to 6.1 and 6.12.

6.12 MVEDR telltale

Many vehicle collisions result from drivers' distraction. One identifiable source of such distraction is the diversion of drivers' attention from the driving task by confusing information displayed in the drivers' field of vision and enigmatic identification of the controls necessary for a vehicle's operation. Travellers that use rental cars at their destinations are faced with drivers message systems on the vehicle dashboards and dissimilar identification of vehicle hand controls. The same applies to people purchasing new vehicles in countries allowing motor vehicles type-approved by, or certified in, different jurisdictions. The world travellers and new vehicle owners need time to learn their dashboard messages and to identify their vehicle controls. During this time, these vehicle operators have to divide their attention between the increasingly difficult task of driving and the task of identification of controls and comprehension of messages that the modern vehicles provide to their operators to "ease" their driving task. An MVEDR telltale located in a windshield mirror-borne display housing with a planar surface denotes the MVEDR is activated and operational, the location used for emergency medical download, and the occupant restraint status of front seat occupants at crash time in vehicles under 10 000 lb (4500 kg) gross vehicle weight rating (GVWR). This standard specifies requirements for the location, identification, color, and illumination of a an MVEDR telltale:

Location: Inside the vehicle, in a zone above and forward of the seating reference point (SGRP) H-point of the driver seat, when that seat is in its forward most position.

Tasks: Indicate MVEDR health status, faults, and data captured at trigger.

Colors: Green and red for health status, blue for data capture at trigger, in conformance with global harmonization of telltales (ISO 2575-2004).

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Illumination: Multiple levels of illumination based on changes in the ambient light conditions.

6.13 Information in owner's manual

The owner's manual must contain the following statement: "This vehicle is equipped with a motor vehicle event data recorder. In the event of a crash, this device records data related to vehicle dynamics and safety systems for a short period of time, typically 30 seconds or less. These data can help provide a better understanding of the circumstances in which crashes and injuries occur and lead to the designing of safer vehicles. This device does not collect or store personal information."

7. MVEDR data attributes

7.1 Classification methodology

To understand the factors underlying injuries from motor vehicle crashes, the Haddon Matrix proposes that the elements of the epidemiology triad should be considered in unison with the crash sequence. The crash sequence can be examined in terms of three items: the circumstances surrounding the event prior to the crash occurring; the circumstances involved during the crash; and those involved after the crash. This standard uses a modified Haddon approach, as shown in Table 11. "Time-invariant" is added to the Haddon Matrix to illustrate items that do not have a time dependency. The use of this matrix illustrates how the crash sequence interacts with human, environment, and vehicular factors to define the frequency and severity of injury. In this approach, the environment includes entities outside the human-vehicle pairing that may have influenced either the actions leading to the crash or the outcome of the crash. Examples of environmental factors would be the weather, road curvature, or guardrail systems. Advantages of the Haddon Matrix are that it is relevant to all transportation modes, is well-known and widely applied in the injury field, and it can be expanded to accommodate various taxonomies related to motor vehicle crashes. It can be used to organize risk factors, exposure, circumstances of injury, and preventive measures.

Table 11—Modified Haddon Matrix

	Pre-crash	Crash	Post-crash	Time-invariant
Human				
Vehicle				
Environment				

7.2 Characteristic time durations

The event can be subdivided 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 is measured in milliseconds to seconds. The characteristic duration of the post-crash phase is measured in seconds to hours.

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7.3 Division of data collected

MVEDR crash data shall be collected, stored, and transmitted as one or all of the following: *high-frequency data* shall have 1000 Hz sampling rate (1 ms intervals) or higher; *low-frequency data* shall have 1 Hz sampling rate (1 s intervals) or higher; *static data* is not connected to temporal resolution and shall be recorded once per event.

7.3.1 Amount of data and sampling rate

This standard determines the amount of time and the number of samples per second that data shall be collected prior to, during, and after the event.

Crash events typically last for less than a second, and for light vehicles, the period of time during which the high crash forces exist (often referred to as the *crash pulse*) typically last about 0.1 s. Collecting crash pulse data is important in determining crash characteristics.

7.4 Classification to determine collection of data elements

The objective of classification is to identify the location where data elements can be collected. The location where data elements could be measured 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.

7.5 Time-based categories

Categorization by time or crash phase allows a lengthy list of data elements to be disaggregated by when the elements could be measured by an MVEDR.

7.5.1 Pre-crash variables

These variables are data elements pertaining to the time before the event (not including time-invariant variables).

7.5.2 Crash variables

These variables are descriptors of the crash event and the surrounding environment at the time of the crash.

7.5.3 Post-crash variables

These are characterization variables pertaining to the time after the incident.

7.5.4 Time-invariant variables

Time-invariant variables are fixed over the characteristic time of the event. Time-invariant variables would include: (a) fixed identifiers that are not time-dependent (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).

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7.6 Location-based categories

7.6.1 Human variables

These variables are descriptive identifiers applying specifically to the human(s) involved in the incident. Typically, this includes the crash victim(s), vehicle occupants, and non-occupants, such as pedestrians. This may be a quantitative measure (i.e., driver weight) or be based on a legal system (i.e., license status, regulatory compliance). Human variables would also include the affect of the human(s) to the crash event (i.e., injury severity).

7.6.2 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., air bag deployment).

7.6.3 Environmental variables

These include descriptive identifiers applying specifically to the surroundings of the crash location, such as weather, road curvature, or guardrail systems.

7.7 Data capture

The MVEDR shall collect and store the data elements for events in accordance with the following conditions and circumstances:

1) The MVEDR collects data for an event, starting at time zero and not less than 500 ms later.

2) The MVEDR shall be capable of recording not less than three events in a multi-event crash.

3) The highest Δv of any of the events in a crash sequence is used to quantify the maximum Δv for a multi-event crash.

4) If an air bag, either side or frontal, deployment occurs in a single or multi-event crash, the data captured from any previous crash must be deleted, the data related to that deployment must be captured, and the memory must be locked to prevent any future overwriting of these data.

5) If an air bag deployment does not occur and if the absolute value of the maximum Δv recorded from a multi-event crash is greater than the absolute value of the maximum Δv currently stored in the MVEDR's memory, all previously captured data in the MVEDR's memory must be deleted and the current data must be captured.

6) If an air bag deployment does not occur and if the absolute value of the maximum Δv from a multi-event crash is less than or equal to the absolute value of the maximum Δv currently in the MVEDR's memory, the recorded data must not be captured.

7.7.1 Universal set of attributes format table

The "universal" set of attributes in Table 12 define the data elements for the MVEDR data dictionary catalogue.

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Table 12—Format for MVEDR data element definitions

<table>
<tr><td colspan="3">Data element name:
Data element name recommended by IEEE P1616 Working Group.</td><td colspan="5">Other names:
Other names used for this data element in other documents, by other groups.</td><td>Abbreviations/ acronyms:
Common acronyms for this element.</td><td colspan="2">Index number:
Reference number for this standard, IEEE Std 1616-2004.</td></tr>
<tr><td colspan="5">Accident investigation uses:
Use of data obtained from this data element.</td><td colspan="5">Possible alternative/additional uses:
Other uses of this data.</td></tr>
<tr><td rowspan="2">Agency recommendations</td><td>NHTSA top 10</td><td>NHTSA truck & bus</td><td>NHTSA general list</td><td>NTSB</td><td>TRB</td><td>FHWA-OMC</td><td>NASA JPL</td><td>ATA-TMC</td><td>ComCARE</td><td>Modified Haddon Matrix</td><td>Pre-crash</td><td>Crash</td><td>Post-crash</td><td>Time-invariant</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Vehicle</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="9"></td><td>Driver</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="9"></td><td>Environment</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="14">Definition/operation/filter class:
Complete description of the data element, including its physical meaning, why it should be recorded, and any filtering requirements that should be used on the analog signal before it is sampled.</td></tr>
<tr><td colspan="7">Range:
Upper/lower, “special” values</td><td colspan="7">Unit of measure:
Physical data units</td></tr>
<tr><td colspan="7">Resolution:
Smallest data unit</td><td colspan="7">Accuracy:
Accuracy of data</td></tr>
<tr><td colspan="7">Sampling rate:
Rate at which data is recorded</td><td colspan="7">Sampling timing:
Data recording timing</td></tr>
<tr><td colspan="7">Data format:
Format of data when off-loaded</td><td colspan="7">Discussion/references:
General discussion, miscellaneous notes, and references used to define the data element.</td></tr>
</table>

NOTES

1—Data element name definition section: This section lists the formal name of the data element, other names that were used for the data element by the IEEE P1616 Working Group or other organizations, abbreviations or acronyms used for this data element, and a data element index number that is used to help organize the data element section of this standard, IEEE Std 1616-2004.

2—Uses section: This section defines the practical use of the data element—for both accident investigation and other uses. Other uses may include maintenance, back office, and other applications that are not necessarily related to vehicular/accident researcher purposes.

3—Agency recommendation section: This section documents which agencies have recommended the data element in the past.

4—Modified Haddon Matrix section: This section documents the data element’s usefulness by illustrating what aspects of data are included in the modified Haddon Matrix. The difference between the “standard” and “modified” Haddon Matrix is that the modified matrix includes the “time-invariant” column.

5—Data element details section: This section includes all of the attributes required to completely define the data element. Using these attributes, designers can completely define the data acquisition, storage, and downloading tasks.

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8. MVEDR data dictionary

A data dictionary is a collection of entries specifying the name, source, usage and format of each data element used in a system or set of systems. The MVEDR data dictionary is a collection of data definitions. Data definition is a description of the format, structure, and properties of data elements in a data dictionary. For this standard, data elements are uniquely named as a defined component of data definition—a data "cell" in which items (actual values) can be placed.

8.1 List of MVEDR data elements

8.1.1 Acceleration, pre-crash, *x*-axis

8.1.2 Acceleration, pre-crash, *y*-axis

8.1.3 Acceleration, crash, *x*-axis

8.1.4 Acceleration, crash, *y*-axis

8.1.5 Acceleration, crash, *z*-axis

8.1.6 Air bag suppression, passenger air bag

8.1.7 Air bag, deployment level, driver

8.1.8 Air bag, deployment level, passenger

8.1.9 Air bag, driver deployment, time

8.1.10 Air bag, driver's side air bag deployment

8.1.11 Air bag, passenger deployment, time

8.1.12 Air bag, passenger's side air bag deployment

8.1.13 Air bag, time from enable to first/single-stage deploy, driver

8.1.14 Air bag, time from enable to first/single-stage deploy, passenger

8.1.15 Air bag, time from enable to pretensioner fire, driver

8.1.16 Air bag, time from enable to pretensioner fire, passenger

8.1.17 Air bag, time from enable to second-stage deploy, driver

8.1.18 Air bag, time from enable to second-stage deploy, passenger

8.1.19 Braking activity, ABS

8.1.20 Braking activity, service

8.1.21 Brake line pressure, heavy-duty

8.1.22 Brake, engine retarder, heavy-duty

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8.1.23 Braking, stability control (engaged/disengaged)

8.1.24 Braking, truck parking

8.1.25 Braking, truck trailer

8.1.26 Change in velocity (*x*-axis)

8.1.27 Change in velocity (*y*-axis)

8.1.28 Change in velocity (*z*-axis)

8.1.29 Principal direction of force

8.1.30 Engine manifold pressure

8.1.31 Engine data, r/min

8.1.32 Engine data, throttle

8.1.33 Engine data, torque

8.1.34 Environment, inside temperature

8.1.35 Environment, outside temperature

8.1.36 Exterior headlamp—daytime running lights

8.1.37 Exterior headlamp—high beam

8.1.38 Exterior lamp—low beam

8.1.39 Exterior lamp—park

8.1.40 GNSS latitude

8.1.41 GNSS longitude

8.1.42 GNSS status

8.1.43 GNSS HDOP

8.1.44 GNSS ground travel direction

8.1.45 GNSS ground travel speed

8.1.46 Heading, direction of vehicle

8.1.47 Ignition cycle count, event

8.1.48 Ignition cycle count, investigation

8.1.49 Indicator lamp, air bag

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8.1.50 Indicator lamp, MVEDR

8.1.51 Indicator lamp, ABS

8.1.52 Indicator lamp, traction control

8.1.53 Number of seat positions occupied

8.1.54 Vehicle mileage indicator, event

8.1.55 PRNDL (gear selection, time series)

8.1.56 Pitch rate

8.1.57 Restraint usage, driver

8.1.58 Restraint usage, other positions

8.1.59 Restraint usage, passenger

8.1.60 Roll rate

8.1.61 Rollover

8.1.62 School bus warning indicator lamps

8.1.63 Seat position, driver

8.1.64 Seat position, passenger

8.1.65 Seat, passenger, occupant classification

8.1.66 Steering wheel position

8.1.67 EMS text field

8.1.68 Time between events

8.1.69 Tire pressure (inflation pressure per tire)

8.1.70 Tire, total air loss, time, heavy-duty (Y/N)

8.1.71 Trigger event date

8.1.72 Trigger event time

8.1.73 Vehicle system status, adaptive cruise control

8.1.74 Vehicle system status, automatic collision notification

8.1.75 Vehicle system status, battery voltage

8.1.76 Vehicle system status, clutch

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8.1.77 Vehicle system status, door ajar

8.1.78 Vehicle system status, door lock status

8.1.79 Vehicle system status, dive status

8.1.80 Vehicle system status, hazard signal status

8.1.81 Vehicle system status, traction control

8.1.82 Vehicle system status, turn signal status

8.1.83 Vehicle system status, windshield wiper status

8.1.84 Vehicle identification number

8.1.85 Wheel speeds (each wheel end)

8.1.86 Yaw rate

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8.1.1 Acceleration, pre-crash, *x*-axis

Table 13—Acceleration, pre-crash, *x*-axis

Data element name: Acceleration, pre-crash, *x*-axis	**Other names:** ACCELERATION.PRECRASH_Xaxis	**Abbreviation/ acronyms:** Ax	**Index number:** 8.1.1
Accident investigation uses: Describes the longitudinal motion of the vehicle prior to event trigger.	**Possible alternative/additional uses:** May help infer driver inputs (braking) or possible accident causation.		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
	X	X					

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
				X	X		X

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time-invariant
Vehicle	X			
Driver/occupants	X			
Environment				

Description/operation/filter class:
Vehicle acceleration vs. time before impact (longitudinal direction) of the vehicle.
Records pre-crash kinematics of vehicle.
Vehicle acceleration as determined by either air bag accelerometer or other accelerometer. According to SAE J211/1-2003, utilize a CFC 180 filter to permit integration for velocity or position.

Data definition/sign convention/coordinate system:	**Unit of measure:**
SAE J670-1976 [B68] defines the sign convention and coordinate system (forward is positive from vehicle center of gravity). Data range: –100 g_n to +100 g_n Special cases: 998 = invalid data, 999 = data unavailable	g_n = 9.806 65 m/s^2, exactly [~ 32.2 ft/s^2, ~21.9 (mi/h)/s)] This is the internationally used standard value for calculational purposes.
Resolution: 0.048 g_n per bit	**Accuracy:** ±0.01 g_n
Sampling rate: 10 samples per second (minimum); i.e., ≥ 0 Hz	**Sampling timing:** –8 s trigger +5 s
Data format: Floating point	**Discussion/references:** None

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8.1.2 Acceleration, pre-crash, *y*-axis

Table 14—Acceleration, pre-crash, *y*-axis

Data element name: Acceleration, pre-crash, *y*-axis	**Other names:** ACCELERATION.PRECRASH_Yaxis	**Abbreviation/ acronyms:** Ay	**Index number:** 8.1.2
Accident investigation uses: Describes the lateral motion of the vehicle prior to event trigger.	**Possible alternative/additional uses:** May help infer driver inputs (steering) or possible accident causation. Data could be an aid to access rollover event.		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
	X	X					

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
				X	X		X

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time-invariant
Vehicle	X			
Driver/occupants	X			
Environment				

Description/operation/filter class:
Vehicle acceleration vs. time before impact (lateral direction).
Records pre-crash kinematics of vehicle.
Vehicle acceleration as determined by either air bag accelerometer or other accelerometer. According to SAE J211/1-2003, utilize a CFC 180 filter to permit integration for velocity or position.

Data definition/sign convention/coordinate system:	**Unit of measure:**
SAE J670-1976 [B68] defines the sign convention and coordinate system (lateral to the right is positive from vehicle center of gravity). Data range: –100 g_n to +100 g_n Special cases: 998 = invalid data, 999 = data unavailable	g_n = 9.806 65 m/s^2, exactly [~ 32.2 ft/s^2, ~21.9 (mi/h)/s)] This is the internationally used standard value for calculational purposes.
Resolution: 0.048 g_n per bit	**Accuracy:** ±0.01 g_n
Sampling rate: 10 samples per second (minimum) (Š1000 Hz)	**Sampling timing:** –8 s trigger +5 s
Data format: Floating point	**Discussion/references:** None

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8.1.3 Acceleration, crash, *x*-axis

Table 15—Acceleration, crash, *x*-axis

Data element name: Acceleration, *x*-axis (longitudinal)	**Other names:** ACCELERATION.VEHCLE. Longitudinal_quantity	**Abbreviations/ acronyms:** Ax	**Index number:** 8.1.3

Accident investigation uses: Describes the forward motion of the vehicle during the time of the crash.	**Possible alternative/additional uses:** Supports USDOT infrastructure safety evaluation and statistical hazard identification.

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
	X	X					

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engingering	NTSB vehicle factors recorders	Insurance	Roadside
X		X	X	X	X		X

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle		X		
Driver/occupants		X		
Environment				

Description/operation/filter class:
The acceleration in the longitudinal (fore-aft) direction measured just before and after the event trigger.
Determines the longitudinal impact aspects of a crash. Can be combined with the other acceleration channels to determine principal direction of force (PDOF) and velocity.
Typically the MVEDR will have an on-board accelerometer. The accelerometer as determined by either air bag accelerometer of other accelerometer. According to SAE J211/1-2003, utilize a CFC 180 filter to permit integration for velocity or position.

Data definition/sign convention/coordinate system: SAE J670-1976 [B68] defines the sign convention and coordinate system (forward to positive). Data range: –100 g_n to +100 g_n Special cases: 998 = invalid data, 999 = data unavailable	**Unit of measure:** g_n = 9.806 65 m/s^2, exactly [~ 32.2 ft/s^2, ~21.9 (mi/h)/s] This is the internationally used standard value for calculational purposes.
Resolution: 0.048 g_n per bit	**Accuracy:** ±0.01 g_n
Sampling rate: 1,000 samples per second (minimum) (≥1000 Hz)	**Sampling timing:** –8 s trigger +5 s
Data format: Floating point	**Discussion/references:** None

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8.1.4 Acceleration, crash, *y*-axis

Table 16—Acceleration, crash, *y*-axis

Data element name: Acceleration, *y*-axis (lateral)	**Other names:** ACCELERATION.VEHICLE. Lateral_quantity	**Abbreviations/ acronyms:** Ay	**Index number:** 8.1.4

Accident investigation uses: Helps to describe the lateral motion of the vehicle during the time of the crash.	**Possible alternative/additional uses:** Supports USDOT infrastructure safety evaluation and statistical hazard identification.

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
		X					

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X		X	X	X	X		X

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle		X		
Driver/occupants				
Environment				

Description/operation/filter class:
The acceleration in the lateral (side-to-side) direction measured just before and after the event trigger.
Determines the lateral impact aspects of a crash. Can be combined with the other acceleration channels to determine PDOF and Δv.
Typically the MVEDR will have an on-board accelerometer. The accelerometer (and MVEDR) will be oriented to be sensitive in the vehicle's lateral axis.

Data definition/sign convention/coordinate system: SAE J670-1976 [B68] defines the sign convention and coordinate system (forward to positive). Data range: –100 g_n to +100 g_n Special cases: 998 = invalid data, 999 = data unavailable.	**Unit of measure:** g_n = 9.806 65 m/s^2, exactly [~ 32.2 ft/s^2, ~21.9 (mi/h)/s] This is the internationally used standard value for calculational purposes.
Resolution: 0.048 g_n	**Accuracy:** ±0.01 g_n
Sampling rate: 1000 samples per second (≥1000 Hz)	**Sampling timing:** –8 s trigger +5 s
Data format: Floating point	**Discussion/references:** None

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8.1.5 Acceleration, crash, *z*-axis

Table 17—Acceleration, crash, *z*-axis

Data element name: Acceleration, *z*-axis (vertical)	**Other names:** ACCELERATION.VEHICLE. Vertical_quantity	**Abbreviations/ acronyms:** Az	**Index number:** 8.1.5
Accident investigation uses: Helps to describe the motion of the vehicle in the vertical axis during a crash.	**Possible alternative/additional uses:** Supports USDOT infrastructure safety evaluation and statistical hazard identification.		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
		X					

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
		X		X	X		

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle		X		
Driver/occupants				
Environment				

Description/operation/filter class: The acceleration in the vertical (up-down) direction measured just before and after the event trigger. Determines the vertical impact aspects of a crash. Can be combined with the other acceleration channels to determine PDOF and velocity. Typically the MVEDR will have an on-board accelerometer.	
Data definition/sign convention/coordinate system: SAE J670-1976 [B68] defines the sign convention and coordinate system (forward to positive). Data range: –100 g_n to +100 g_n Special cases: 998 = invalid data, 999 = data unavailable	**Unit of measure:** g_n = 9.806 65 m/s^2, exactly [~ 32.2 ft/s^2, ~21.9 (mi/h)/s)] This is the internationally used standard value for calculational purposes.
Resolution: 0.048 g_n per bit	**Accuracy:** ±0.01 g_n
Sampling rate: 1000 samples per second (minimum) (≥1000 Hz)	**Sampling timing:** –8 s trigger +5 s
Data format: Floating point	**Discussion/references:** None

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8.1.6 Air bag suppression, passenger air bag

Table 18—Air bag suppression, passenger air bag

Data element name: Air bag suppression, passenger air bag	**Other names:** Passenger.Airbag.Suppression_code	**Abbreviations/ acronyms:** ASP	**Index number:** 8.1.6

Accident investigation uses: This data records whether the passenger's air bag system was manually placed in a "off" or "on" position at the time surrounding the event trigger.	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X	X	X					

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X		
Driver/occupants				
Environment				

Description/operation/filter class:
This data element will indicate the suppression status of the passenger(s) air bag that can be activated or not activated using the vehicle's ignition key.
The passenger's air bag suppression status is controllable (on/off) by an individual, with the vehicle key. If the suppression status is in the "on" position, the passenger air bag is activated for deployment.
No filter is required.

Data definition/sign convention/coordinate system: 0 = not active, 1 = active Special cases: 3 = invalid data, 4 = No data available	**Unit of measure:** N/A
Resolution: N/A	**Accuracy:** N/A
Sampling rate: 1 1 sample per second	**Sampling timing**: –8 s trigger +5 s
Data format: One byte	**Discussion/references:** Supported by air bag deployment control system.

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8.1.7 Air bag, deployment level, driver

Table 19—Air bag, deployment level, driver

Data element name: Air bag, deployment level, driver	**Other names:** Deployment Level Airbag_driver	**Abbreviations/ acronyms:** ADLd	**Index number:** 8.1.7

Accident investigation uses: This data element indicates the level of deployment for the driver's multi-stage air bag at the time surrounding the triggering event.	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X		X					X

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time Invariant
Vehicle	X	X		
Driver/occupants		X		
Environment				

Description/operation/filter class:
Where there are multi-stage passenger air bags, this data element provides the indication of the air bag deployment level. The deployment level is preprogrammed into the ECM based upon predetermined, authorized scenarios. During a slow-speed collision, the dual-stage inflator system for the steering wheel mounted air bag is triggered in sequence, resulting in slower overall air bag deployment with less initial force. During a higher speed collision, both inflators operate simultaneously for full immediate inflation in order to correspond with the greater impact force.

Data definition/sign convention/coordinate system: Coded by the manufacturer	**Unit of measure:** N/A
Resolution: N/A	**Accuracy:** Time = ±0.001 s
Sampling rate: Fixed by the manufacturer of air bag system	**Sampling timing:** –8 s trigger +5 s
Data format: Byte	**Discussion/references:** Supported by air bag deployment control system.

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8.1.8 Air bag, deployment level, passenger

Table 20—Air bag, deployment level, passenger

Data element name: Air bag, deployment level, passenger	**Other names:** Deployment level passenger airbag	**Abbreviations/ acronyms:** ADLp	**Index number:** 8.1.8

Accident investigation uses: This data element indicates the level of deployment for the passenger's multi-stage air bag at the time surrounding the triggering event.	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X		X					X

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X		
Driver/occupants		X		
Environment				

Description/operation/filter class:
Where there are multi-stage passenger air bags, this data element provides the indication of the air bag deployment level. The deployment level is preprogrammed into the ECM based upon predetermined, authorized scenarios. During a slow-speed collision, the dual-stage inflator system for the passenger side air bag is triggered in sequence, resulting in slower overall air bag deployment with less initial force. During a higher speed collision, both inflators operate simultaneously for full immediate inflation in order to correspond with the greater impact force.
No filtering required.

Data definition/sign convention/coordinate system: Coded by the manufacturer	**Unit of measure:** N/A
Resolution: N/A	**Accuracy:** Time = ±0.001 s
Sampling rate: Fixed by the manufacturer	**Sampling timing:** –8 s trigger +5 s
Data format: Byte	**Discussion/references:** Supported by air bag deployment control system.

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8.1.9 Air bag, driver deployment, time

Table 21—Air bag, driver deployment, time

Data element name: Air bag, driver deployment, time	**Other names:** Driver's air bag deployment	**Abbreviations/ acronyms:** ADdT	**Index number:** 8.1.9
Accident investigation uses: To identify when the driver's air bag activated or cycled during the crash.	**Possible alternative/additional uses:**		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X	X	X					

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X		
Driver/occupants		X		
Environment				

Description/operation/filter class: The MVEDR records the time at which the restraint system's ECM initiated the command for the driver's air bag to deploy.	
Data definition/sign convention/coordinate system: N/A	**Unit of measure:** Time from detected impact
Resolution: 1 ms	**Accuracy:** ±001 s
Sampling rate: N/A	**Sampling timing:** –8 s trigger +5 s
Data format: Integer	**Discussion/references:** The deployment of the air bag works in tandem with the seat belt pretensioner. Supported by air bag deployment control system.

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8.1.10 Air bag, driver's side air bag deployment time

Table 22—Air bag, driver's side air bag deployment time

Data element name: Air bag, driver's side air bag deployment, time	**Other names:** Driver's side air bag deployment	**Abbreviations/ acronyms:** ADdST	**Index number:** 8.1.10

Accident investigation uses: To identify when the driver's side air bag activated or cycled during the crash.	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X	X	X					

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X		
Driver/occupants		X		
Environment				

Description/operation/filter class:
The MVEDR records the time at which the ECM commanded the driver's side air bag to activate in accordance with preprogrammed deployment scenarios.
No filter is required.

Data definition/sign convention/coordinate system: Determined by the manufacturer of the ECM/ MVEDR	**Unit of measure:** Time
Resolution: This element requires resolution of the driver's side air bag deployment.	**Accuracy:** ±001 s
Sampling rate: N/A	**Sampling timing:** –8 s trigger +5 s
Data format: Integer	**Discussion/references:** Supported by air bag deployment control system.

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8.1.11 Air bag, passenger deployment, time

Table 23—Air bag, passenger deployment, time

Data element name: Air bag, passenger deployment, time	**Other names:** Deployment Passenger_airbag	**Abbreviations/ acronyms:** APDT	**Index number:** 8.1.11
Accident investigation uses: To identify when the passenger's air bag activated/ cycled during the crash.	**Possible alternative/additional uses:**		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X	X	X					

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X		
Driver/occupants		X		
Environment				

Description/operation/filter class:
The MVEDR records the time at which the restraint system's ECM commanded the passenger's air bag to activate. The manufacturer of the restraint system preprograms the command instructions into the ECM based upon authorized crash scenarios.
No filter is required.

Data definition/sign convention/coordinate system: N/A	**Unit of measure:** Time
Resolution: 1 ms	**Accuracy:** Time = ±0.001 s
Sampling rate: N/A	**Sampling timing:** –8 s trigger +5 s
Data format: Integer	**Discussion/references:** Supported by air bag deployment control system.

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8.1.12 Air bag, passenger's side air bag deployment

Table 24—Air bag, passenger's side air bag deployment

Data element name: Air bag, passenger's side air bag deployment	**Other names:** Passenger's side air bag deployment	**Abbreviations/ acronyms:** PSAB	**Index number:** 8.1.12

Accident investigation uses: To identify when the passenger's side air bag activated or cycled during the crash.	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X	X	X					

Modified Haddon Matrix	Pre-crash	Crash	Post- crash	Time invariant
Vehicle	X	X		
Driver/occupants		X		
Environment				

Description/operation/filter class:
The MVEDR records the time at which the ECM commanded the passenger's side air bag initially to activate in accordance with preprogrammed deployment scenarios.
No filter is required.

Data definition/sign convention/coordinate system: N/A	**Unit of measure:** Time
Resolution: 1 ms	**Accuracy:** Time = ±0.001 s
Sampling rate: N/A	**Sampling timing:** –8 s trigger +5 s
Data format: Integer	**Discussion/references:** Supported by air bag deployment control system.

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8.1.13 Air bag, time from enable to first/single-stage deploy, driver

Table 25—Air bag, time from enable to first/single-stage deploy, driver

Data element name: Air bag, time from enable to first/ single-stage deploy, driver	**Other names:** $T_{to\ first/single\text{-}stage\ air\ bag\ deployment}$	**Abbreviations/ acronyms:** ABTD	**Index number:** 8.1.13

Accident investigation uses: This data records the elapsed time from the time of the initial triggering event to the time of the first-stage air bag deployment.	**Possible alternative/additional uses:** This time history will also include the signal provided to the pretensioners associated with the driver's air bag.

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X		X					

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X		
Driver/occupants		X		
Environment				

Description/operation/filter class:
The MVEDR records the time at which the restraint system's ECM authorized the driver's first-stage air bag to activate.
The manufacturer of the restraint system programs the command instructions into the ECM based upon predetermined authorized scenarios.
No filter is required.

Data definition/sign convention/coordinate system: Coded by the ECM and MVEDR manufacturer(s) IAW FARS.	**Unit of measure:** N/A
Resolution: This data element requires resolution of the command signal provided to the first-stage air bag deployment system with respect to time.	**Accuracy:** Time = ±0.001 s
Sampling rate: 1000 samples per second (1000 Hz)	**Sampling timing:** –8 s trigger +5 s
Data format: Integer	**Discussion/references:** Supported by air bag deployment control system.

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8.1.14 Air bag, time from enable to first/single-stage deploy, passenger

Table 26—Air bag, time from enable to first/single-stage deploy, passenger

Data element name: Air bag, time from enable to first/ single-stage deploy, passenger	**Other names:** T_0 to first/single-stage of passenger air bag	**Abbreviations/ acronyms:** ATEF	**Index number:** 8.1.14

Accident investigation uses: The MVEDR will record total elapsed time from the initial triggering event to the time of first-stage air bag deployment.	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X		X					

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X		
Driver/occupants		X		
Environment				

Description/operation/filter class:
The MVEDR records the time at which the restraint system's ECM authorized the passenger's first-stage air bag to activate.
The manufacturer of the restraint system programs the command instructions into the ECM based upon authorized scenarios.
No filter is required.

Data definition/sign convention/coordinate system: Coded by the manufacturer of the ECM and/or the MVEDR in accordance with FARS.	**Unit of measure:** N/A
Resolution: This data element requires resolution of the command signal provided to the first-stage air bag system with respect to time.	**Accuracy:** Time = ±0.001 s
Sampling rate: 1000 samples per second (1000 Hz)	**Sampling timing:** –8 s trigger +5 s
Data format: Integer	**Discussion/references:** Supported by air bag deployment control system.

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8.1.15 Air bag, time from enable to pretensioner fire, driver

Table 27—Air bag, time from enable to pretensioner fire, driver

Data element name: Air bag, time from enable to pretensioner fire, driver	**Other names:** Pretensioner elapsed time to activate	**Abbreviations/ acronyms:** ABTFEP	**Index number:** 8.1.15
Accident investigation uses: Provides the time history from the initial triggering event to the time that the driver's seat belt pretensioner device activated.	**Possible alternative/additional uses:**		

Agency recommendations

NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases

Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X		X					

Modified Haddon Matrix	Pre-crash	Crash	Post- crash	Time invariant
Vehicle	X	X		
Driver/occupants		X		
Environment				

Description/operation/filter class:
The MVEDR records the time at which the restraint system's ECM authorized the driver's pretensioner to activate or cycle. If the driver seat belt is in use the pretensioner is commanded to activate. If the seat belt is not engaged then the pretensioner will not be activated.
The manufacturer of the restraint system programs the command instructions into the ECM based upon authorized scenarios.
No filter is required.

Data definition/sign convention/coordinate system: Coded by the manufacturer of the vehicle.	**Unit of measure:** N/A
Resolution: This element requires resolution of the command signal with respect to time.	**Accuracy:** Time = ±0.001 s
Sampling rate: 1000 samples per second (1000 Hz)	**Sampling timing:** –8 s trigger +5 s
Data format: Integer	**Discussion/references:** Supported by air bag deployment control system.

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8.1.16 Air bag, time from enable to pretensioner fire, passenger

Table 28—Air bag, time from enable to pretensioner fire, passenger

Data element name: Air bag, time from enable to pre-tensioner fire, passenger	**Other names:** Enable to Pretensioner_airbag	**Abbreviations/ acronyms:** ABTPF	**Index number:** 8.1.16

Accident investigation uses: Provides the time history from the initial triggering event to the time that the passenger's pretensioner device was initially commanded to activate or cycled.	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X		X					

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X		
Driver/occupants		X		
Environment				

Description/operation/filter class:
The MVEDR records the time at which the restraint system's ECM authorized the passenger's pretensioner to activate or cycle. If the passenger seat belt is in use, the pretensioner is commanded to activate. If the seat belt is not engaged, then the pretensioner will not be activated. The amount of elapsed time of this evaluation and activation, if any, is recorded in the MVEDR. The manufacturer of the restraint system programs the command instructions into the ECM based upon authorized scenarios.
No filter is required.

Data definition/sign convention/coordinate system: Coded by the manufacturer of the restraint systems in accordance FARS.	**Unit of measure:** N/A
Resolution: This element requires resolution of activation signal or no activation command signal to the passenger's seat pretensioner.	**Accuracy:** Time = ±0.001 s
Sampling rate: 1000 samples per second (1000 Hz)	**Sampling timing:** –8 s trigger +5 s
Data format: Integer	**Discussion/references**: Supported by air bag deployment control system.

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8.1.17 Air bag, time from enable to second-stage deploy, driver

Table 29—Air bag, time from enable to second-stage deploy, driver

Data element name: Air bag, time from enable to second-stage deploy, driver	**Other names:** Driver's air bag time from activation to deployment of the second stage	**Abbreviations/ acronyms:** ADSS	**Index number:** 8.1.17
Accident investigation uses: Provides the time history from the initial triggering event to the time that the driver's second-stage air bag was deployed or cycled.	**Possible alternative/additional uses:**		

Agency recommendations

NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases

Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X	X	X					

Modified Haddon Matrix

	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X		
Driver/occupants		X		
Environment				

Description/operation/filter class:
The MVEDR records the time at which the restraint system's ECM authorized the driver's second-stage air bag to activate.
The manufacturer of the restraint system programs the command instructions into the ECM using authorized scenarios.
No filter is required.

Data definition/sign convention/coordinate system: Coded by the manufacturer of the ECM and or the MVEDR.	**Unit of measure:** N/A
Resolution: This element requires the resolution of the second-stage air bag activation signal with respect to time.	**Accuracy:** Time = ±0.001 s
Sampling rate: 1000 samples per second (1000 Hz)	**Sampling timing:** –8 s trigger +5 s
Data format: Integer	**Discussion/references:** In using dual-stage air bags, the stages may deploy simultaneously or be staged to maintain inflation for a longer period of time. Supported by air bag deployment control system.

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8.1.18 Air bag, time from enable to second-stage deploy, passenger

Table 30—Air bag, time from enable to second-stage deploy, passenger

Data element name: Air bag, time from enable to second-stage deploy, passenger	**Other names:** Passenger second-stage deployment timing	**Abbreviations/ acronyms:** PSSD	**Index number:** 8.1.18
Accident investigation uses:	**Possible alternative/additional uses:**		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
		X		X			

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X		
Driver/occupants		X		
Environment				

Description/operation/filter class:
The MVEDR records the time at which the restraint system's ECM authorized the passenger's second-stage air bag to activate.
The manufacturer of the restraint system programs the command instructions into the ECM based upon authorized scenarios.
No filter is required.

Data definition/sign convention/coordinate system: Coded by the manufacturer of the ECM/MVEDR.	**Unit of measure:** N/A
Resolution: This element requires resolution of whether the initial command signal was emitted or not emitted.	**Accuracy:** Time = ±0.001 s
Sampling rate: Must be determined by the manufacturer of the restraint system.	**Sampling timing:** –8 s trigger +5 s
Data format: Integer	**Discussion/references:** In using dual-stage air bags, the stages may deploy simultaneously or be staged to maintain inflation for a longer period of time. Supported by air bag deployment control system.

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8.1.19 Braking activity, ABS

Table 31—Braking activity, ABS

Data element name: Braking activity, ABS	**Other names:** BRAKING.ABS_code	**Abbreviations/ acronyms:** ABS, antilock	**Index number:** 8.1.19
Accident investigation uses: ABS activity at the time surrounding the event trigger.	**Possible alternative/additional uses:** Could also indicate the rear brake light activity.		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X	X	X					

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
	X		X	X	X		

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants	X	X	X	
Environment				

Description/operation/filter class: Represents ABS activity. No filter required.	
Data definition/sign convention/coordinate system: Data range: 0 = not active, 1 = active Special cases: 2 = invalid data, 3 = data not available	**Unit of measure:** ABS active (on) or not active (off)
Resolution: On/off resolution	**Accuracy:** N/A
Sampling rate: 2 samples per second (2 Hz)	Sampling timing: –8 s trigger +5 s
Data format: 1 byte per sample	**Discussion/references:** None

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8.1.20 Braking activity, service

Table 32—Braking activity, service

Data element name: Braking activity, service	**Other names:** BRAKING.SERVICE_code	**Abbreviations/ acronyms:** BAS	**Index number:** 8.1.20

Accident investigation uses:	**Possible alternative/additional uses:**
Service brake activity at the time surrounding the event trigger.	The brake service activity would also indicate tail lamp illumination events.

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X	X	X				X	

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X	X		X	X	X	X	X

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants	X	X	X	
Environment				

Description/operation/filter class:
Represents service brake activity. This data would be indicated by the activation of the brake lamp switch.
No filter required.

Data definition/sign convention/coordinate system:	**Unit of measure:**
Data range: 0 = not active, 1 = active Special cases: 2 = invalid data, 3 = data not available	Brake lamp switch active (on) or not active (off)
Resolution: The data element requires on/off resolution.	**Accuracy:** N/A
Sampling rate: 2 samples per second (2 Hz)	**Sampling timing:** –8 s trigger +5 s
Data format: 1 byte per sample	**Discussion/references:** None

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8.1.21 Brake line pressure, heavy-duty

Table 33—Brake line pressure, heavy-duty

Data element name: Brake, line pressure (heavy-duty, air pressure)	**Other names:** BRAKING.LINE. PRESSURE_air_quantity	**Abbreviations/ acronyms:** BLP	**Index number:** 8.1.21
Accident investigation uses: Brake line pressure at the time surrounding the event trigger.	**Possible alternative/additional uses:** Air pressure performance can be base-lined. The data can be used as criteria for preventive maintenance of air brake systems. Braking line pressure data recording systems can be adapted to the hydraulic type systems.		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
		X					

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
				X			

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants	X	X	X	
Environment				

Description/operation/filter class: Represents the quantitative level of brake air line pressure being provided. Line pressure would be indicated from the same source as the brake pressure indicator. No filter required.	
Data definition/sign convention/coordinate system: Data range: 0 = 0 kPa to 120 = 1200 kPa (~180 psi or ~180 lbf/in^2) Example normal data: 1 = 10 kPa (~1.5 psi), 10 = 100 kPa (~14.5 psi), 120 = 1200 kPa (~180 psi) Special cases: 126 = invalid data, 127 = data not available	**Unit of measure:** kilopascal (kPa)[a] 1 MPa = 1000 kPa = 1 000 000 Pa 1 psi = 1 lbf/in^2 = ~6.9 kPa Atmospheric pressure = ~101.3 kPa
Resolution: 1 kPa/bit	**Accuracy:** ±1 kPa
Sampling rate: 2 samples per second (2 Hz)	**Sampling timing:** –8 s trigger +5 s
Data format: 1 byte per sample	**Discussion/references:** Heavy-duty vehicles (pneumatic brakes) only

[a]1 kPa is numerically equal to 10 mbar.

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8.1.22 Brake, engine retarder, heavy-duty

Table 34—Brake, engine retarder, heavy-duty

Data element name: Brake, engine retarder (heavy-duty), engine retarder	**Other names:** BRAKING.RETARDER_code	**Abbreviations/ acronyms:** BR	**Index number:** 8.1.22

Accident investigation uses: Retarder status at the time surrounding the event trigger.	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
	X	X					

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
				X	X		

Modified Haddon Matrix	Pre-Crash	Crash	Post-Crash	Time Invariant
Vehicle	X	X	X	
Driver/occupants	X	X	X	
Environment				

Description/operation/filter class: Represents the retarder status as indicated by different sources according to retarder system. Retarders are often activated automatically in order to slow the vehicle when the accelerator pedal is released. No filter required.	
Data definition/sign convention/coordinate system: Data range: 0 = not on, 1 = on, 2 = activated Special cases: 3 = invalid data, 4 = data not available	**Unit of measure:** Not applicable
Resolution: N/A	**Accuracy:** N/A
Sampling rate: 2 samples per second (2 Hz)	**Sampling timing:** –8 s trigger +5 s
Data format: 1 byte per sample	**Discussion/references:** Retarder system includes mechanical, electrical, compression release.

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8.1.23 Braking, stability control (engaged/disengaged)

Table 35—Braking, stability control (engaged/disengaged)

Data element name: Braking stability control (engaged/disengaged)	**Other names:** BRAKING. STABILITY.CONTROL_code	**Abbreviations/ acronyms:** BSC	**Index number:** 8.1.23
Accident investigation uses: Stability control status at the time surrounding the event trigger.	**Possible alternative/additional uses:**		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X		X					

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
				X			

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants				
Environment				

Description/operation/filter class:
Determines the status of the stability control system. This data would be indicated by the activation of the stability control indicator lamp.
No filter required.

Data definition/sign convention/coordinate system: Data range: 0 = off, 1 = on, 2 = active, Special cases: 3 = invalid data, 4 = data not available	**Unit of measure:** Engaged (on) or not engaged (off)
Resolution: This data element requires on/off resolution.	**Accuracy:** 10 ms
Sampling rate: 2 samples per second (2 Hz)	**Sampling timing:** –8 s trigger +5 s
Data format: 1 byte per sample	**Discussion/references:** None

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8.1.24 Braking, truck parking

Table 36—Braking, truck parking

Data element name: Braking, truck parking	**Other names:** BRAKING.TRUCK.PARKING_code	**Abbreviations/ acronyms:** TEB	**Index number:** 8.1.24

Accident investigation uses: Truck parking status at the time surrounding the event trigger.	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
	X	X					

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
					X		

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants	X	X	x	
Environment				

Description/operation/filter class: Represents the emergency braking status as indicated by the position of the emergency brake switch on the dash or the emergency brake line pressure. No filter required.	
Data definition/sign convention/coordinate system: Data range: 0 = not active, 1 = active Special cases: 2 = invalid data, 3 = data not available	**Unit of measure:** Emergency brake switch active (on) or not activated (off)
Resolution: N/A	**Accuracy:** N/A
Sampling rate: 2 samples per second (2 Hz)	**Sampling timing:** –8 s trigger +5 s
Data format: 1 byte per sample	**Discussion/references:** Heavy-duty (pneumatic) vehicles only.

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8.1.25 Braking, truck trailer

Table 37—Braking, truck trailer

Data element name: Braking, truck trailer	**Other names:** BRAKING.TRUCK.TRAILER_code	**Abbreviations/ acronyms:** TTB	**Index number:** 8.1.25

Accident investigation uses: Truck trailer brake activation at the time surrounding the event trigger.	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA- OMC	NASA JPL	ATA-TMC	ComCARE
	X	X					

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
					X		

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants				
Environment				

Description/operation/filter class: Represents the truck trailer brake status. This data would be indicated by the position of the trailer brake switch on dash. No filter required.	
Data definition /sign convention/coordinate system: Data range: 0 = not active, 1 = active Special cases: 2 = invalid data, 3 = data not available	**Unit of measure:** Truck trailer brake active (on) or not active (off).
Resolution: This data element requires on/off resolution.	**Accuracy:** N/A
Sampling rate: 2 samples per second (2 Hz)	**Sampling timing:** –8 s trigger +5 s
Data format: 1 byte per sample	**Discussion/references:** Heavy-duty (pneumatic) vehicles only.

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8.1.26 Change in velocity (*x*-axis)

Table 38—Change in velocity (*x*-axis)

Data element name: Change in velocity (*x*-axis)	**Other names:** RATE.VELOCITY. VEHICLE_ChangeX-Axis_rate	**Abbreviations/ acronyms:** Δv_x	**Index number:** 8.1.26

Accident investigation uses:	**Possible alternative/additional uses:**
Vehicle change in velocity in the *x*-axis during the impact event to understand the magnitude of the impact. In conjunction with *y*-axis change in velocity, can determine PDOF.	Can be used to develop estimates of impact speed. Supports USDOT infrastructure safety evaluation and statistical hazard identification.

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA- OMC	NASA JPL	ATA-TMC	ComCARE
X		X					X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X				X		X	X

Modified Haddon Matrix	Pre-crash	Crash	Post- crash	Time invariant
Vehicle		X		
Driver/occupants		X		
Environment				

Description/operation/filter class:
Vehicle's change in velocity during the impact sequence in the longitudinal axis fore and aft direction. Change in velocity is commonly used to describe impact severity. Data is derived from integration of accelerometer signal. An SAE class 180 filter would be appropriate.

Data definition /sign convention/coordinate system:	**Unit of measure:**
Sign convention (see SAE J211/1-2003, 7.2.); coordinate system (see SAE J670-1976 [B68], Fig. 2)	kilometer per hour (km/h) 1 km/h = 1000 m/h = ~16.7 m/min = ~0.28 m/s 1 km/h = ~0.62 mi/h
Resolution: 1 km/h	**Accuracy:** ±1 km/h
Sampling rate: 500 Hz (minimum)	**Sampling timing:** –8 s trigger +5 s
Data format: Floating point	**Discussion/references:** None

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8.1.27 Change in velocity (*y*-axis)

Table 39—Change in velocity (*y*-axis)

Data element name: Change in velocity (*y*-axis)	**Other names:** RATE.VELOCITY. VEHICLE_ChangeY-Axis_rate	**Abbreviations/ acronyms:** Δv_y	**Index number:** 8.1.27

Accident investigation uses: Vehicle change in velocity in the *y*-axis during the impact event to understand the magnitude of the impact. In conjunction with *x*-axis change in velocity, can determine PDOF.	**Possible alternative/additional uses:** Supports USDOT infrastructure safety evaluation and statistical hazard identification.

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X		X					X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
				X		X	X

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle		X		
Driver/occupants		X		
Environment				

Description/operation/filter class:
Vehicle's change in velocity during the impact sequence in the lateral direction. Change in velocity is commonly used to describe impact severity. Data is derived from integration of accelerometer signal. According to SAE J211/1-2003, utilize a CFC 180 filter to permit integration for velocity or position is required.

Data definition/sign convention/coordinate system: Sign convention (see SAE J211/1-2003, 7.2.); coordinate system (see SAE J670-1976 [B68], Fig. 2)	**Unit of measure:** kilometer per hour (km/h) 1 km/h = 1000 m/h = ~16.7 m/min = ~0.28 m/s 1 km/h = ~0.62 mi/h
Resolution: 1 km/h	**Accuracy:** ±1 km/h
Sampling rate: 500 Hz (minimum)	**Sampling timing:** –8 s trigger +5 s
Data format: Floating point	**Discussion/references:** None

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8.1.28 Change in velocity (*z*-axis)

Table 40—Change in velocity (*z*-axis)

Data element name: Change in velocity (*z*-axis)	**Other names:** RATE.VELOCITY. VEHICLE_ChangeZ-axis_rate	**Abbreviations/ acronyms:** Δv_z	**Index number:** 8.1.28

Accident investigation uses: Vehicle change in velocity in the *z*-axis during the impact event to understand the magnitude of the impact.	**Possible alternative/additional uses:** Can be used to develop estimates of impact speed. Supports USDOT infrastructure safety evaluation and statistical hazard identification.

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
		X					X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
				X			

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle		X		
Driver/occupants		X		
Environment				

Description/operation/filter class: Vehicle's change in velocity during the impact in the vertical direction. Vehicle change in velocity (z-axis) during the impact event to understand the magnitude of the impact. Data is derived from integration of accelerometer signal. According to SAE J211/1-2003, utilize a CFC 180 filter to permit integration for velocity or position.	
Data definition/sign convention/coordinate system: Sign convention (see SAE J211/1-2003, 7.2.); coordinate system (see SAE J670-1976 [B68], Fig. 2)	**Unit of measure:** kilometer per hour (km/h) 1 km/h = 1000 m/h = ~16.7 m/min = ~0.28 m/s 1 km/h = ~0.62 mi/h
Resolution: 1 km/h	**Accuracy:** ± km/h
Sampling rate: 500 Hz (minimum)	**Sampling timing:** –8 s trigger +5 s
Data format: Floating point	**Discussion/references:** None

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8.1.29 Principal direction of force

Table 41—Principal direction of force

Data element name: Principal direction of force	**Other names:** Derived force vector	**Abbreviations/ acronyms:** PDOF	**Index number:** 8.1.29

Accident investigation uses:	**Possible alternative/additional uses:**
Post-crash reconstruction via data reduction and analysis.	Supports USDOT infrastructure safety evaluation and statistical hazard identification.

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X	X	X					X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
	X	X					

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X		
Driver/occupants		X		
Environment				

Description/operation/filter class:
Derived from 3 normal and 3 angular accelerations measured by MVEDR after transformation to SAE coordinate system—however, this requires the MVEDR send its location and orientation in the vehicle as part of the download. Determine the instantaneous vector direction of force during the crash event.
Not computed within the MVEDR—computed after the data is downloaded—may require all 6 degrees of freedom measurements plus the the location and angular orientation of the MVEDR mounting in the vehicle.

Data definition/sign convention/coordinate system:	**Unit of measure:**
Sign convention (see SAE J211/1-2003, 7.2); coordinate system (see SAE J670-1976 [B68], Fig 2)	newtons (N) I N = 0.2248 lbf
Resolution: Limited by data that is downloaded from the MVEDR.	**Accuracy:** Limited by acceleration data available—may not be deterministic unless both 3 linear and 3 rotational accelerations are measured.
Sampling rate: Calculated by the MVEDR	**Sampling timing:** Derived from measured accelerations during pre- and post-crash recording periods.
Data format: N/A	**Discussion/references:** None

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8.1.30 Engine manifold pressure

Table 42—Engine manifold pressure

Data element name: Engine manifold pressure	**Other names:** PRESSURE. ABS.ENGINE.Manifold_quantity	**Abbreviations/ acronyms:** PABSE	**Index number:** 8.1.30
Accident investigation uses: Indicates the magnitude of load on an internal combustion engine.	**Possible alternative/additional uses:** Can be used to monitor engine performance along with r/min and throttle position.		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
	X						

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants	X			
Environment				

Description/operation/filter class:
Absolute pressure in the engine's intake manifold.
Measure of engine's load (low pressure = high vacuum = high engine load)
Engine control module reads the manifold absolute pressure (MAP) sensor and presents that data on the vehicle's data network.

Data definition/sign convention/coordinate system:	**Unit of measure:**
0 = full vacuum, 1 = 2 kPa, 50 = 100 kPa Special cases: 254 = invalid data, 255 = data available	kilopascal (kPa)[a] 1 MPa = 1000 kPa = 1 000 000 Pa 1 psi = 1 lbf/in^2 = ~6.9 kPa atmospheric pressure = ~101.3 kPa
Resolution: 2 kPa/bit	**Accuracy:** ±2%
Sampling rate: 1 sample per second	**Sampling timing:** –8 s trigger +5 s
Data format: Byte	**Discussion/references:** None

[a]1 kPa is numerically equal to 10 mbar.

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8.1.31 Engine data, r/min

Table 43—Engine data, r/min

Data element name: Engine data, r/min	**Other names:** RATE.ENGINE.r/min_quanitity	**Abbreviations/ acronyms:** r/min	**Index number:** 8.1.31

Accident investigation uses: Establishes the relationship between accelerator control and engine r/min.	**Possible alternative/additional uses:** May help infer driver inputs or possible accident causation. Can be used for engine diagnosis purposes.

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA -TMC	ComCARE
		X					

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X	X		X		X		

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants	X	X	X	
Environment				

Description/operation/filter class:
Engine speed, expressed in revolutions per minute (r/min).
Measure of engine's speed.
Engine control module determines the engine speed and presents that data on the vehicle's data network.

Data definition/sign convention/coordinate system: Data range: 0 to 12 000 r/min	**Unit of measure:** r/min
Resolution: 0.25 (r/min)/bit	**Accuracy:** ±1%
Sampling rate: 5 samples per second	**Sampling timing:** –8 s trigger +5 s
Data format: Integer (2 bytes) (0.25 r/min per bit)	**Discussion/references:** None

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8.1.32 Engine data, throttle

Table 44—Engine data, throttle

Data element name: Engine data, throttle	**Other names:** POSITION.ENGINE.Throttle_quantity	**Abbreviations/ acronyms:** APP	**Index number:** 8.1.32

Accident investigation uses:	**Possible alternative/additional uses:**
Indicates the driver control input to the engine.	Data acquired may resolve so-called *sudden unintended acceleration* (SUA) issues.

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA - OMC	NASA JPL	ATA-TMC	ComCARE
		X					

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X			X	X	X	X	

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants	X	X	X	
Environment				

Description/operation/filter class:
Position of the engine's throttle, expressed as a percentage of full throttle
Measure of driver's control input to engine
Engine control module reads the throttle position sensor and presents that data on the vehicle's data network.

Data definition/sign convention/coordinate system:	**Unit of measure:**
0 = 0%, 250 = 100%, Special cases: 254 = invalid data, 255 = data unavailable	%
Resolution: 0.4%/bit	**Accuracy:** ±1%
Sampling rate: 4 samples per second	**Sampling timing:** –8 s trigger +5 s
Data format: 1 byte	**Discussion/references:** None

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8.1.33 Engine data, torque

Table 45—Engine data, torque

Data element name: Engine data, torque	**Other names:** POSITION.ENGINE.Torque_quantity	**Abbreviations/ acronyms:** EDT	**Index number:** 8.1.33

Accident investigation uses:	**Possible alternative/additional uses:**
Engine torque data will reflect the actual torque the engine delivers as requested by the driver. This torque value will be different from the torque values delivered by the driving wheels.	A computerized engine control module that senses engine torque would optimize the driver's input resulting in lower fuel consumption.

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X	X	X					

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X					X		

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X			
Driver/occupants	X			
Environment				

Description/operation/filter class: Provides the percent torque of the vehicle's engine, as a fraction of the engines maximum torque output.	
Data definition/sign convention/coordinate system: 0 = 0%, 250 = 100% Special cases: 254 = invalid data, 255 = data unavailable, 0 = no torque, 1 = full engine torque	**Unit of measure:** % of full engine torque
Resolution: 0.4%/bit	**Accuracy:** ±sample 1%
Sampling rate: 5 samples per second—heavy-duty 1 sample per second—light-duty	**Sampling timing:** –8 s trigger +5 s
Data format: 1 byte	**Discussion/references:** None

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8.1.34 Environment, inside temperature

Table 46—Environment, inside temperature

Data element name: Interior temperature	**Other names:** Temperature.INTERIOR.VEHICLE.quantity	**Abbreviations/ acronyms:** Ti	**Index number:** 8.1.34
Accident investigation uses: Measure temperature before and after triggering event.	**Possible alternative/additional uses:**		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors recorders	Insurance	Roadside
	X						

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle				
Driver/occupants				
Environment	X		X	

Description/operation/filter class: Temperature measurement of the temperature inside the vehicle as measured by temperature sensor. No filtering.	
Data definition/sign convention/coordinate system: Values above 0 °C are positive, values below 0 °C are negative. Minimum value –40 °C to +80 °C. –40 = –40 °C, 80 = +80 °C. Special cases: 126 = invalid data, 127 = data unavailable.	**Unit of measure:** degrees Celsius (°C)
Resolution: 1 °C/bit	**Accuracy:** ±1 °C
Sampling rate: 1 sample /second	**Sampling timing:** –8 s trigger +5 s
Data format: Byte	**Discussion/references:** None

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8.1.35 Environment, outside temperature

Table 47—Environment, outside temperature

Data element name: Exterior temperature	**Other names:** Temperature.AMBIENT_quantity	**Abbreviations/ acronyms:** T amb	**Index number:** 8.1.35

Accident investigation uses: Measure temperature before and after triggering event.	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
						X	

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors recorders	Insurance	Roadside

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle				
Driver/occupants				
Environment	X		X	

Description/operation/filter class: Measurement of the temperature outside the vehicle as measured by temperature sensor. No filtering.	
Data definition/sign convention/coordinate system: Values above 0 °C are positive, values below 0 °C are negative. Minimum value –40 °C to +80 °C maximum value. Special cases: 126 = invalid data, 127 = data unavailable	**Unit of measure:** degrees Celsius (°C)
Resolution: 1 °C/bit	Accuracy: ±1 °C
Sampling rate: 1 s	**Sampling timing:** –8 s trigger +5 s
Data format: Byte	**Discussion/references:** None

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8.1.36 Exterior headlamp—daytime running lights

Table 48—Exterior headlamp—daytime running lights

Data element name: Exterior lamp—daytime running lights	**Other names:** LAMP.EXTERIOR. VEHICLE_Running.daytime_code	**Abbreviations/acronyms:** DRL	**Index number:** 8.1.36
Accident investigation uses: Determine what lighting was being used prior to the triggering event.	**Possible alternative/additional uses:**		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
		X					

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors recorders	Insurance	Roadside
					X	X	

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X			
Driver/occupants				
Environment				

Description/operation/filter class: Determine running lights normally controlled by ignition switch (on/off). Flag to indicate whether lamp was illuminated (on) or not illuminated (off). Switch to turn on activated or not activated. No filtering.	
Data definition/sign convention/coordinate system: Data range: 0 = not active, 1 = active, 2 = invalid data, 3 = data not available	**Unit of measure:** N/A
Resolution: N/A	**Accuracy:** N/A
Sampling rate: 1 sample per second	**Sampling timing:** –8 s trigger +5 s
Data format: Byte	**Discussion/references:** None

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8.1.37 Exterior headlamp—high beam

Table 49—Exterior headlamp—high beam

Data element name: Exterior headlamp—high beam	**Other names:** LAMP.EXTERIOR. VEHICLE_Headlamp.high	**Abbreviations/ acronyms:** LXH	**Index number:** 8.1.37

Accident investigation uses: Determine operating status of headlight system prior to an event.	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA General List	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
		X					

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors recorders	Insurance	Roadside
					X	X	

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X			
Driver/occupants				
Environment				

Description/operation/filter class:
Flag to indicate whether lamp was illuminated (on) or not illuminated (off). Switch to turn on activated or not activated. No filtering.

Data definition/sign convention/coordinate system: Data range: 0 = not active, 1 = active, 2 = invalid data, 3 = data not available	**Unit of measure:** N/A
Resolution: N/A	**Accuracy:** N/A
Sampling rate: 1 sample per second (1 Hz)	**Sampling timing:** –8 s trigger +5 s
Data format: Byte	**Discussion/references:** None

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8.1.38 Exterior lamp—low beam

Table 50—Exterior lamp—low beam

Data element name: Exterior lamp—low beam	**Other names:** LAMP.EXTE-RIOR.VEHICLE_Headlamp.low	**Abbreviations/ acronyms:** LEL	**Index number:** 8.1.38

Accident investigation uses: Determine what lighting was being used prior to the triggering event	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
		X					

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors recorders	Insurance	Roadside
					X	X	

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X			
Driver/occupants				
Environment				

Description/operation/filter class:
Flag to indicate whether low beam lamp was illuminated (on) or not illuminated (off). Switch to turn on activated or not activated. No filtering.

Data definition/sign convention/coordinate system: Data range: 0 = not active, 1 = active, 2 = invalid data, 3 = data not available	**Unit of measure:** N/A
Resolution: N/A	**Accuracy:** N/A
Sampling rate: 1 sample per second (1 Hz)	**Sampling timing:** –8 s trigger +5 s
Data format: Byte	**Discussion/references:** None

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8.1.39 Exterior lamp—park

Table 51—Exterior lamp—park

Data element name: Exterior lamp—park	**Other names:** LAMP.EXTERIOR.VEHICLE_Parking	**Abbreviations/ acronyms:** LEP	**Index number:** 8.1.39

Accident investigation uses: Determine what lighting was being used prior to the triggering event	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA- OMC	NASA JPL	ATA-TMC	ComCARE
		X					

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
					X	X	

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X			
Driver/occupants				
Environment				

Description/operation/filter class: Flag to indicate whether parking lamp was illuminated (on) or not illuminated (off) by recording whether switch to turn on activated or not activated. No filtering required.	
Data definition/sign convention/coordinate system: Data range: 0 = not active, 1 = active, 2 = invalid data, 3 = data not available	**Unit of measure:** N/A
Resolution: N/A	**Accuracy:** N/A
Sampling rate: 1 sample per second (1 Hz)	**Sampling timing:** –8 s trigger +5 s
Data format: Byte	**Discussion/references:** None

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8.1.40 GNSS latitude

Table 52—GNSS latitude

Data element name: Global Navigation Satellite System latitude	**Other names:** Latitude, GPS latitude	**Abbreviations/ acronyms:** Lat	**Index number:** 8.1.40

Accident investigation uses: Provides absolute vehicle position from the GNSS solution. Allows track of vehicle path over ground.	**Possible alternative/additional uses:** Supports ACN. Supports USDOT infrastructure safety evaluation and statistical hazard identification.

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
		X					X

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants				
Environment	X	X	X	

Description/operation/filter class:
Provides the absolute vehicle position (latitude component) of the vehicle. Will be useful for detailed reconstruction, including path over ground. Will also support infrastructure safety evaluation and statistical hazard identification by USDOT.

Data definition/sign convention/coordinate system: Coordinate system: World Geodetic System (WGS84) 0° ð lat ð 90°, N (north) or S (south) Special cases: 98xx.xxxx = invalid data, 99xx.xxxx = data unavailable	**Unit of measure:** degrees (°), minutes ('), and decimal fraction of minutes.
Resolution: 0.0001'	**Accuracy:** 0.06' (0.001°), corresponds to about 111 m (varies very little with latitude)
Sampling rate: 1 Hz	**Sampling timing:** –8 s trigger +5 s
Data format: ddmm.mmmmD Using byte format (ASCII representation) for dd (degree), mm (minutes), and mmmm (fraction minutes) and direction D = N or S	**Discussion/references:** Based on typical GPS/GNSS systems and the format provided in NMEA 0183 messages (see NMEA 0183-2002 [B64]). Latitude is available in NMEA 0183 messages including RMC and GGA. Accuracy requirements assume sea level for altitude. Accuracy of 100 m assumes use of high-sensitivity GNSS for increased availability, leading to higher error rates due to multipath. For lower-sensitivity GNSS, accuracy increases to about 10 m (95%, with code-based receiver).

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8.1.41 GNSS longitude

Table 53—GNSS longitude

Data element name: Global Navigation Satellite System longitude	**Other names:** Longitude, GPS longitude	**Abbreviations/ acronyms:** Long	**Index number:** 8.1.41
Accident investigation uses: Provides absolute vehicle position from the GNSS solution. Allows track of path over ground.	**Possible alternative/additional uses:** Supports ACN. Supports USDOT infrastructure safety evaluation and statistical hazard identification.		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
		X					X

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants				
Environment	X	X	X	

Description/operation/filter class:
Provides the absolute vehicle position (longitude component) of the vehicle. Will be useful for detailed reconstruction, including path over ground. Will also support infrastructure safety evaluation and statistical hazard identification by USDOT.

Data definition/sign convention/coordinate system:	**Unit of measure:**
Coordinate system: World Geodetic System (WGS84) 000° ð long ð 180°, E (east) or W (west) Special cases: 998xx.xxxx = invalid data, 999xx.xxxx = data unavailable	degrees (°), minutes ('), and decimal fraction of minutes of arc
Resolution: 0.0001'	**Accuracy:** 0.06' (0.001°), corresponds to about 96 m at 30° N or S, 85 m at 40° N or S, 72 m at 50° N or S, exactly 0 m at the poles
Sampling rate: 1 Hz	**Sampling timing:** –8 s trigger +5 s
Data format: dddmmm.mmmm Using byte format (ASCII representation) for ddd (degrees), mm (minutes), and mmmm (fraction minutes) and direction D = E or W.	**Discussion/references:** Based on typical GPS/GNSS systems and the format provided in NMEA 0183 messages (see NMEA 0183-2002 [B64]). Longitude is available in NMEA 0183 messages including RMC and GGA. Accuracy requirements assume sea level for altitude and operation near equator. Will be valid up to reasonable altitude and latitude. Fundamentally, accuracy should correspond to 95%-level of receiver. Accuracy of 100 m assumes use of high-sensitivity GNSS for increased availability, leading to higher error rates due to multipath. For lower-sensitivity GNSS, accuracy increases to about 10 m (95%, with code-based receiver).

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8.1.42 GNSS status

Table 54—GNSS status

Data element name: Global Navigation Satellite System status	**Other names:** GPS status	**Abbreviations/ acronyms:** GNSS Status	**Index number:** 8.1.42
Accident investigation uses: Determines the validity of the GNSS solution, and provides factors (number of satellites, differential status, ambiguity resolution) to evaluate the level of quality and reliability of the GNSS solution.	**Possible alternative/additional uses:**		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
		X					X

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants				
Environment				

Description/operation/filter class:
Provides information on the GNSS solution status. First, is the solution valid? Second, what is the quality of the solution with respect to differential corrections and ambiguity resolution (for RTK)? Also, number of satellites used in solution, age of differential correction in seconds (when appropriate), and base station ID (when appropriate). Status is given in a comma-delimited string form consistent with NMEA 0183 message formats, so that conversion is not required.

Data definition/sign convention/coordinate system: S, Q, N, DA, SID (see “data format” for individual field definitions)	**Unit of measure:** N/A
Resolution: Smallest data unit	**Accuracy:** N/A (status as obtained from the GNSS receiver)
Sampling rate: 1 Hz	**Sampling timing:** –8 s trigger +5 s

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Table 54—GNSS status *(continued)*

Data format:	**Discussion/references:**
S, Q, N, DA, SID where *Solution status* (S): A = valid, V = invalid, X = unknown *Quality* (Q): 0 = fix not valid, 1 = GNSS fix, 2 = differential GNSS fix, 4 = real-time kinematic (fixed integers), 5 = real-time kinematic (float integers), 9 = WAAS, X = unknown *Number satellites* (N): 00–24 (assuming GPS and Galileo), XX = unknown *Differential age* (DA): 00.0–99.9 (seconds), time since last differential update. XX.X = unknown. Practical maximum for DA is about 60 s. *Differential station ID* (SID): 0000–1023. XXXX = unknown	The elements of the status string can be obtained from the NMEA 0183 messages (see NMEA 0183-2002 [B64]). *Solution status* (S) is available in RMC, while all others are available in GGA. Solution status values are based on existing RMC format, wherein A = valid and V = invalid. For *Quality* (Q), Q = 0 is equivalent to S = V (not a valid solution). Also, Q = 9 for Wide-Area Augmentation System (WAAS) is not part of the GGA standard message, but is used by some manufacturers. Real-time kinematic (RTK) refers to carrier-phase tracking with integer wave count ambiguity resolution. Q = 4 indicates ambiguity has been resolved, while Q = 5 is during the resolution process. *Number satellites* (N) will be 12 or less for a single GNSS system, but may be higher (up to 24) for dual-system receiver, e.g., GPS and Galileo. *Differential age* (DA) should be small in practice, on the order of 1 s to 2 s for station-based differential, but up to 10 s for satellite-based differential. DA is important in evaluating the relevance and accuracy of differential corrections.

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8.1.43 GNSS HDOP

Table 55—GNSS HDOP

Data element name: Global Navigation Satellite System horizontal dilution of precision (HDOP)	**Other names:** HDOP, GPS HDOP, GPS dilution of precision	**Abbreviations/ acronyms:** HDOP	**Index number:** 8.1.43

Accident investigation uses: Provides an indication of the position accuracy (scaling factor for standard deviation) of the GNSS solution.	**Possible alternative/additional uses:** For high HDOP, may reject the solution for some purposes.

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
		X					X

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants				
Environment				

Description/operation/filter class:
Provides the HDOP related to the GNSS position solution. This factor amplifies the anticipated error (standard deviation) under nominal conditions. HDOP is related to satellite geometry, with higher HDOP coming from degraded satellite geometry, indicating higher solution error. HDOP is available in NMEA 0183 messages, including GGA.

Data definition/sign convention/coordinate system: Data range: 0.1–6.0 Special cases: 9.8 = invalid data, 9.9 = data unavailable	**Unit of measure:** N/A
Resolution: 0.1 m	**Accuracy:** Based on receiver used/nominally ±0.1
Sampling rate: 1 sample per second (minimum) (≥1 Hz)	**Sampling timing:** –8 s trigger +5 s
Data format: 2 byte: X.y ASCII representation for units X and tenths y	**Discussion/references:** Based on typical GPS systems and the format provided in NMEA 0183 messages (see NMEA 0183-2002 [B64]). HDOP may be slightly less than unity. There is no theoretical upper bound, but higher than 6 corresponds to effectively no solution.

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8.1.44 GNSS ground travel direction

Table 56—GNSS ground travel direction

Data element name: Global Navigation Satellite System ground travel direction	**Other names:** Travel direction, GPS ground travel direction, GPS heading	**Abbreviations/ acronyms:** GNSS-GTD	**Index number:** 8.1.44
Accident investigation uses: Provides a vehicle-independent measure of the direction of motion over the ground. Based on use of GNSS position solution and filtering provided by the GNSS receiver.	**Possible alternative/additional uses:**		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
		X					X

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants				
Environment				

Description/operation/filter class: Provides an independent measure of the absolute direction of travel of the vehicle. This can be combined with the GNSS ground travel speed to obtain the vector of motion at each sample. It will be independent of wheel speed, driveshaft, and any other in-vehicle speed sensing means.	
Data definition/sign convention/coordinate system: 000.0° <= GTD <= 359.9° 000.0° is true north, while 090.0° is east Special cases: 800.x = invalid data, 900.x = data unavailable	**Unit of measure:** degrees (°)
Resolution: 0.1°	**Accuracy:** ±1°
Sampling rate: 1 Hz	**Sampling timing:** –8 s trigger +5 s
Data format: 4 byte ASCI I representing “xxx.x”	**Discussion/references:** GNSS ground travel direction (GTD) is available from NMEA 0183 messages (see NMEA 0183-2002 [B64]), including RMC and VTG. GNSS-GTD should not be confused with vehicle heading. GTD is based on vehicle velocity direction, rather than vehicle orientation (heading). Vehicle heading can be obtained by an on-board compass, while GTD requires sensing or estimation of latitude and longitude velocity components. Note also that GNSS-derived heading will be relative to true north (000°), rather than magnetic north.

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8.1.45 GNSS ground travel speed

Table 57—GNSS ground travel speed

Data element name: Global Navigation Satellite System ground travel speed	**Other names:** Speed, GPS speed	**Abbreviations/ acronyms:** GNSS-GTS	**Index number:** 8.1.45
Accident investigation uses: Measure of vehicle speed independent from wheel speed and driveshaft sensors.	**Possible alternative/additional uses:**		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA- OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
		X					X

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants				
Environment				

Description/operation/filter class: Provides an independent measure of the vehicle speed. This will be absolute speed, combining any longitudinal and lateral motion. This can be combined with the GNSS GTD to obtain the vector of motion at each sample. It will be independent of wheel speed, driveshaft, and any other in-vehicle speed sensing means.	
Data definition/sign convention/coordinate system: 0 ð GTS < 300 Special cases: 800.x = Invalid data, 900.x = data unavailable	**Unit of measure:** kilometer per hour (km/h)
Resolution: 0.02 km/h	**Accuracy:** ±1 km/h
Sampling rate: 1 Hz	Sampling timing: –8 s trigger +5 s
Data format: 5 byte ASCII representing “xxx.xx”	**Discussion/references:** GNSS ground travel speed (GTS) is available from NMEA 0183 messages (see NMEA 0183-2002 [B64]), including RMC. NMEA format provides reading as xx.yy and is often given in knots. Conversion is 1 knot = 1.852 km/h, exactly. Some NMEA messages (e.g., VTG) will provide GNSS-GTS directly in km/h.

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8.1.46 Heading, direction of vehicle

Table 58—Heading, direction of vehicle

Data element name: Heading, direction of vehicle	**Other names:** ANGLE.VEHICLE. Travel_Heading_quantity	**Abbreviations/ acronyms:** Hv	**Index number:** 8.1.46
Accident investigation uses: Determine the heading of the vehicle prior to the event.	**Possible alternative/additional uses:**		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
				X	X		X

Modified Haddon Matrix	Pre-crash	Crash	Post- crash	Time invariant
Vehicle	X			
Driver/occupants				
Environment				

Description/operation/filter class: Angular direction, as in a compass heading vs. true north in which a vehicle points at trigger. GPS receiver.	
Data definition/sign convention/coordinate system: 0 = 0°, 239 = 358.5°, 254 = data invalid, 255 = data invalid	**Unit of measure:** degree (°)
Resolution: 1°	**Accuracy:** ±1.5°
Sampling rate: 1 sample per second	**Sampling timing:** –8 s trigger +5 s
Data format: Byte (360/240 = 1.5°/bit)	**Discussion/references:** None

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8.1.47 Ignition cycle count, event

Table 59—Ignition cycle count, event

Data element name: Ignition cycle count, event	**Other names:** IGNITION_CYCLE.event, quantity	**Abbreviations/ acronyms:** ICE	**Index number:** 8.1.47

Accident investigation uses: Provides the number of ignition switch cycles from "off" to "on" of the vehicle from its first use to the time of the event.	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors recorders	Insurance	Roadside
X			X				

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle				X
Driver/occupants				
Environment				

Description/operation/filter class:
Indicates the number of times the ignition has been cycled starting from the time the vehicle was manufactured and ending on the cycle in which the crash occurred.
Measures the vehicle's usage in terms of ignition cycles.
Counter.
No filter required.

Data definition/sign convention/coordinate system: Data range: 0 = no counts, 1 = ignition on once, 999,999,998 = invalid data, 999,999,999 = data not available	**Unit of measure:** Each
Resolution: N/A	**Accuracy:** N/A
Sampling rate: Once at trigger	**Sampling timing:** N/A
Data format: Integer (4 bytes)	**Discussion/references:** None

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8.1.48 Ignition cycle count, investigation

Table 60—Ignition cycle count, investigation

Data element name: Ignition cycle count, investigation	**Other names:** IGNITION_CYCLE. investigation, quantity	**Abbreviations/ acronyms:** ICCI	**Index number:** 8.1.48

Accident investigation uses:	**Possible alternative/additional uses:**
Provides the number of ignition switch "on/off" cycles to when the data is downloaded from the vehicle from its first use.	

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X			X				

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle				X
Driver/occupants				
Environment				

Description/operation/filter class:
Indicates the number of times the ignition has been cycled starting from the time the vehicle was manufactured and ending on the cycle concurrent with the crash investigation.
By comparing to the event ignition counter, measures the number of cycles since the event.
No filter required.

Data definition/sign convention/coordinate system:	**Unit of measure:**
Data range: 0 = no counts, 1= ignition on once, 999,999,998 = invalid data, 999,999,999 = data not available	Count
Resolution: N/A	**Accuracy:** N/A
Sampling rate: Once	**Sampling timing:** Count at request
Data format: Integer (4 bytes)	**Discussion/references:** None

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8.1.49 Indicator lamp, air bag

Table 61—Indicator lamp, air bag

Data element name: Indicator lamp, air bag	**Other names:** Air bag warning light status	**Abbreviations/ acronyms:** ILAB	**Index number:** 8.1.49

Accident investigation uses: Provides an indication as to the operational readiness of the air bag system prior to the event. Could also be used to provide the operational readiness status of the restraint systems (i.e., seat belt).	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA -TMC	ComCARE
		X					

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
			X		X		

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants				
Environment				

Description/operation/filter class: Indicate if air bag warning lamp is lighted. Indicate if occupant restraints and engaged. Status light upon engine start or ignition key on.	
Data definition/sign convention/coordinate system:	**Unit of measure:** status bit
Resolution: 1 count per bit	**Accuracy:** 10 counts
Sampling rate: Sample last ignition key on cycle	**Sampling timing:** –8 s trigger +5 s
Data format: Byte	**Discussion/references:** Lamp as required in FMVSS 208.

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8.1.50 Indicator lamp, MVEDR

Table 62—Indicator lamp, MVEDR

Data element name: Indicator lamp, MVEDR	**Other names:** MVEDR light status telltale	**Abbreviations/ acronyms:** ILMVEDR	**Index number:** 8.1.50

Accident investigation uses: Provides clear visual indication as to the operational readiness of the MVEDR system prior to the event and signals data capture at trigger. Enables first responders to determine MVEDR location for rapid download.	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
		X				X	

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants				
Environment				

Description/operation/filter class: MVEDR Status from start-up to event. Indicate by green color if MVEDR is enabled and able to record at key on, engine on. Indicate by red color if MVEDR fault has occurred at key on, engine on. Indicate by blue color MVEDR data capture at trigger.	
Data definition/sign convention/coordinate system: 0 = light off = MVEDR off, 1 = green on = MVEDR operational, 2 = red on = MVEDR fault, 3 = blue on = data capture, 254 = invalid data, 255 = data not available	**Unit of measure:** status bit
Resolution: N/A	**Accuracy:** N/A
Sampling rate: Sample last ignition key on cycle.	**Sampling timing:** Time series:
Data format: Byte	**Discussion/references:** None

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8.1.51 Indicator lamp, ABS

Table 63—Indicator lamp, ABS

Data element name: Indicator lamp, ABS	**Other names:** ABS readiness status indicator	**Abbreviations/ acronyms:** ILABS	**Index number:** 8.1.51

Accident investigation uses: Provides an indication as to the operational status of the ABS system around an object or central space of the event.	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
	X						

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X			
Driver/occupants				
Environment				

Description/operation/filter class: Indicate operational status of ABS. ABS voltage is monitored and displayed on the instrument panel.	
Data definition/sign convention/coordinate system: 0 = lamp off, ABS “ok”, 1 = lamp on, ABS “fault” 2 = invalid data, 3 = data not available	**Unit of measure:** N/A
Resolution: This data element is on/off. There is no resolution required.	**Accuracy:** N/A
Sampling rate: 1 sample per second	**Sampling timing:** –8 s trigger +5 s
Data format: Byte	**Discussion/references:** None

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8.1.52 Indicator lamp, traction control

Table 64—Indicator lamp, traction control

Data element name: Indicator lamp, traction control	**Other names:** Traction Control_lamp	**Abbreviations/ acronyms:** ILTC	**Index number:** 8.1.52
Accident investigation uses: Provides the status of the traction control lamp status before, during, and after the time of the event.	**Possible alternative/additional uses:**		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
	X						

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X			
Driver/occupants				
Environment				

Description/operation/filter class: Traction control system is engaged or not engaged. Traction control system voltage is monitored and displayed on the instrument panel.	
Data definition/sign convention/coordinate system: 0 = lamp off = traction system OK and on; 1 = lamp on = traction system off or fault; 2 = invalid data; 3 = data not available	**Unit of measure:** Binary value
Resolution: N/A	**Accuracy:** N/A
Sampling rate: 1 sample per second	**Sampling timing:** –8 s trigger +5 s
Data format: Byte	**Discussion/references:** This element records the lamp status of the traction control system.

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8.1.53 Number of seat positions occupied

Table 65—Number of seat positions occupied

Data element name Number of seat positions occupied	**Other names:** Vehicle occupants total	**Abbreviations/ acronyms:** NoOcc	**Index number:** 8.1.53
Accident investigation uses: Determine which occupant positions have occupants in them at the time surrounding the event.	**Possible alternative/additional uses:** EMS could use coded signal from vehicle at the time of triggering event and be advised of the number of occupants that are in the vehicle.		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X		X					

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants	X	X	X	
Environment				

Description/operation/filter class: The signal obtained from weight sensors or switches embedded in each seat position or IR occupant sensors is recorded by the MVEDR, thus preventing a misreading of an adult holding a child. In special coded messages, local EMS crews could receive the signal that is emitted or extracted from the vehicle.	
Data definition/sign convention/coordinate system: 1= position occupied, 2 = position not occupied, 3 = RFCSS or CSS sensed in this position, 5 = other, 15 = occupant sense not available at this location	**Unit of measure:** N/A
Resolution: This element requires resolution of position occupied (on) or not occupied (off).	**Accuracy:** N/A
Sampling rate: One sample per second	**Sampling timing:** –8 s trigger +5 s
Data format: 2 byte	**Discussion/references:** Weight sensors or IR sensors would be needed to discriminate between an empty vehicle seat and an occupied vehicle seat(s), or if an adult was holding a child.

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8.1.54 Vehicle mileage indicator, event

Table 66—Vehicle mileage indicator, event

Data element name: Vehicle mileage indicator, event	**Other names:** ODOMETER_READING.event, quantity	**Abbreviations/ acronyms:** OR	**Index number:** 8.1.54

Accident investigation uses: Provides the age of the vehicle in terms of distance traveled at the time of the event trigger.	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
	X						

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle		X		
Driver/occupants				
Environment				

Description/operation/filter class:
Indicates the number of miles or kilometers from the time the vehicle was manufactured and ending when the crash/event occurred.
Measures the vehicle's useage in terms of miles or kilometers traveled.
Counter.
No filter required.

Data definition/sign convention/coordinate system: Data range: 0 = 0 mi or 0 km, 1 = 0.1 mi or 0.1 km, 999,999,998 = data invalid, 999,999,999 = data unavailable, 254 = invalid data, 255 = data not available	**Unit of measure:** mile (mi) or kilometer (km) depending on odometer style
Resolution: 0.1 mi/bit or 0.1 km/bit	**Accuracy:** N/A
Sampling rate: Once at trigger	**Sampling timing:** –8 s trigger +5 s
Data format: Integer (4 bytes)	**Discussion/references:** None

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8.1.55 PRNDL (gear selection, time series)

Table 67—PRNDL (gear selection, time series)

Data element name: PRNDL gear selection	**Other names:** Gear selection PRNDL code	**Abbreviations/ acronyms:** PRNDL	**Index number:** 8.1.55

Accident investigation uses:	**Possible alternative/additional uses:**
Indicates what transmission gear position (PRNDL) that the operator of the vehicle or the automatic shifter has selected surrounding the time of the event trigger.	

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle				
Driver/occupants				
Environment				

Description/operation/filter class:
This data element will utilize the signals from the gear selector to record the gear position that was selected by the operator or by the automatic electric gear shifter. The data element should indicate, at a minimum, the status of the transmission as P = park, R = reverse, N = neutral, D = drive, and L = low.
No filter required.

Data definition/sign convention/coordinate system:	**Unit of measure:**
Data range: 0 = P, 1 = R, 2 = N, 3 = D, 4 = L, 254 = no data, 255 = invalid data	N/A
Resolution: This data element requires on/off resolution for each of the gear positions.	**Accuracy:** N/A
Sampling rate: 1 sample per second	**Sampling timing:** –8 s trigger +5 s
Data format: Byte	**Discussion/references:** Some vehicles may have more than five gear positions. This element would be expanded as necessary for heavy trucks, multiple reverse gears, etc.

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8.1.56 Pitch rate

Table 68—Pitch rate

Data element name: Pitch rate	**Other names:** RATE.ANGULAR.VEHICLE.Pitch	**Abbreviations/ acronyms:** PRy	**Index number:** 8.1.56

Accident investigation uses:	**Possible alternative/additional uses:**
The pitch rate describes the rotation of speed around the lateral axis of the vehicle at the time surrounding the event trigger.	Could support USDOT infrastructure safety evaluation and statistical hazard identification.

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants				
Environment				

Description/operation/filter class:
Vehicle pitch rate (angular velocity) about lateral axis (*y*-axis).
Vehicle pitch rate at the time surrounding the event trigger.
Y-axis gyro, inertial measurement unit.
According to SAE J211/1-2003, utilize a CFC 180 filter to permit integration for velocity of position.

Data definition/sign convention/coordinate system:	**Unit of measure:**
±180°/s. Sign convention (see SAE J211/1-2003, 7.2); coordinate system (see SAE 670-1976 [B68], Fig. 2), 254 = data invalid, 255 = data unavailable	degree per second (°/s)
Resolution: 0.1°/s	**Accuracy:** ±0.1°/s
Sampling rate: 10 samples per second from –10 s to –1 s (before the event). 1000 samples per s from –1 s to the event trigger to 5 s following the event.	**Sampling timing:** –8 s trigger +5 s
Data format: Floating point (4 bytes)	**Discussion/references:** Ideally, the *y*-axis gyro should be located near the center of gravity of the vehicle, but accelerometers may suffice.

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8.1.57 Restraint usage, driver

Table 69—Restraint usage, driver

Data element name: Restraint usage, driver	**Other names:** Driver's seat belt status	**Abbreviations/ acronyms:** ResD	**Index number:** 8.1.57

Accident investigation uses: This signal provides the data that reports the utilization of the driver's seat belt/shoulder harness at the time surrounding the triggering event.	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X		X					

Modified Haddon Matrix	Pre-crash	Crash	Post- crash	Time invariant
Vehicle	X	X	X	
Driver/occupants	X	X	X	
Environment				

Description/operation/filter class: The driver's seat belt connector communicates with the ECM to determine if the seat belt is connected or not. This seat belt status is also recorded by the MVEDR. IR signaling can indicate vehicle occupancy and seat belt status.	
Data definition/sign convention/coordinate system: 0 = engaged, 1 = disengaged, 254 = invalid data, 255 = data not available	**Unit of measure:** N/A
Resolution: N/A	**Accuracy:** ±.01 s
Sampling rate: 10 samples per second	**Sampling timing:** –8 s trigger +5 s
Data format: 2 byte integer	**Discussion/references:** None

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8.1.58 Restraint usage, other positions

Table 70—Restraint usage, other positions

Data element name: Restraint usage, other positions	**Other names:** Other passenger's seat belt status	**Abbreviations/ acronyms:** ResOP	**Index number:** 8.1.58

Accident investigation uses: This signal provides the data that reports the utilization of the seat belt of the passenger's seats other than the driver and the front seat passenger at the time surrounding the triggering event.	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA -TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X		X					

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants	X	X	X	
Environment				

Description/operation/filter class:
All of the other passenger's seat belt connectors communicate with the ECM to determine if the seat belt is connected or not. This seat belt status is also recorded by the MVEDR. IR signaling can indicate vehicle occupancy and seat belt status. This element does not include the driver or the front seat passenger.
It is possible that the seat buckle can be engaged, but the seat position unoccupied, especially when the child car seat is employed. Weight and IR sensors will determine if an occupant is in the seat or not.
No filter is required.

Data definition/sign convention/coordinate system: 0 = engaged, 1= disengaged, 254 = invalid data, 255 = data not available for up to 15 other positions	**Unit of measure:** N/A
Resolution: N/A	**Accuracy:** ±.01 s
Sampling rate 10 samples per second (10 Hz)	**Sampling timing:** –8 s trigger +5 s
Data format: 1 byte per sample	**Discussion/references:** None

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8.1.59 Restraint usage, passenger

Table 71—Restraint usage, passenger

Data element name: Restraint usage, passenger	**Other names:** Passenger's seat belt status	**Abbreviations/ acronyms:** RESP	**Index number:** 8.1.59

Accident investigation uses: This signal provides the data that reports the utilization of the passenger's seat belt/shoulder harness at the time surrounding the triggering event.	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X		X					

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants	X	X	X	
Environment				

Description/operation/filter class:
The passenger's seat belt connector communicates with the ECM to determine if the seat belt is connected or not. This seat belt status is also recorded by the MVEDR. IR signaling can indicate vehicle occupancy and seat belt status. The restraints system's ECM monitors the passenger's seat belt connection status. Depending on the connection status, an air bag deployment scenario has been preprogrammed.
No filter required.

Data definition/sign convention/coordinate system: 0 = engaged, 1 = disengaged, 2 = invalid data, 3 = data not available	**Unit of measure:** N/A
Resolution: This data element requires resolution of the engaged (on) or disengaged (off) status of the restraint for the passenger's position versus time.	**Accuracy:** ±0.01 s
Sampling rate: 10 samples per second	**Sampling timing:** –8 s trigger +5 s
Data format: 1 byte per sample	**Discussion/references:** This is one component of a complex vehicle restraint system. All components must act in tandem with all other critical components.

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8.1.60 Roll rate

Table 72—Roll rate

Data element name: Roll rate	**Other names:** RATE.ANGULAR. VEHICLE.Roll_quantity	**Abbreviations/ acronyms:** RRX	**Index number:** 8.1.60

Accident investigation uses:	**Possible alternative/additional uses:**
The roll rate describes the rotation of speed around the longitudinal axis of the vehicle at the time surrounding the event trigger.	This type of crash data could support USDOT infrastructure safety evaluation and statistical hazard identification.

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors recorders	Insurance	Roadside
							X

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants				
Environment				

Description/operation/filter class:
Vehicle Roll Rate (angular velocity) about longitudinal axis (*x*-axis).
Vehicle roll rate at the time surrounding the event trigger.
X-axis gyro, inertial measurement unit.
According to SAE J211/1-2003, utilize a CFC 180 filter to permit integration for velocity of position.

Data definition/sign convention/coordinate system:	**Unit of measure:**
±180°/s, sign convention (see SAE J211/1-2003, 7.2); coordinate system (see SAE 670-1976 [B68], Fig. 2), 254 = invalid data, 255 = data unavailable	degrees per second (°/s)
Resolution: 0.1°/s	**Accuracy:** ±0.1°/s
Sampling rate: 10 samples per second from –8 s to –1 s before the event. 1000 samples per second from –1 s prior to the event trigger to 5 s following the event trigger.	**Sampling timing:** –8 s trigger +5 s
Data format: Floating point (4 bytes)	**Discussion/references:** None

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8.1.61 Rollover

Table 73—Rollover

Data element name: Rollover	**Other names:** Event rollover_code	**Abbreviations/ acronyms:** ROLO	**Index number:** 8.1.61

Accident investigation uses:	**Possible alternative/additional uses:**
This element will allow investigators to evaluate the effectiveness of the "early warning" rollover alert system that was in operation at the time surrounding the event.	Transmit rollover event signal to local EMS crew and law enforcement personnel. The GPS will provide the exact location of the rollover.

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
		X					

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle		X		
Driver/occupants		X		
Environment				

Description/operation/filter class:
The rollover event can be predicted up to 0.5 s prior to the occurrence of the actual rollover by using a combination of rate gyros, accelerometers, input/output interface structures, and knowing the physical characteristics of the vehicle. When the criteria for a predicted rollover is met, then safety countermeasures (side air bags, window curtains, pop-up roll bars for convertibles, etc.) can be deployed to protect the occupants of the vehicle.
The engineering rollover algorithms will be programmed into the EDR recorder at the site of the vehicle manufacturer.
According to SAE J211/1-2003, utilize a CFC 180 filter to permit integration for velocity or position.

Data definition/sign convention/coordinate system:	**Unit of measure:**
Data range: $-100g_n$ to $+100g_n$ accelerometer	Acceleration as multiples of the standard quantity g_n Roll rate = rad/s^2
Resolution: 0.1 rad/s^2, 0.048 g_n per bit	**Accuracy;** ±0.1 rad/s^2, ±0.048 g_n
Sampling rate: 1000 samples per second from –1 s to +5 s following trigger 10 samples per second from –8 s to –1 s prior to event	**Sampling timing:** –8 s trigger +5 s
Data format: Integer	**Discussion/references:** None

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8.1.62 School bus warning indicator lamps

Table 74—School bus warning indicator lamps

Data element name: School bus warning indicator lamps	**Other names:** LAMP.EXTERIOR. VEHICLE_School.bus_code	**Abbreviations/ acronyms:** SBWL	**Index number:** 8.1.62
Accident investigation uses: Provides the status of the warning lights of the school bus at the time surrounding the event trigger.	**Possible alternative/additional uses:**		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
	X						

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
					X		

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X		X	
Driver/occupants				
Environment				

Description/operation/filter class:
This element records the status of the school bus warning lamp network as: *off*, *yellow,* or *red* at the time surrounding the event trigger. A manual switch typically activates amber school bus warning lamps when the bus is approaching a pick-up or drop-off stop. The amber light is deactivated and the red lamps are activated when the school bus door is opened. Once activated the amber or red warning lamps flash alternately side to side. The school bus warning lamp system is defined in FMVSS 108 [B13].
No filter required.

Data definition/sign convention/coordinate system: 0 = off, 1 = red, 2 = amber, 3 = no data available, 4 = invalid data	**Unit of measure:** Status bit
Resolution: N/A	**Accuracy:** N/A
Sampling rate: 1 sample per second	**Sampling timing:** –8 s trigger +5 s
Data format: Byte	**Discussion/references:** FMVSS 108 [B13] regulates the school bus lamp system in all states except Wisconsin.

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8.1.63 Seat position, driver

Table 75—Seat position, driver

Data element name: Seat position, driver	**Other names:** Driver seat_position	**Abbreviations/ acronyms:** DsP	**Index number:** 8.1.63

Accident investigation uses:	**Possible alternative/additional uses:**
The position of the driver's seat within the seat track can be determined at the time surrounding the triggering event.	

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X		X					

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants	X	X	X	
Environment				

Description/operation/filter class:
The signal reports the position of the drivers seat at the time surrounding the triggering event using a sensor that is installed in the driver's seat track.
Any movement of the driver's seat is recorded via the displacement transducer and associated electrical signal conditioning circuit that is located in the seat track.
No filtering is required.

Data definition/sign convention/coordinate system:	**Unit of measure:**
0 = foremost position, 1 = rearmost position, 254 = invalid data, 255= no data available	millimeter
Resolution: Range 25 mm to 300 mm (1 in to 12 in) total displacement with ±1.25 mm (±0.5 in) resolution.	**Accuracy:** ±1.25 mm (±0.05 in)
Sampling rate: One sample per second prior to the event. Ten samples per second following the triggering event.	**Sampling timing:** –8 s trigger +5 s
Data format: Byte	**Discussion/references:** None

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8.1.64 Seat position, passenger

Table 76—Seat position, passenger

Data element name: Seat position, passenger	**Other names:** Passenger seat location	**Abbreviations/ acronyms:** SPP	**Index number:** 8.1.64

Accident investigation uses: The position of the passenger's seat within the seat track can be determined at the time surrounding the triggering event.	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X		X					

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants	X	X	X	
Environment				

Description/operation/filter class:
The signal reports the position of the passenger's seat at the time surrounding the triggering event using a sensor that is installed in the passenger's seat track.
Any movement of the passenger's seat is recorded via the displacement transducer and associated electrical signal conditioning circuit that is located in the seat track.
No filtering is required.

Data definition/sign convention/coordinate system: 0 = foremost position, 1 = rearmost position, 254 = invalid data, 255 = no data available	**Unit of measure:** millimeter
Resolution: Range 25 mm to 300 mm (1 in to 12 in) total displacement with ±1.25 mm (±0.05 in) resolution	**Accuracy:** ±1.25 mm (±0.05 in)
Sampling rate: One sample prior to the triggering event. Ten samples per second following the event.	**Sampling timing:** –8 s trigger +5 s
Data format: 2 byte integer	**Discussion/references:** None

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8.1.65 Seat, passenger, occupant classification

Table 77—Seat, passenger, occupant classification

Data element name: Seat, passenger, occupant classification	**Other names:** Passenger seat identification	**Abbreviations/ acronyms:** SPOC	**Index number:** 8.1.65
Accident investigation uses: This data system will recognize and record the passenger seat occupant by weight and size.	**Possible alternative/additional uses:** This data system will recognize and record the status of the child's car seat that may be placed in the front passenger seat. This is a special circumstance that occurs in vehicles that accommodate one passenger.		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X		X					

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X	X	X	
Driver/occupants	X	X	X	
Environment				

Description/operation/filter class:
The occupant recognition (OR) system will record the presence of the passenger seat occupant by size and weight using strain gages and/or weigh sensors located in the lower seat frame assembly. This data element will work with several other data elements, such as seat position, passenger restraint, air bag deployment, that are all elements of the overall safety restraint system.
The information will be automatically entered into the restraint system ECM for reference at the time surrounding the triggering vent.
No filter is required.

Data definition/sign convention/coordinate system: To be determined by the manufacturer. Data output to be in accordance with FMVSS 208 and FARS.	**Unit of measure:** N/A
Resolution: Will be determined by the vehicle's system designers and entered into the ECM for use at the time surrounding the triggering event.	**Accuracy:** Must be compatible with the overall system restraint system performance.
Sampling rate: Must be set by the manufacturer as part of the overall performance of the restraint system.	**Sampling timing:** –8 s trigger +5 s
Data format: 4 byte	**Discussion/references:** Future OR systems will employ optical, infrared, ultrasonic, or electric field sensors to classify the occupant.

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8.1.66 Steering wheel position

Table 78—Steering wheel position

Data element name: Steering wheel position	**Other names:** STEERING WHEEL POSITION_angular rate	**Abbreviations /acronyms:** SWP	**Index number:** 8.1.66
Accident investigation uses:	**Possible alternative/additional uses:**		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
	X						

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X		X	
Driver/occupants	X		X	
Environment				

Description/operation/filter class:
This data element describes the angular position and direction, clockwise (CW) or counterclockwise (CCW), of the steering wheel when measured from the wheel's neutral position at the time surrounding the event trigger.
The operation is defined as the steering wheel rotation, CW or CCW that causes the front wheels of the vehicle to turn right (CW) or left (CCW). The steering wheel is typically mechanically connected to the front wheels through the various mechanical subsystems, and the resulting steering gear ratio (from the steering wheel angle to the road angle) varies between vehicles types and models. The range of steering wheel angle will go from 0° to ±720° and may result in turning the front wheels up to 45°, in the left or right directions. Depending on the sensor used, no filtering may be required. However, for some type sensors, e.g., potentiomer, an SAE class 180 filter would be appropriate.

Data definition/sign convention/coordinate system:	**Unit of measure:**
Range: –720° (CCW) to +720° (CW), 0 = steering wheel straight Special cases: 998 = invalid data, 999 = data not available	degrees
Resolution: 1°	**Accuracy:** ±1°
Sampling rate: 10 samples per second	**Sampling timing:** –8 s trigger +5 s
Data format: Integer (2 bytes)	**Discussion/references:** Measurement could be made using a sensor that converts steering wheel rotation into an electrical signal. Examples include potentiometer or encoder.

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8.1.67 EMS text field

Table 79—EMS text field

Data element name: EMS Text File	**Other names:** Emergency Roadside Medical Messaging, National EMS Information System	**Abbreviations/ acronyms:** ERMM NEMSIS	**Index number:** 8.1.67

Accident investigation uses: Evaluate from an EMS viewpoint essential information about a crash occupant(s) and potential injuries.	**Possible alternative/additional uses:** Revision of the NHTSA Uniform Pre-Hospital EMS Dataset.

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
		X					

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle				X
Driver/occupants				X
Environment				

Description/operation/filter class:
Vehicle owners and/or the authorized designated occupant(s) can enter the specific emergency contact information, medical data, and health care provider profile into the MVEDR. Specific changes can be made via a unique text message protocol. The text message can be changed when authorized by the owner or the designated authorized vehicle operator in the case of corporate fleet vehicles. Enhance medical care at the scene and in-transit to the hospital with value added data availibility. EMS text field populated from vehicle owner at retail point of purchase. Information about the crash is not available from this field.

Data definition/sign convention/coordinate system: N/A	**Unit of measure:** N/A
Resolution: N/A	**Accuracy:** N/A
Sampling rate: N/A	**Sampling timing:** Data harvested from vehicle post incident.
Data format: Text field, 10 bytes	**Discussion/references:** Create an emergency roadside medical messaging schema mapped to the NHTSA dataset with XML linkage

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8.1.68 Time between events

Table 80—Time between events

Data element name: Time between two events	**Other names:** TIME.EVENT_BetweenTriggerEvents_quantity	**Abbreviations/ acronyms:** TBE	**Index number:** 8.1.68

Accident investigation uses:	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
X			X				

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle		X		
Driver/occupants				
Environment				

Description/operation/filter class:
Elapsed time between two recorded impact events.
Timing between events to understand the relative proximity of triggering events. Derived from MVEDR triggering event data. No filtering.

Data definition/sign convention/coordinate system: Value is always positive indicating the time between the first and second trigger events.	**Unit of measure:** millisecond
Resolution: 1 ms	**Accuracy:** ±1 ms
Sampling rate: N/A	**Sampling timing:** –8 s trigger +5 s
Data format: Integer (4 bytes)	**Discussion/references:** None

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8.1.69 Tire Pressure (inflation pressure per tire)

Table 81—Tire Pressure (inflation pressure per tire)

Data element name: Tire pressure (inflation pressure per tire)	**Other names:** TIRE.PRESSURE_quantity	**Abbreviations/ acronyms:** TPx, where x denotes exact tire	**Index number:** 8.1.69
Accident investigation uses: Tire inflation pressure per tire at the time surrounding the event trigger.	**Possible alternative/additional uses:** Can also be monitored for maintenance purposes.		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
				X			

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X		X	
Driver/occupants				
Environment				

Description/operation/filter class: Use either of two types of tire pressure monitoring systems (TPMS). The wheel speed based (WSB) provides an indirect method of determining tire pressure. The pressure based sensor (PSB) reports the pressure of each tire directly. An icon on the dash panel could represent tire inflation pressure of each tire. No filter required.	
Data definition/sign convention/coordinate system: Data range: 0 = 0 kPa (0 psi) to 130 = 1300 kPa (~195 psi) Example normal data: 1 = 10 kPa, 10 = 100 kPa (~15 lbf/in^2), 130 = 1300 kPa (~195 lbf/in^2) Special cases 254 = invalid data, 255 = data not available	**Unit of measure:** kilopascal (kPa)[a] 1 MPa = 1000 kPa = 1 000 000 Pa 1 psi = 1 lbf/in^2 = ~6.9 kPa atmospheric pressure = ~101.3 kPa
Resolution: 10 kPa/bit	**Accuracy:** ±10 kPa
Sampling rate: 2 samples per second	**Sampling timing:** –8 s trigger +5 s
Data format: 1 byte per sample	**Discussion/references:** DOT HS 809 297 [B7] provides detailed insight on this data element.

[a]1 kPa is numerically equal to 10 mbar.

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8.1.70 Tire, total air loss, time, heavy-duty (Y/N)

Table 82—Tire, total air loss, time, heavy-duty (Y/N)

Data element name: Tire, total air loss, time, heavy-duty (Y/N)	**Other names:** TIRE.AIR.LOSS_code	**Abbreviations/ acronyms:** TALx, where x denotes exact tire	**Index number:** 8.1.70

Accident investigation uses: Total tire air loss indication at the time surrounding the event trigger.	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
		X					

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
				X			

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X		X	
Driver/occupants				
Environment				

Description/operation/filter class: This data element provides the indication that a total loss of pressure (blowout) occurred in any one tire as indicated by either individual tire sensors (direct), or by the wheel based system (indirect) detection system(s) at the time surrounding the event trigger. Either of two TPMS, direct or indirect, or ABS calculation can be used to record the sudden loss of tire pressure and transmit the signal to the MVEDR. No filter is required.	
Data definition/sign convention/coordinate system: N/A	**Unit of measure:** Not applicable
Resolution: This element requires resolution of the system to be either not active (off) or active (on).	**Accuracy:** N/A
Sampling rate: 1 sample per second	**Sampling timing:** –8 s trigger +5 s
Data format: 1 byte per sample	**Discussion/references:** Refer to DOT HS 809 297 [B7] for detailed information.

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8.1.71 Trigger event date

Table 83—Trigger event date

Data element name: Trigger event date	**Other names:** EVENT.DATE.Trigger_Value	**Abbreviations/ acronyms:**	**Index number:** 8.1.71

Accident investigation uses: Provides the day, month, and year that a triggering event occurred.	**Possible alternative/additional uses:** A unique electronic signal can be transmitted to local authorized EMS crews and law enforcement personnel that would alert the authorized personnel that a triggering event did occur on a certain date.

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
		X			X	X	

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle				X
Driver/occupants				
Environment				

Description/operation/filter class:
The date at which the MVEDR detected an event.
To know when the trigger event occurred.
Date may be derived from a GPS receiver or an on-board real-time clock.

Data definition/sign convention/coordinate system:	**Unit of measure:** Not applicable
Resolution: 1 day	**Accuracy:** ±15 min
Sampling rate: Once at time of event trigger	**Sampling timing:** –8 s trigger +5 s
Data format: Long integer (4 bytes) using "ddmmyy" form where "dd" = day, "mm" = month, "yy" = year	**Discussion/references:** None

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8.1.72 Trigger event time

Table 84—Trigger event time

Data element name: Trigger event time	**Other names:** EVENT.TIME.Trigger_Value	**Abbreviations/ acronyms:** TET	**Index number:** 8.1.72
Accident investigation uses: Provides the hour, minute, and second that a triggering event occurs.	**Possible alternative/additional uses:**		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA -TMC	ComCARE

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
		X			X	X	

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle				X
Driver/occupants				
Environment				

Description/operation/filter class:
The time at which the MVEDR detected an event.
To know when the trigger event occurred.
Time may be derived from a GPS receiver or an on-board real-time clock.

Data definition/sign convention/coordinate system: N/A	**Unit of measure:** Not applicable
Resolution: 1 s	**Accuracy:** ±1 s
Sampling rate: Once at time of event trigger	**Sampling timing:** –8 s trigger +5 s
Data format: Long integer (4 bytes) using “hhmmss” form in coordinated universal time (UTC) format where “hh” = hour, “mm” = minute, “ss” = second	**Discussion/references:** May serve to test and improve EMS response time.

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8.1.73 Vehicle system status, adaptive cruise control

Table 85—Vehicle system status, adaptive cruise control

Data element name: Adaptive cruise control	**Other names:** CONTROL.ADAPTIVE.CRUISE_code	**Abbreviations/ acronyms:** ACC	**Index number:** 8.1.73
Accident investigation uses: Determines the status of the cruise control system at the time surrounding the event.	**Possible alternative/additional uses:**		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X		X	
Driver/occupants				
Environment				

Description/operation/filter class: Operation of adaptive cruise control. Determine if the system is on, off, or in automatic headway mode. No filter required.	
Data definition/sign convention/coordinate system: Data provided from ACC manufacturers.	**Unit of measure:** N/A
Resolution: This data requires on/off resolution.	**Accuracy:** N/A
Sampling rate: 2 samples per second	**Sampling timing:** –8 s trigger +5 s
Data format: Byte	**Discussion/references:** None

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8.1.74 Vehicle system status, automatic collision notification

Table 86—Vehicle system status, automatic collision notification

Data element name: Automatic collision notification	**Other names:** NOTIFICATION.AUTOMATIC. COLLISION_code	**Abbreviations/ acronyms:** ACN	**Index number:** 8.1.74
Accident investigation uses: Determines the ACN signal sent at the time surrounding the event.	**Possible alternative/additional uses:** Emitted ACN signal could be used by local EMS organizations.		

Agency recommendations

NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
X							X

IEEE P1616 WG use cases

Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
		X					X

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle			X	
Driver/occupants				
Environment				

Description/operation/filter class: Operation of ACN system. Determines if the ACN system has sent a signal. No filter required.	
Data definition/sign convention/coordinate system: Range: 0 = not activated, 1 = activated, 254 = data invalid, 255= data not available	**Unit of measure:** N/A
Resolution: This element requires resolution of the ACN signal being active (on) or not active (off) with respect to time.	**Accuracy:** N/A
Sampling rate: One sample	**Sampling timing:** –8 s trigger +5 s
Data format: Byte	**Discussion/references:** None

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8.1.75 Vehicle system status, battery voltage

Table 87—Vehicle system status, battery voltage

Data element name: Battery voltage	**Other names:** VEHICLE.BATTERY. VOLTAGE.Quantity	**Abbreviations/ acronyms:** B+	**Index number:** 8.1.75

Accident investigation uses: Provides the battery voltage at the time surrounding the event.	**Possible alternative/additional uses:** Indicates the performance of the alternator at the time of the event.

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA -TMC	ComCARE
	X						

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
					X		

Modified Haddon Matrix	Pre-crash	Crash	Post- crash	Time invariant
Vehicle	X		X	
Driver/occupants				
Environment				

Description/operation/filter class: Battery voltage (dc) and vehicle system voltage. Indicates primary vehicle voltage level. Output of battery when engine if off. Output of charging system when engine is running.	
Data definition/sign convention/coordinate system: 0 = 0.0 V, 1 = 0.2 V, 250 = 50.0 V, 254 = data invalid, 255 = data unavailable	**Unit of measure:** volt (V)
Resolution: 0.2 V/b	**Accuracy:** 0.02 V
Sampling rate: 1 sample per second	**Sampling timing:** –8 s trigger +5 s
Data format: Byte (1 bit = 0.2 V)	**Discussion/references:** Forty-two voltage systems are in development. Refer to the SAE J1113 series for EMI susceptibility, design, test, and measurement criteria.

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8.1.76 Vehicle system status, clutch

Table 88—Vehicle system status, clutch

Data element name: Clutch	**Other names:** CLUTCH_code	**Abbreviations/ acronyms:** CL	**Index number:** 8.1.76
Accident investigation uses: Assess the driver's control of the vehicle by determining the position of the clutch pedal.	**Possible alternative/additional uses:**		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
	X						

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
	X						

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X		X	
Driver/occupants	X		X	
Environment				

Description/operation/filter class:
Activation of the vehicle's clutch.
For vehicles equipped with manual transmision.
Determines whether the clutch is released or not released.

Data definition/sign convention/coordinate system: 0 = engaged, 1 = disengaged, 254 = invalid data, 255 = data unavailable	**Unit of measure:** N/A
Resolution: N/A	**Accuracy:** N/A
Sampling rate: 2 samples per second	**Sampling timing:** –8 s trigger +5 s
Data format: Byte	**Discussion/references:** May also be able to be determined from vehicle speed and engine r/min ratios.

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8.1.77 Vehicle system status, door ajar

Table 89—Vehicle system status, door ajar

Data element name: Door ajar	**Other names:** DOOR.AJAR_code	**Abbreviations/ acronyms:** DajS	**Index number:** 8.1.77
Accident investigation uses: Provides the degrees of mechanical security status of the vehicle's door(s) and/or gate at the time surrounding the event.	**Possible alternative/additional uses:**		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside

Modified Haddon Matrix	Pre-crash	Crash	Post- crash	Time invariant
Vehicle	X		X	
Driver/occupants				
Environment				

Description/operation/filter class: Saves the signal from the door ajar detection system. Determines if any of the vehicle's doors are ajar. No filter required.	
Data definition/sign convention/coordinate system: Door switch: 0 = not active, 1 = active, 2 = invalid data, 3 = data not available	**Unit of measure:** N/A
Resolution: This element requires the door ajar switch to be "engaged" or "disengaged."	**Accuracy:** N/A
Sampling rate: 1 sample per second	**Sampling timing:** –8 s trigger +5 s
Data format: Byte	**Discussion/references:** None

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8.1.78 Vehicle system status, door lock status

Table 90—Vehicle system status, door lock status

Data element name: Door lock status	**Other names:** DOOR.LOCK_code	**Abbreviations/ acronyms:** DIS	**Index number:** 8.1.78
Accident investigation uses: Provides the mechanical security status of the door(s) and/or gates of the vehicle at the time surrounding the event.	**Possible alternative/additional uses:**		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA -TMC	ComCARE

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X		X	
Driver/occupants				
Environment				

Description/operation/filter class:
Saves the signal from the door lock status system.
Determines if any of the vehicle's doors are in their locked position.
No filter required.

Data definition/sign convention/coordinate system: Indicates which door.	**Unit of measure:** N/A
Resolution: N/A	**Accuracy:** N/A
Sampling rate: 1 sample per second	**Sampling timing:** –8 s trigger +5 s
Data format: Byte	**Discussion/references:** None

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8.1.79 Vehicle system status, drive status

Table 91—Vehicle system status, drive status

Data element name: Drive status, 2 WD vs. 4 WD	**Other names:** DRIVE.STATUS_code	**Abbreviations/ acronyms:** VSS	**Index number:** 8.1.79

Accident investigation uses: Provides the wheel drive operational mode of the vehicle at the time surrounding the event trigger.	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA -TMC	ComCARE

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X			
Driver/occupants				
Environment				

Description/operation/filter class:
Drive status.
Determines status of 2-wheel drive vs. 4-wheel drive for vehicles equipped with selectable drive transfer cases.
No filter required.

Data definition/sign convention/coordinate system: 0 = 2-wheel drive active, 1 = 4-wheel drive active, 254 = invalid data, 255= data not available	**Unit of measure:** N/A
Resolution: N/A	**Accuracy:** N/A
Sampling rate: One sample/second	**Sampling timing:** –8 s trigger +5 s
Data format: Byte	**Discussion/references:** None

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8.1.80 Vehicle system status, hazard signal status

Table 92—Vehicle system status, hazard signal status

Data element name: Hazard signal status, 4-way signal status	**Other names:** SIGNAL.HAZARD_code	**Abbreviations/ acronyms:** HSS	**Index number:** 8.1.80
Accident investigation uses: Hazard signal status at the time surrounding the event trigger.	**Possible alternative/additional uses:**		

Agency recommendations							
NHTS general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
	X	X					

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
					X		

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X		X	
Driver/occupants	X		X	
Environment				

Description/operation/filter class: Represents the hazard signal status as indicated by the hazard signal switch. No filter required.	
Data definition/sign convention/coordinate system: Data range: 0 = active, 1 = not active Special cases: 254 = invalid data, 255 = data not available	**Unit of measure:** N/A
Resolution: N/A	**Accuracy:** N/A
Sampling rate: 2 samples per second	**Sampling timing:** –8 s trigger +5 s
Data format: 1 byte per sample	**Discussion/references:** None

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8.1.81 Vehicle system status, traction control

Table 93—Vehicle system status, traction control

Data element name: Traction control (engaged/disengaged)	**Other names:** TRACTION.CONTROL_code	**Abbreviations/ acronyms:** TCSS	**Index number:** 8.1.81

Accident investigation uses: Provides the vehicle traction control status, engaged or not engaged, at the time surrounding the event.	**Possible alternative/additional uses:**

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA -TMC	ComCARE
X							

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
					X		

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X		X	
Driver/occupants				
Environment				

Description/operation/filter class: Traction control status. Determines status of traction control system: off/on/engaged. No filter required.	
Data definition/sign convention/coordinate system: 0 = system disabled; 1 = system on, not active; 2 = system on, active; 254 = data invalid; 255 = data unavailable	**Unit of measure:** N/A
Resolution: N/A	**Accuracy:** N/A
Sampling rate: 2 samples per second	**Sampling timing:** –8 s trigger +5 s
Data format: Byte	**Discussion/references:** None

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8.1.82 Vehicle system status, turn signal status

Table 94—Vehicle system status, turn signal status

Data element name: Vehicle system status, turn signal (left/ right off request)	**Other names:** SIGNAL.TURN_code, turn signal status	**Abbreviations/ acronyms:** ST	**Index number:** 8.1.82
Accident investigation uses: Turn signal lever status for a left or right turn at the time surrounding the event trigger.	**Possible alternative/additional uses:**		

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA -TMC	ComCARE
X	X	X					

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
	X				X	X	

Modified Haddon Matrix	Pre-crash	Crash	Post- crash	Time invariant
Vehicle	X		X	
Driver/occupants	X		X	
Environment				

Description/operation/filter class: Represents the turn signal lever status and setting as indicated by the position of the turn signal lever.	
Data definition/sign convention/coordinate system: Data range: 0 = active, 1 = left, 2 = right Special cases: 254 = invalid data, 255 = data not available	**Unit of measure:** N/A
Resolution: N/A	**Accuracy:** N/A
Sampling rate: 2 samples per second	**Sampling timing:** –8 s trigger +5 s
Data format: 1 byte per sample	**Discussion/references:** None

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8.1.83 Vehicle system status, windshield wiper status

Table 95—Vehicle system status, windshield wiper status

Data element name: Vehicle system status, windshield wiper status	**Other names:** WIPER.WINDSHIELD_code	**Abbreviations/ acronyms:** WIP	**Index number:** 8.1.83

Accident investigation uses: Windshield wiper status at the time surrounding the event trigger.	**Possible alternative/additional uses:** May also be an indication of visibility and/or the weather.

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE
	X						

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
					X	X	

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X		X	
Driver/occupants	X		X	
Environment	X		X	

Description/operation/filter class: Represents the windshield wiper status and setting as indicated by the status of the wiper switch.	
Data definition/sign convention/coordinate system: Data range: 0 = not active, 1 = intermittent, 2 = low, 3 = high Special cases: 254 = invalid data, 255 = data not available	**Unit of measure:** N/A
Resolution: N/A	**Accuracy:** N/A
Sampling rate: 1 sample per second	**Sampling timing:** –8 s trigger +5 s
Data format: 1 byte per sample	**Discussion/references:** None

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8.1.84 Vehicle identification number

Table 96—Vehicle identification number

Data element name: Vehicle identification number	**Other names:** VEHICLE.VIN_Value	**Abbreviations/ acronyms:** VIN	**Index number:** 8.1.84

Accident investigation uses:	**Possible alternative/additional uses:**
This element is the VIN assigned by the manufacturer. The MVEDR by serial number is linked to the VIN.	The VIN can be provided to DOT and law enforcement agencies upon request with proper authorization.

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
		X			X	X	X

Modified Haddon Matrix	Pre-crash	Crash	Post- crash	Time invariant
Vehicle				X
Driver/occupants				
Environment				

Description/operation/filter class:
A unique number used to identify the vehicle and some information about the vehicle.
To uniquely identify the vehicle and link the vehicle's identity to state databases. VIN is a static variable that uniquely identifies the vehicle and links the MVEDR data to that vehicle. It assigned at the vehicle manufacturer.
No filter required.

Data definition/sign convention/coordinate system:	**Unit of measure:**
N/A	N/A
Resolution:	**Accuracy:**
N/A	N/A
Sampling rate:	**Sampling timing:**
Once at time of installation	Recorded at power-up from vehicle network or programmed at MVEDR installation.
Data format:	**Discussion/references:**
Fixed 17 byte array that is filled with alphanumeric characters. If VIN is less than 17 digits (older vehicles), then left justify and fill with spaces.	SAE J272-1981 [B67].

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8.1.85 Wheel speeds (each wheel end)

Table 97—Wheel speeds (each wheel end)

Data element name: Wheel speeds (each wheel end)	**Other names:** WHEEL.SPEED.LOCATION_quantity	**Abbreviations/ acronyms:** WS where denotes the wheel	**Index number:** 8.1.85

Accident investigation uses: Indicates the speed of the individual wheels on the vehicle at the time surrounding the event trigger.	**Possible alternative/additional uses:** Infer vehicle dynamics prior to and after the event (e.g., skidding).

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA-TMC	ComCARE

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors recorders	Insurance	Roadside
					X		

Modified Haddon Matrix	Pre-crash	Crash	Post- crash	Time invariant
Vehicle	X	X	X	
Driver/occupants				
Environment				

Description/operation/filter class: Indicates the speed of the individual vehicle wheels prior to, during, and after an event trigger occurs. Data can be obtained from ABS system information. This metric is related to other metrics such as brake application and traction control. Each wheel needs to be determined. No filtering required.	
Data definition/sign convention/coordinate system: Forward roll is positive. Data range: –80 km/h to 240 km/h (–50 mi/h to 150 mi/h) (each wheel) Special cases: 998 = invalid data, 999 = data unavailable	**Unit of measure:** kilometer per hour (km/h)
Resolution: 0.32 km/h per bit (4 wheels total)	**Accuracy:** ±3.2 mi/h
Sampling rate: 100 times per second (100 Hz)	**Sampling timing:** –8 s trigger +5 s
Data format: Integer	**Discussion/references:** Provides valuable information regarding vehicle dynamics as tires and wheels are the only mechanism for vehicles to apply forces to the roadway.

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8.1.86 Yaw rate

Table 98—Yaw rate

Data element name: Yaw rate	**Other names:** RATE.ANGULAR. VEHICLE.Yaw_quantity	**Abbreviations/ acronyms:** YRz	**Index number:** 8.1.86

Accident investigation uses:	**Possible alternative/additional uses:**
The yaw rate describes the speed of the rotation around the vertical axis (*z*-axis) of the vehicle at the time surrounding the event trigger.	This type of crash data could support DOT infrastructure safety evaluation and statistical hazard identification.

Agency recommendations							
NHTSA general list	NHTSA truck & bus	NTSB	TRB	FHWA-OMC	NASA JPL	ATA -TMC	ComCARE

IEEE P1616 WG use cases							
Current OEM	Defect investigation	EMS	NHTSA ESV	NTSB research engineering	NTSB vehicle factors	Insurance	Roadside
							X

Modified Haddon Matrix	Pre-crash	Crash	Post-crash	Time invariant
Vehicle	X		X	
Driver/occupants				
Environment				

Description/operation/filter class:
Vehicle yaw rate (angular velocity) about vertical axis (*z*-axis).
Vehicle yaw rate at the time surrounding the event trigger.
Z-axis gyro, inertial measurement unit.

Data definition/sign convention/coordinate system: ±180°/s	**Unit of measure:** °/s
Resolution: 0.1°/s	**Accuracy:** ±0.1°/s
Sampling rate: 10 samples per second from –8 s to –1 s before the event. 1000 samples per second from –1 s prior to the event trigger to 5 s following the event trigger.	**Sampling timing:** –8 s trigger +5 s
Date format Float	**Discussion/references:** None

8.2 Recommended data elements for light vehicles under 4500 kg

1) *Data elements for all light vehicles.* Each vehicle equipped with an MVEDR should record all of the data elements listed in Table 99, during the interval/time and at the sample rate specified in that table.

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2) *Data elements for light vehicles under specified conditions.* Each vehicle equipped with an MVEDR should record each of the data elements listed in column 1 of Table 100 for which the vehicle meets the condition specified in column 2 of that table, during the interval/time and at the sample rate specified in that table.

Table 99—Data elements for all light vehicles equipped with an MVEDR

Data elements recorded for light vehicles (R = recommended; IE = if equipped)			
Data element	**R/IE**	**Recording interval/time**	**Condition for recommendation (IE)**
Longitudinal acceleration	R	–0.1 to 0.5 s	N/A
Maximum Δv	R	Computed after event	N/A
Speed, vehicle indicated	R	–8.0 s to 0 s	N/A
Engine RPM	R	–8.0 s to 0 s	N/A
Engine throttle, % full	R	–8.0 s to 0 s	N/A
Service brake, on/off	R	–8.0 s to 0 s	N/A
Ignition cycle, crash	R	–1.0 s	N/A
Ignition cycle, download	R	At time of download	N/A
Safety belt status, driver	R	–1.0 s	N/A
Frontal air bag warning lamp, on/off	R	–1.0 s	N/A
Frontal air bag deployment level, driver	R	Event	N/A
Frontal air bag deployment level, right front passenger	R	Event	N/A
Frontal air bag deployment, time to deploy, in the case of a single-stage air bag, or time to first-stage deployment, in the case of a multi-stage air bag, driver	R	Event	N/A
Frontal air bag deployment, time to deploy, in the case of a single-stage air bag, or time to first-stage deployment, in the case of a multi-stage air bag, right front passenger	R	Event	N/A
Multi-event, number of events (1, 2, 3)	R	Event	N/A
Time from event 1 to 2	R	As needed	N/A
Time from event 1 to 3	R	As needed	N/A
Complete file recorded (yes, no)	R	Following other data	N/A
Lateral acceleration	IE	–0.1 s to 0.5 s	If vehicle is equipped to measure acceleration in the vehicle's lateral (y) direction

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Table 99—Data elements for all light vehicles equipped with an MVEDR *(continued)*

Data elements recorded for light vehicles (R = recommended; IE = if equipped)			
Data element	**R/IE**	**Recording interval/time**	**Condition for recommendation (IE)**
Normal acceleration	IE	–0.1 s to 0.5 s	If vehicle is equipped to measure acceleration in the vehicle's normal (z) direction
Vehicle roll angle	IE	–1.0 s to 6.0 s	If vehicle is equipped to measure or compute vehicle roll angle
ABS activity (engaged, nonengaged)	IE	–8.0 s to 0 s	If vehicle is equipped with ABS
Stability control status, on, off, engaged	IE	–8.0 s to 0 s	If vehicle is equipped with stability control, ESP, or other yaw control system
Steering input (steering wheel angle)	IE	–8.0 s to 0 s	If vehicle equipped to measure steering wheel steer angle
Safety belt status, right front passenger (buckled, not buckled)	IE	–1.0 s	If vehicle equipped to measure safety belt buckle latch status for the right front passenger
Frontal air bag suppression switch status, right front passenger (on, off, or auto)	IE	–1.0 s	If vehicle equipped with a manual switch to suppress the frontal air bag for the right front passenger
Frontal air bag deployment, time to n^{th} stage, driver[a]	IE	Event	If vehicle equipped with a driver's frontal air bag with a second-stage inflator
Frontal air bag deployment, time to n^{th} stage, right front passenger[a]	IE	Event	If vehicle equipped with a right front passenger's frontal air bag with a second-stage inflator
Frontal air bag deployment, n^{th} stage disposal, driver, Y/N (whether the nth stage deployment was for occupant restraint or propellant disposal purposes)[a]	IE	Event	If vehicle equipped with a driver's frontal air bag with a second stage that can be ignited for the sole purpose of disposing of the propellant
Frontal air bag deployment, n^{th} stage disposal, right front passenger, Y/N (whether the nth stage deployment was for occupant restraint or propellant disposal purposes)[a]		Event	If vehicle equipped with a right front passenger's frontal air bag with a second stage that can be ignited for the sole purpose of disposing of the propellant
Side air bag deployment, time to deploy, driver		Event	If the vehicle is equipped with a side air bag for the driver
Side air bag deployment, time to deploy, right front passenger		Event	If the vehicle is equipped with a side air bag for the right front passenger
Side curtain/tube air bag deployment, time to deploy, driver side		Event	If the vehicle is equipped with a side curtain or tube air bag for the driver
Side curtain/tube air bag deployment, time to deploy, right side		Event	If the vehicle is equipped with a side curtain or tube air bag for the right front passenger
Pretensioner deployment, time to fire, driver		Event	If the vehicle is equipped with a pretensioner for the driver safety belt system

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Table 99—Data elements for all light vehicles equipped with an MVEDR *(continued)*

Data elements recorded for light vehicles (R = recommended; IE = if equipped)			
Data element	**R/IE**	**Recording interval/time**	**Condition for recommendation (IE)**
Pretensioner deployment, time to fire, right front passenger		Event	If the vehicle is equipped with a pretensioner for the right front passenger safety belt system
Seat position, driver (whether or not the seat is forward of a certain position along the seat track)		–1.0	If the vehicle is equipped to measure the position of the driver's seat
Seat position, passenger (whether or not the right front passenger seat is forward of a certain position along the seat track)		–1.0	If the vehicle is equipped to measure the position of the right front passenger's seat
Occupant size classification, driver		–1.0	If the vehicle is equipped to determine the size classification of the driver
Occupant size classification, right front passenger		–1.0	If the vehicle is equipped to determine the size classification of the right front passenger
Occupant position classification, driver		–1.0	If the vehicle is equipped to dynamically determine position of the driver.
Occupant position classification, right front passenger		–1.0	If the vehicle is equipped to dynamically determine position of the right front occupant.

[a]List this element n–1 times, once for each stage of a multi-stage air bag system.

Table 100—Data elements recommended for light vehicles under specified conditions

Data elements and application			
Data element name	**Crash investigation**	**Advanced restraints operation**	**ACN**
Longitudinal acceleration	X	X	X
Maximum Δv	X	X	X
Speed, vehicle indicated	X		
Engine speed, r/min	X		
Engine throttle, % full	X		
Service brake, on/off	X		
Ignition cycle, crash	X		
Ignition cycle, download	X		

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Table 100—Data elements recommended for light vehicles under specified conditions *(continued)*

Data elements and application			
Data element name	**Crash investigation**	**Advanced restraints operation**	**ACN**
Safety belt status, driver	X	X	X
Frontal air bag warning lamp, on/off	X	X	
Frontal air bag deployment level, driver	X	X	
Frontal air bag deployment level, right front passenger	X	X	
Frontal air bag deployment, time to first stage, driver	X	X	
Frontal air bag deployment, time to first stage, right front passenger	X	X	
Frontal air bag deployment, time to second stage, driver	X	X	
Frontal air bag deployment, time to second stage, right front passenger	X	X	
Frontal air bag deployment, second-stage disposal, driver, Y/N	X	X	
Frontal air bag deployment, second-stage disposal, right front passenger, Y/N	X	X	
Multi-event, number of events	X	X	
Time from event 1 to 2	X		
Time from event 1 to 3	X		
Complete file recorded	X	X	X
Lateral acceleration	X	X	X
Normal acceleration	X		
Vehicle roll angle	X		X
ABS activity	X		
Stability control, on, off, engaged	X		
Steering input	X		
Safety belt status, right front passenger	X	X	X
Frontal air bag suppression switch status, right front passenger	X	X	
Side air bag deployment, time to deploy, driver	X	X	
Side air bag deployment, time to deploy, right front passenger	X	X	
Side curtain/tube air bag deployment, time to deploy, driver side	X	X	
Side curtain/tube air bag deployment, time to deploy, right side	X	X	

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Table 100—Data elements recommended for light vehicles under specified conditions *(continued)*

Data elements and application			
Data element name	**Crash investigation**	**Advanced restraints operation**	**ACN**
Pretensioner deployment, time to fire, driver	X	X	
Pretensioner deployment, time to fire, right front passenger	X	X	
Seat position, driver	X	X	
Seat position, right front passenger	X	X	
Occupant size classification, driver	X	X	
Occupant size classification, right front passenger	X	X	
Occupant position classification, driver	X	X	
Occupant position classification, right front passenger	X	X	

Table 101—MVEDR recorded data element format light vehicles

Data element	Range	Accuracy	Precision	Filter class
Longitudinal acceleration	–100 g_n to +100 g_n	±1 g_n	1 g_n	SAE J211, Class 60
Lateral acceleration	–100 g_n to +100 g_n	±1 g_n	1 g_n	SAE J211, Class 60
Normal acceleration	–100 g_n to +100 g_n	±1 g_n	1 g_n	SAE J211, Class 60
Δv	–100 km/h to 100 km/h	±1 km/h	1 km/h	N/A
Vehicle roll angle	–1080° to +1080°	±10°	10°	N/A
Speed, vehicle indicated	0 km/h to 200 km/h	±1 km/h	1 km/h	N/A
Engine speed, in r/min	0 r/min to 10 000 r/min	±100 r/min	100 r/min	N/A
Engine throttle, percent full	0% to 100%	±5%	5%	N/A
Service brake, on, off	On and off	N/A	On and off	N/A
ABS activity	On and off	N/A	On and off	N/A
Stability control, on, off, engaged	On, off, engaged	N/A	On, off, engaged	N/A

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Table 101—MVEDR recorded data element format light vehicles *(continued)*

Data element	Range	Accuracy	Precision	Filter class
Steering wheel angle	–250° CW to +250° CCW	±5°	5°	N/A
Ignition cycle, crash	0 to 60 000	±1 cycle	1 cycle	N/A
Ignition cycle, download	0 to 60 000	±1 cycle	1 cycle	N/A
Safety belt status, driver	On or off	N/A	On or off	N/A
Safety belt status, right front passenger	On or off	N/A	On or off	N/A
Frontal air bag suppression switch status, right front passenger	On or off	N/A	On or off	N/A
Frontal air bag warning lamp, on, off	On or off	N/A	On or off	N/A
Frontal air bag deployment level, driver	1 to 100	±0	1	N/A
Frontal air bag deployment level, right front passenger	1 to 100	±0	1	N/A
Frontal air bag deployment, time to deploy/first stage, driver	0 ms to 250 ms	±2 ms	2 ms	N/A
Frontal air bag deployment, time to deploy/first stage, right front passenger	0 ms to 250 ms	±2 ms	2 ms	N/A
Frontal air bag deployment, time to n^{th} stage, driver	0 ms to 250 ms	±2 ms	2 ms	N/A
Frontal air bag deployment, time to n^{th} stage, right front passenger	0 ms to 250 ms	±2 ms	2 ms	N/A
Frontal air bag deployment, n^{th} stage disposal, driver, y/n	Yes/No	N/A	Yes/No	N/A
Frontal air bag deployment, n^{th} stage disposal, right front passenger, y/n	Yes/No	N/A	Yes/No	N/A
Side air bag deployment, time to deploy, driver	0 ms to 250 ms	±2 ms	2 ms	N/A
Side air bag deployment, time to deploy, right front passenger	0 ms to 250 ms	±2 ms	2 ms	N/A
Side curtain/tube air bag deployment, time to deploy, driver side	0 ms to 250 ms	±2 ms	2 ms	N/A
Side curtain/tube air bag deployment, time to deploy, right side	0 ms to 250 ms	±2 ms	2 ms	N/A
Pretensioner deployment, time to fire, driver	0 ms to 250 ms	±2 ms	2 ms	N/A
Pretensioner deployment, time to fire, right front passenger	0 ms to 250 ms	±2 ms	2 ms	N/A
Seat position, driver	Yes/No	N/A	Yes/No	N/A
Seat position, right front passenger	Yes/No	N/A	Yes/No	N/A
Occupant size driver occupant 5th female size y/n	Yes/No	N/A	Yes/No	N/A

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Table 101—MVEDR recorded data element format light vehicles *(continued)*

Data element	Range	Accuracy	Precision	Filter class
Occupant size right front passenger child y/n	Yes/No	N/A	Yes/No	N/A
Occupant position classification, driver on/off y/n	Yes/No	N/A	Yes/No	N/A
Occupant position classification, right front passenger on/off y/n	Yes/No	N/A	Yes/No	N/A
Multi-event, number of events (1, 2, 3)	1, 2, or 3	N/A	1, 2, or 3	N/A
Time from event 1 to 2	0 s to 5.0 s	0.1 s	0.1 s	N/A
Time from event 1 to 3	0 s to 5.0 s	0.1 s	0.1 s	N/A
Complete file recorded (Yes/No)	Yes/No	N/A	Yes/No	N/A

9. Conformance

To claim conformance to this standard, IEEE Std 1616-2004, the complete MVEDR system shall meet all mandatory requirements defined by this standard, including items described and required to interface with data input sources, all items necessary to process and encode data, the recording medium in its capsule, the power supply, the dedicated reserve power source, and recorder health status indicator and telltale.

As part of the conformance claim, the implementation shall provide an implementation conformance statement that shall include each of the following requirements:

- Interface description to data input sources
- Component description to process and encode data
- Recording medium description in its capsule
- Component description to interface with data output sources
- Power supply description
- Survivability characteristics by class of vehicle
- Dedicated reserve power-supply description and disconnect indicator
- Recorder health status and telltale
- VIN at event time

A state, province, or territory may reference 1.3, 6.12, and 6.13 of this standard in creating legislation to protect the privacy and security of their citizens while traveling in motor vehicles.

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Annex A

(informative)

Test control program

A.1 Purpose

This annex identifies the requirements necessary to establish and implement a test control program. The test control program will verify that items or systems conform to the specified requirements, will determine functional characteristics, and will demonstrate satisfactory performance.

A.2 Requirement references

SAE J1113/1-2002 [B69].

SAE J1113/21-1998 [B70].

SAE J1113/41-2000 [B71].

SAE J1399-1984 [B77].

SAE J1455-1994.

SAE J1812-2003 [B86].

A.2.1 Interface standards

SAE J1587-2002 [B79].

SAE J1708-2004 [B82].

SAE J1939-2003 [B90].

A.2.2 Controller Area Network (CAN) conformance testing

The CAN conformance test plan standardized in ISO/DIS 16845:2000 [B48] specifies the methodology and the abstract test suite necessary to check the conformance of any CAN implementation to the harmonized CAN specification. The test plan is a specific application of ISO/IEC 9646-1:1994 [B49]. The test plan environment consists of a lower tester, the IUT (implementation under test), and the upper tester running on a micro-controller, for example. Since the message storage capability, the hardware acceptance filter, and the CPU interface are not standardized, the only link between lower tester and IUT are the PLS-Data.indicate and PLS-Data.request interfaces.

The abstract test suites are independent of one another. Each test suite checks the behavior of the IUT for a particular parameter of the CAN specification. The test cases are grouped to received frame type cases, to transmitted frame type cases, and to bi-directional frame type cases. Each test type is subdivided in six test classes, as follows:

1) Valid frame format class

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2) Error detection class
3) Active error frame management class
4) Overload frame class
5) Passive error state and bus-off class
6) Bit-timing class

A.3 Scope and limitations

This standard applies to prototype qualification testing, production testing, proof testing before installation, vendor testing, construction acceptance testing, preoperational testing, operational testing, receipt acceptance testing, and in-service testing.

A.4 Definitions

CAN is a controller area network.

A.5 Requirements

1) Tests required to verify conformance of an item, prototype, production model, subsystem, or system to specified requirements and to demonstrate satisfactory performance may be defined through test plans (TP) and executed accordingly. Characteristics to be tested may be specified in an engineering specification, TP, purchase requisition, or other documents.
2) Test and acceptance criteria, unless otherwise designated, may be specified or approved by the organization responsible for designing the item to be tested.
3) When an organization performs its own testing, personnel with the organization should not test their own work for acceptance.
4) Test results may be documented and their conformance to acceptance criteria may be evaluated.
5) Tests required to collect data, such as for siting or design input, may be planned, executed, documented, and evaluated.

A.6 Test plan (TP)

A TP may be prepared and may include a sequential listing of vendor tests, construction acceptance tests, receiving tests, and other designated preoperational tests to be performed before operating division start-up testing when required by the project or program quality assurance plans or other documents. The TP may identify the items to be tested and corresponding test procedures, schedule requirements, responsibilities for conducting tests, reporting requirements, and records retention requirements.

A.7 Test procedures

Test procedures may include or reference the test objective and provisions for the test prerequisites, the types of test equipment to be used, the monitoring to be performed, the test acceptance criteria, and the environmental conditions to be maintained.

A.8 Test Prerequisites

1) The test prerequisites may include the following (as applicable):

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a) Calibrated instruments

b) Appropriate equipment

c) Trained personnel,

d) Condition of the test equipment and the item to be tested,

e) Suitable environmental conditions

f) Provisions for data acquisition and recording.

2) Appropriate sections of American Society for Testing Material methods, supplier manuals, equipment maintenance instructions, approved drawings, or national standards or codes (such as American National Standards Institute/American Society of Mechanical Engineers) may be used instead of specially written test procedures when agreed upon or specified in the TP. In these cases, adequate instructions may be included to ensure the required quality of work.

A.9 Test results

The testing organization may document the results in accordance with specified or established procedures. The organization responsible for accepting the item may evaluate the test results (unless otherwise designated). The disposition of the item may be according to the acceptance criteria.

A.10 Test records

The test records may, at a minimum, identify and contain the following:

1) Identification of the item tested (part number, prototype, production model, or other information as required)

2) Date of the text

3) Test equipment used, with identification numbers and calibration status

4) Type of observation

5) Test results, test anomalies, and test acceptability

6) Actions taken in connection with any noted deviations

7) Signatures of persons evaluating the test results and the disposition of the item

8) Signature of personnel performing the test or identification of the data recorder

9) Identification of personnel monitoring the test, where applicable

10) Reference to documented test procedures or instructions

11) Individuals evaluating test results

A.10.1 Required records

Test records may be retained in accordance with this standard and appropriate referenced sources to meet legal and other considerations, as a minimum.

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Annex B

(informative)

In-vehicle networks

In the mid-1980s, Bosch developed the controller area network (CAN). CAN is a widely used vehicular network. A typical vehicle can contain two or three separate CANs operating at different transmission rates.

B.1 CAN—an overview

CAN is a serial bus system especially suited to interconnect smart devices to build smart systems or subsystems.

The attributes of a CAN are as follows:

— Multi-master capabilities that allow building smart and redundant systems without the need of a valuable master

— Broadcast messaging that is the first piece of the guarantee for 100% data integrity as any device within the network uses the very same information

— Sophisticated error detecting mechanism and the retransmission of faulty messages, which is the second piece of the guarantee for 100% data integrity

— Availability of more than 50 controllers from low-cost devices to high-end chips from more than 15 manufacturers

— Availability of CAN for the next 15 years as its use within the European automotive industry and the decision for CAN from the U.S. and Japanese automotive industries is guaranteed

B.2 CAN in trucks and buses

In trucks and buses, CAN is used as the in-vehicle network (IVN) for power train applications as well as for communication between truck and trailer. Most of the American and European truck and bus manufacturers have already implemented CAN-based IVNs. Some of the truck-based superstructure control systems (e.g., for forfeiting equipment or concrete mixers) also use CAN as embedded control network.

In some trucks, there are several CAN-based IVNs installed that are interconnected via gateways. This is done in order not to mix functions, such as power train, body electronics, superstructure control, and trailer communication, in one physical network in order to avoid interferences and disturbances.

B.3 CAN in passenger cars

The automotive industry uses CAN as the IVN for engine management, body electronics (e.g., door and roof control), air conditioning, and lightning, as well as for entertainment control. The majority of the European carmakers use CAN-based IVNs. The American and the Far East passenger car manufacturers have also started implementing CAN-based IVNs.

CAN networks used in engine management connect several ECUs. Most of the European automobile manufacturers have also installed CAN high-speed networks (e.g., 500 kbit/s) in their power-engine systems.

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In addition, most of the European passenger cars are equipped with CAN-based multiplex systems connecting body ECUs. These multiplex networks link door and roof control units as well as lighting control units and seat control units. They run at lower data rates, e.g., 125 kbit/s. Many of them use fault-tolerant transceivers compliant with ISO 11898-3:2000 [B40]. In North America, single-wire CAN networks are also used in body electronics.

Some passenger cars implement a CAN-based diagnostic interface. This interface may be based on ISO 15765-1:2004 [B45], describing physical layer, transport layer, application layer, and how to use the Keyword 2000 diagnostic services.

Another application of CAN-based networks in passenger cars is to connect infotainment devices. There are some proprietary solutions, but also the IDB-C network. The SAE defined the IDB-C application profile in the ITS data bus series of standards (SAE J2366/1-2001 [B115]). IDB-C is based on high-speed CAN (29-bit identifiers) with a baud-rate of 250 kbit/s.

The different CAN-based IVNs are connected via gateways. In many system designs, the gateway functionality is implemented in the dashboard. The dashboard itself may equipped with a local CAN network connecting the different displays and instruments.

B.4 J1939 in trucks and buses

In most of the trucks and buses, the J1939-71 application profile is or will be used. The CAN-based network controls the engine as well as body control units. In North America, the J1939-71 profile is also used for truck/trailer communication. In Europe, the ISO 11992 application profile has to be implemented by regulation of the European administration. In particular, the brakes have to be connected via ISO 11992 networks.

B.4.1 J1939-based higher layer protocols

In the early 90s, the Society of Automotive Engineers (SAE) Truck and Bus Control and Communications Subcommittee started the development of a CAN-based application profile for in-vehicle communication in trucks. In 1998 the SAE published the J1939 set of standards supporting SAE class A, B, and C communication functions. A J1939 network connects ECUs within a truck and trailer system. SAE J1939-2003 [B90]—with its engine, transmission, and brake message definition—is dedicated to diesel engine applications. It is supposed to replace J1587/J1708 networks.

Other industries adopted the general J1939 communication functions, in particular the J1939/21 and J1939/31 protocol definitions—they are required for any J1939-compatible system. They added other physical layers and they defined other application parameters. The ISO standardized the J1939-based truck and trailer communication (ISO 11992) and the J1939-based communication for agriculture and forestry vehicles (ISO 11783). The National Marine Electronics Association (NMEA) specified the J1939-based communication for navigation systems in marine applications (NMEA 2000® [B65]). One reason for the incorporation of J1939 standards into others is the fact that it makes sense to re-invent the basic communication services. An industry-specific document defines the particular combination of layers for that industry.

B.5 The SAE J1939 set of profiles

The SAE J1939 set of profiles is based on the CAN data link layer (ISO 11898-1:2003) using the extended frame format (29-bit identifiers). Several documents have undergone revision after the initial publication in 1998. The standards have been added to, parts taken off and clarified. The set of standards includes:

— SAE J1939/11/1999 [B91]

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— SAE J1939/12-xxxx [B92]

— SAE J1939/13-2004 [B93]

— SAE J1939/15-2003 [B94]

— SAE J1939/21-2001 [B95]

— SAE J1939/31-2004 [B96]

— SAE J1939/71-2003 [B97]

— SAE J1939/73-2004 [B98]

— SAE J1939/81-2003 [B99]

The naming of the layers is not always compliant to the OSI reference model and to the recommended terminology of CAN in Automation (CiA). SAE J1939/21-2001 [B95] and SAE J1939/31-2004 [B96] define partly an application layer, and the SAE J1939/71-2003 [B97] and SAE J1939/73-2004 [B98] specify an application profile.

B.5.1 SAE J1939/11-1999 [B91]

This physical layer specification is based on ISO 11898-2:2003. It defines a single, linear, shielded twisted pair of wires running around the vehicle linking each of its ECUs together. The topology is supposed to be a linear bus running at 250 kbit/s with termination resistors to reduce reflections. A J1939 network can be made of multiple bus sections, each one linked with a bridge. The main function of the bridge is to provide electrical isolation between different segments so that electrical failure of one system will not cause such failure to an adjacent system. For example, the failure of the CAN/J1939 system on the trailer should not cause the failure of the truck's tractor main CAN/J1939 control system. The maximum number of ECUs is 30, and the maximum bus length is 40 m.

B.6 SAE J1939/21-2001 [B95]

SAE J1939/21-2001 [B95] is the heart of the J1939 set of standards. It describes commonly used messages such as *request, acknowledgement,* and *transport protocol* messages. The transport protocol specifies the breaking up of large amounts of data into multiple CAN-sized frames, along with adequate communication and timing to support effective frame transmission between nodes. Slight modifications have added flexibility to the transport protocol, allowing the sender (server) of data to specify the number of CAN frames to be sent at any one time. Previously, this number was greatly determined by the receiver's (client's) limitations in the number of frames it could receive.

The 29-bit identifier comprises the following subfields: *priority, reserve, data page, PDU format, PDU specific,* and *source address.* The source address field ensures unique CAN identifiers, so no two nodes can ever transmit the very same CAN identifier.

In the beginning, SAE J1939 grouped several parameters (signals) together into a parameter group (PG). Each PG was then assigned a number, its parameter group number (PGN). The PGN identifier contained a reserve bit, a data page bit, a PDU format field, and a PDU-specific field. This structure has since caused some confusion with regard to PDU1-type (destination-specific) messages. Since the PDU-specific (group extension) field becomes the *destination address* in a PDU1 message, the question arose if the PGN changes, which is does not. The PGN is a static number referring to the data being transmitted and should be considered independently of the CAN identifier.

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B.7 SAE J1939/31-2004 [B96]

This standard describes bridge functionality, how CAN messages from one network to an another are transferred. The message filter function in the bridge reduces the transmission of CAN messages in the individual network segments.

B.8 SAE J1939/71-2003 [B97]

In the so-called application layer (in CiA terms, it is an application profile), all parameters as well as assembled messages called parameter groups are specified. Each CAN message is referenced by a unique number, the PGN. SAE J1939/71-2003 [B97] incorporates several approved additions and brings the total number of defined messages up to almost 150. New message additions support anti-theft, fuel-specific, turbocharger, ignition, and tire pressure functions, among others. These additions and enhancements include the addition of the "source address of controlling device" parameter to several engine, transmission, and brake controller messages. Inclusion of this parameter in a message will allow the receiving device to identify the original source of the message (e.g., a particular device from a bridged network).

B.9 SAE J1939/73-2004 [B98]

Additions to the diagnostics standard (SAE J1939/73-2004 [B98]) involve memory access, start/stop functions, binary data transfer, security, and calibration information. Memory access is provided with security levels. The start/stop message is used during diagnostics performance, to quiet other devices (including nodes providing bridges to other networks). Revisions of SAE J1939/73-2004 [B98] also provide clarification regarding diagnostic trouble code (DTC) encoding in the data field. This encoding, previously interpreted differently by various manufacturers, was standardized, utilizing the reserved bit as the conversion method (CM) bit.

B.10 SAE J1939/81-2003 [B99]

This standard includes state diagrams for initialization and more clearly defines constraints on the use of addresses.

Draft standard SAE J1939/82 [B100] specifies the proper procedure for self-compliance and presents a scripting language that tightly defines compliance processes, and the J1939/83 Tutorial Draft provides an explanation of J1939.

B.11 J1939-based application fields

The J1939-based protocols and profiles are used in CAN-based embedded networks that are implemented in a broad range of vehicles and transportation systems.

The SAE J1939/71 application profile is mainly suitable for diesel engine management applications in trucks and buses as well as off-highway and off-road vehicles. The ISO 11992 set of standards is used for truck/trailer communication. The ISO 11783 application profile (also known as Isobus) specifies the communication between tractor and agriculture implements (e.g., harvester).

The main J1939-based protocol application fields include:

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B.11.1 CAN—Protocol

The CAN protocol is an international standard defined in the ISO 11898. Beside the CAN protocol itself the conformance test for the CAN protocol is defined in the ISO/DIS 16845:2000 [B48], which guarantees the interchangeability of the CAN chips.

B.11.2 Principles of data exchange

CAN is based on the so-called broadcast communication mechanism. This broadcast communication is achieved by using a message-oriented transmission protocol. Thus, not defining stations and station addresses, it only defines message. These messages are identified by using a message identifier. Such a message identifier has to be unique within the whole network, and it defines not only the content but also the priority of the message. This will be important when several stations compete for bus access.

A high degree of system and configuration flexibility is achieved as a result of the content-oriented addressing scheme. It is very easy to add stations to an existing CAN network without making any hardware or software modifications to the existing stations as long as the new stations are purely receivers. This allows the concept of modular electronics and also permits multiple receptions and the synchronization of distributed processes; data needed as information by several stations can be transmitted via the network in such a way that it is unnecessary for each station to have to know who the producer of the data is. This allows easy servicing and upgrading of networks as data transmission is not based on the availability of specific types of stations.

B.11.3 Real-time data transmission

In real-time processing, the urgency of messages to be exchanged over the network can differ greatly; a rapidly changing dimension, e.g., engine load, has to be transmitted more frequently and therefore with less delays than other dimensions, e.g., engine temperature.

The priority at which a message is transmitted compared to another less urgent message is specified by the identifier of each message. The priorities are laid down during system design in the form of corresponding binary values and cannot be changed dynamically. The identifier with the lowest binary number has the highest priority.

Bus access conflicts are resolved by bit-wise arbitration on the identifiers involved by each station observing the bus level bit for bit. This happens in accordance with the “wired and” mechanism, by which the dominant state overwrites the recessive state. The competition for bus allocation is lost by all those stations (nodes) with recessive transmission and dominant observation. All those “losers” automatically become receivers of the message with the highest priority and do not reattempt transmission until the bus is available again.

Transmission requests are handled in the order of the importance of the messages for the system as a whole. This proves especially advantageous in overload situations. Since bus access is prioritized on the basis of the messages, it is possible to guarantee low individual latency times in real-time systems.

B.12 Message frame formats

The CAN protocol supports two message frame formats, the only essential difference being in the length of the identifier. The so-called CAN standard frame, also known as CAN 2.0 A, supports a length of 11 bits for the identifier, and the so-called CAN extended frame, also known as CAN 2.0 B, supports a length of 29 bits for the identifier.

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B.13 CAN standard frame

A message in the CAN standard frame format begins with the start bit called “Start Of Frame (SOF),” this is followed by the “Arbitration field” which consist of the identifier and the “Remote Transmission Request (RTR)” bit used to distinguish between the data frame and the data request frame, called *remote frame*. The following “Control field” contains the “IDentifier Extension (IDE)” bit to distinguish between the CAN standard frame and the CAN extended frame, as well as the “Data Length Code (DLC)” used to indicate the number of following data bytes in the “Data field.” If the message is used as a remote frame, the DLC contains the number of requested data bytes. The “Data field” that follows is able to hold up to 8 data bytes. The integrity of the frame is guaranteed by the following “Cyclic Redundant Check (CRC)” sum. The “ACKnowledge (ACK) field” compromises the ACK slot and the ACK delimiter. The bit in the ACK slot is sent as a recessive bit and is overwritten as a dominant bit by those receivers that have at this time received the data correctly. Correct messages are acknowledged by the receivers regardless of the result of the acceptance test. The end of the message is indicated by “End Of Frame (EOF).” The “Intermission Frame Space (IFS)” is the minimum number of bits separating consecutive messages. If there is no following bus access by any station, the bus remains idle.

B.14 CAN extended frame

A message in the CAN extended frame format is likely the same as a message in CAN standard frame format. The difference is the length of the identifier used. The identifier is made up of the existing 11-bit identifier (so-called *base identifier*) and an 18-bit extension (so-called *identifier extension*). The distinction between CAN standard frame format and CAN extended frame format is made by using the IDE bit, which is transmitted as dominant in the case of a frame in CAN standard frame format, and transmitted as recessive in the case of a frame in CAN extended frame format. As the two formats have to coexist on one bus, it is laid down which message has higher priority on the bus in the case of bus access collision with different formats and the same identifier/base identifier. The message in CAN standard frame format always has priority over the message in extended format.

CAN controllers that support the messages in CAN extended frame format are also able to send and receive messages in CAN standard frame format. When CAN controllers that only cover the CAN standard frame format are used in one network, then only messages in CAN standard frame can be transmitted in the entire network. Messages in CAN extended frame format would be misunderstood. However, there are CAN controllers that only support CAN standard frame format but recognize messages in CAN extended frame format and ignore them (version 2.0 B passive).

B.15 Detecting and signaling errors

Unlike other bus systems, the CAN protocol does not use acknowledgement messages but instead signals any errors immediately as they occur. For error detection, the CAN protocol implements three mechanisms at the message level, as follows:

Cyclic Redundancy Check (CRC). The CRC safeguards the information in the frame by adding redundant check bits at the transmission end. At the receiver, these bits are recomputed and tested against the received bits. If they do not agree, there has been a CRC error.

Frame check. This mechanism verifies the structure of the transmitted frame by checking the bit fields against the fixed format and the frame size. Errors detected by frame checks are designated *format errors*.

ACK errors. As already mentioned, frames received are acknowledged by all receivers through positive acknowledgement. If no acknowledgement is received by the transmitter of the message, an ACK error is indicated.

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The CAN protocol also implements two mechanisms for error detection at the bit level, as follows:

Monitoring. The ability of the transmitter to detect errors is based on the monitoring of bus signals. Each station that transmits also observes the bus level and thus detects differences between the bit sent and the bit received. This permits reliable detection of global errors and errors local to the transmitter.

Bit stuffing. The coding of the individual bits is tested at bit level. The bit representation used by CAN is "Non Return to Zero (NRZ)" coding, which guarantees maximum efficiency in bit coding. The synchronization edges are generated by means of bit stuffing. That means after five consecutive equal bits, the transmitter inserts into the bit stream a stuff bit with the complementary value, which is removed by the receivers.

If one or more errors are discovered by at least one station using the above mechanisms, the current transmission is aborted by sending an "error flag." This prevents other stations accepting the message and thus ensures the consistency of data throughout the network. After transmission of an erroneous message that has been aborted, the sender automatically reattempts transmission (automatic retransmission). There may again be competition for bus allocation.

However effective and efficient the method described may be, in the event of a defective station, it might lead to all messages (including correct ones) being aborted. If no measures for self-monitoring were taken, the bus system would be blocked by this. The CAN protocol therefore provides a mechanism to distinguish sporadic errors from permanent errors and local failures at the station. This is done by statistical assessment of station error situations with the aim of recognizing a station's own defects and possibly entering an operation mode in which the rest of the CAN network is not negatively affected. This may go as far as the station switching itself off to prevent other nodes' messages from being recognized erroneously as incorrect.

B.15.1 CAN high-speed physical layer

The CAN high-speed physical layer is defined by ISO 11898-2:2003. It describes the medium access unit (MAU) functions as well as some medium-dependent interface (MDI) features. It is the most important physical layer standard for CAN networks in industrial automation; further specifications are included in the CANopen and DeviceNet standards. Also, the J1939-based standards are based on ISO 11898-2:2003. In passenger cars, this physical layer is used for power- and drive-train applications.

The theoretical maximum bus length at 1 Mbit/s bit rate is 40 m. The actual maximum bus length depends on the bit-timing configuration. At bit rates lower than 1 Mbit/s, the bus may be lengthened. The maximum bus length is 1 km with a bit rate of 50 kbit/s. The total number of nodes is limited by the electrical bus load. However, in order to increase the number of nodes, bridges or repeaters may be used.

The physical medium is a two-wire bus line with common return terminated at both ends by resistors. In order for a node to interpret the bus voltage levels correctly, reflections of the electrical signals on the bus have to be suppressed. This is done with termination resistors (nominal 120 Ω) at each end of both bus lines. The location of the termination resistor within a device should be avoided, because the bus lines lose termination if one of these devices is disconnected from the bus line. Also, the wiring topology of a CAN network should be as close as possible to a single line structure in order to avoid cable-reflected waves. In practice, however, stub lines are necessary to connect devices to the bus. Reflections can be minimized by making stubs as short as possible, especially at high bit rates. At 1 Mbit/s, the length of the cable stubs should not exceed 0.3 m. The bus wires may be routed parallel, twisted, and/or shielded, depending on EMC requirements.

A connector used to plug devices to the bus line should have a nominal impedance of 120 Ω and a nominal transmission resistance of 70 mΩ The cables chosen for the CAN bus lines should have a nominal

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impedance of 120 Ω, a length-related resistance of 70 mΩ/m, and a nominal line delay of 5 ns/m. At bus line length greater than 40 m, the specific resistance of the bus cable should be lower.

For general purpose applications, the CiA recommends the use of driver circuits compliant to ISO 11898-2:2003. Several companies provide such integrated transceiver chips.

B.15.2 CAN fault-tolerant physical layer

There are several different fault-tolerant physical layers for CAN-based networks. ISO 11519-2:1995 [B39] describes transceiver circuitry with a very limited fan-out capability. This standard will be withdrawn very soon. The physical layer specified in ISO 11992 is dedicated to truck/trailer applications providing high differential voltage. The ISO TC22 SC3 WG1 standardization group has initiated a new work item proposal regarding a CAN fault-tolerant physical layer (ISO 11898-3:2000 [B40]), which will substitute ISO 11519-2:1995 [B39]. The new fault-tolerant transceiver specification will specify low-power consumption and switch-off modes as well as wake-up procedure. The most significant feature of all fault-tolerant physical layers is the capability to perform a single-wire transmission in case of short circuits of one bus line against ground or battery voltage. Short circuits between both bus lines lead also to a single-wire transmission.

ISO 11898-3:2000 [B40] specifies the fault-tolerant CAN bus access for slower requirements regarding data rate and bus length. It is mainly used for comfort electronic networks in motor vehicles. In order to provide the fault-tolerant means, the overall network termination resistor should be in a range of about 100 Ω (but not less than 100 Ω). Low power bus transceivers can be used, which keep the power consumption of the network at a minimum. The number of participating nodes specified in ISO 11898-3:2000 [B40] should not be less than 20 (at 125 kbit/s and an overall network length of 40 m) and can be up to 32. The actual number of nodes varies due to communication speed, capacitive network load, overall line length, network termination concept, etc. In order to provide a maximum communication speed of 125 kbit/s, the overall network length should not exceed 40 m. However, it is possible to increase the overall network length by reducing the bit rate.

The bus line in ISO 11898-3:2000 [B40] can have one of the two logical states: *recessive* and *dominant*. To distinguish between both states, a differential voltage is used. In the recessive state, the CAN_L line is fixed to a higher voltage level than the CAN_H line. In general this leads to a negative differential voltage. The dominant state is represented by a positive differential voltage. This means that the CAN_H line is actively fixed to a higher voltage level and the CAN_L line is actively fixed to a lower voltage level. The dominant state overrides a recessive state and is transmitted during dominant bits.

B.16 CAN conformance testing

The CAN conformance test plan standardized in ISO/DIS 16845:2000 [B48] specifies the methodology and the abstract test suite necessary to check the conformance of any CAN implementation to the harmonized CAN specification. The test plan is a specific application of ISO/IEC 9646-1:1994 [B49]. The test plan environment consists of a lower tester, the IUT, and the upper tester running on a micro-controller, for example. Since the message storage capability, the hardware acceptance filter, and the CPU interface are not standardized, the only link between lower tester and IUT are the PLS-Data.indicate and PLS-Data.request interfaces.

The abstract test suites are independent of one another. Each test suite checks the behavior of the IUT for a particular parameter of the CAN specification. The test cases are grouped to received frame type cases, to transmitted frame type cases, and to bi-directional frame type cases. Each test type is subdivided in six test classes, as follows:

1) Valid frame format class
2) Error detection class

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3) Active error frame management class
4) Overload frame class
5) Passive error state and bus-off class
6) Bit-timing class

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Annex C

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Government databases

This annex identifies some, but not all government databases.

C.1 Government databases

For the purpose of accident causation analysis, a number of accident databases have been developed by government agencies and have been utilized by transportation professionals to identify effective countermeasures to improve the safety of the surface transportation system. MVEDR data has the potential to augment the collection of data required for accident databases.

C.2 Canada

Transport Canada maintains databases containing the results of in-depth investigations of collisions on a number of safety issues. Investigations are conducted both by Transport Canada personnel and by seven contracted research teams based in universities across Canada. Approximately 250 such detailed investigations are completed each year. These cases are frequently supplemented by data from existing MVEDRs. Currently, the following research programs are in progress:

— Air Cushion Restraint Study (ACR5)

— Moderately-Severe Side Impacts (SID4)

— Children's Hospital Injury Pilot (CHI2)

— Special Collision Investigations (ASF3)

C.3 Germany

The German In-Depth Accident Study (GIDAS) was developed in 1999 as a joint project between the Automotive Industry Research Association (FAT) and the Federal Road Research Institute (BASt). Teams in Hanover (MUH) and Dresden (TUD) function in the same manner using the same systems, procedures, and collection of data into one common database. Collisions involving personal injury are investigated according to a statistical sampling process. In both areas, the respective police, rescue services, and fire department headquarters reports all accidents continuously to the research team.

The team then selects about 2000 accidents between the two centers annually, according to a strict selection process, and investigates these cases following detailed procedures contained in a handbook and coding manual.

In order to avoid any bias in the database, the data collected in a study is compared to the official accident statistics for the respective areas, and weighting factors are calculated annually. The studies include such information as: environmental conditions; road design; traffic control; accident details and cause of the accident; crash information, e.g., driving and collision speed, Δv and EES, degree of deformation; vehicle deformation; impact contact points for passengers or pedestrians; technical vehicle data; and information relating to people involved, such as weight, height, etc. Approximately 500–3000 data elements per accident are obtained in total.

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Any personal data included is processed according to German data protection regulations. Medical confidentiality and individual rights are guaranteed. All information is stored anonymously in the database.

C.4 United States

NHTSA and the Federal Highway Administration (FHWA) currently maintain databases that provide a comprehensive record of the anatomy of crash events. Major U.S. crash safety databases include the following:

Fatality Analysis Reporting System (FARS) is a comprehensive census of all traffic related fatalities in the U.S., and is used to assist the traffic safety community in identifying traffic safety problems and evaluating both motor vehicle safety standards and highway safety initiatives. FARS has been maintained and operated by NHTSA since 1975. For a case to be included in FARS, 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 divided among an accident table, a vehicle table, and a person table.

National Automotive Sampling System/General Estimates System (NASS/GES) is a collection of approximately 60,000 randomly sampled crashes per year. The objective is to present a representative sample of all police-reported motor vehicle accidents in the U.S. 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 a combination of each. The accident reports are sampled from approximately 400 police jurisdictions in 60 areas across the U.S. 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.

National Automotive Sampling System/Crashworthiness Data System (NASS/CDS) provides a detailed record of a national sample of 5,000 crashes investigated each year by NHTSA at 24 locations throughout the U.S. NASS was created as part of a nationwide effort to reduce motor vehicle crashes, injuries, and deaths on our nation's highways. Both NASS systems are based on cases selected from a sample of police crash reports. CDS data focus on passenger vehicle crashes and are used to investigate injury mechanisms to identify potential improvements in vehicle design. GES data focus on the bigger overall crash picture and are used for problem-size assessments and tracking trends.

The *Special Crash Investigation (SCI)* file is a collection of targeted crash investigations used to examine the safety impact of new, emerging, and rapidly changing technology (such as air bags and alternative fuel systems) and for exploring alleged or potential vehicle defects. NHTSA to date has over 1100 EDR files in the *Electronic Data Collection System (EDCS).*

Crash Injury & Research Engineering Network (CIREN) is a multi-center research program involving a collaboration of clinicians and engineers in academia, industry, and government. Together, they are pursuing in-depth studies of approximately 400 crashes per year, including occupant injuries and treatments to improve processes and outcomes. CIREN's mission is to improve the prevention, treatment, and rehabilitation of motor vehicle crash injuries to reduce deaths, disabilities, and human and economic costs.

The *State Data System (SDS)* is a collection of crash data from 17 state crash databases. These are the police reported crashes collected within the states and are available to NHTSA researchers and NHTSA contractors.

The *Crash Outcome Data Evaluation System Analysis (CODES)* Data Network is a system of linked crash and medical outcome data. The states have linked EMS, emergency department, and hospital discharge databases with the state's crash files. The number of years linked vary with each state.

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Highway Safety Information System (HSIS) is a database for which eight states (California, Illinois, Maine, Michigan, Minnesota, North Carolina, Utah, and Washington) provide crash, roadway inventory, traffic, driver, vehicle, and other information that can be linked to analysis files for a wide spectrum of safety studies.

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. The data elements are classified into four major groups: crash, vehicle, person, and roadway. Each group may include three different types of data elements: (1) *collected*—data collected by police and recorded directly onto the crash report; (2) *derived*—data generated from computerized crash data; and (3) *linked*—data generated when a crash data file is linked to injury, driver history, vehicle registration, roadway inventory, or other data files. The format for each linked data element includes the source of the data to be linked.

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Annex D

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MVEDRs and implementation of ACN

ACN systems integrate on-board crash sensing and MVEDR technology with other electronic systems, such as global positioning systems and cellular telephones, to provide early notification of the occurrence, nature, and location of serious crashes. Early notification can save many lives. Each year, there are about 42,000 fatalities from motor vehicle traffic crashes in the U.S. In these and other emergencies, more lives can be saved if emergency personnel can determine in advance the likely nature and severity of the injuries, take with them the right resources for treating those particular injuries, and more quickly locate and reach the scene of the crash.

Enhanced communications among all members of the trauma care team during the pre-hospital phase will speed deployment of resources, produce more appropriate triaging, and result in better patient outcomes. Greater use of wireless technology should enable team members to speak to other hospitals and providers in the field and to give direction and assistance wherever the care is being provided. Discovery (ACN), Access (wireless), and Coordination (telemedicine) will all be enhanced through improved MVEDR technology.

MVEDRs will help make this possible since they can provide the data necessary to determine crash severity, which can be used to predict injury severity. Software has been developed for evaluating crash data and predicting injury severity. Standardizing MVEDR data content and format would ensure that these predictions are based on the same foundation data across the entire spectrum of new makes and models of light vehicles.

Implementation of ACN systems requires not only incorporating improved MVEDRs in vehicles, but also use of advanced information and communications technology. Implementation of wireless enhanced 911 (E911) and ACN systems can result in the following:

— Faster incident detection and notification
— Faster emergency response times
— Real-time wireless communications links among emergency response organizations

Emergency medical care experience has shown that for many serious injuries, time is critical. Trauma is a time-dependent disease. The *golden hour* of trauma care is a concept that emphasizes this time dependency. That is, in polytrauma (typically, serious crash victims suffer multiple injuries) patients, the first hour of care is crucial, and the patient must come under restorative care during that first hour. Pre-hospital immediate care seeks to apply supportive measures, and it must do so quickly, within what has been called the *golden ten minutes.*

The goal in trauma care is to get seriously injured patients to a trauma center for diagnosis, critical care and surgical treatment within the golden hour. To get the seriously injured patient into the operating room of a trauma center with an experienced team of appropriately specialized trauma surgeons within the golden hour requires a highly efficient and effective trauma care system. The time/life race of the golden hour to deliver patients to definitive care consists of the following elements:

1) Time between crash occurrence and EMS notification
2) Travel time to the crash scene by EMS
3) On-scene EMS rescue time
4) Transport time to a hospital or trauma center
5) Emergency department resuscitation time

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The nation's existing 911 system is administered through thousands of Public Safety Answering Points (PSAPs). Prior to the advent of wireless telephones, the PSAPs were able to automatically locate nearly all 911 callers. Now, more than half of 911 calls in metropolitan areas cannot be located because they originate from mobile wireless telephones. Lack of location information is a particular problem with 911 calls made from cell phones to report crashes, since the caller is often not be able to determine and report precise location information.

The wireless E911 program is divided into two parts: Phase I and Phase II. Phase I requires carriers, upon appropriate request by a local PSAP, to report the telephone number of a wireless 911 caller and the location of the antenna that received the call. Phase II requires wireless carriers to provide far more precise location information, within 50 m to 100 m in most cases.

The deployment of E911 requires the development of new technologies and upgrades to local 911 PSAPs, as well as coordination among public safety agencies, wireless carriers, technology vendors, equipment manufacturers, and local wire-line carriers. The Federal Communication Commission (FCC) established a four-year rollout schedule for Phase II, beginning October 1, 2001, and to be completed by December 31, 2005.

Under FCC rules adopted in 1996, wireless carriers must provide E911 service by 2005. This service will provide location information for all wireless 911 calls, provided that the local PSAP is equipped to receive and use the information. The U.S. Department of Transportation (USDOT) has been actively involved in providing stakeholder leadership, technical assistance, and technological innovation to accelerate full and effective implementation of E911. This includes not only regulating and coordinating the service provided by wireless carriers, but ensuring that local PSAPs are able to receive and effectively use the information.

In the meantime, efforts to provide ACN services have already begun. Current ACN systems provide automatic notification that a motor vehicle has been involved in a crash, information about the nature of the crash, and the location of the crash. While current ACN systems provide the information to a private call center, which then relays this information to 911 dispatchers, future systems may be integrated with the 911 system.

The ACN systems offer great potential for reducing deaths and injuries from motor vehicle crashes, and improving MVEDRs would make a contribution toward the continued development and implementation of these systems.

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[15]ISO publications are available from the 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 (http://www.ansi.org/).

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[B38] ISO 9141-3:1998, Road Vehicles—Diagnostic Systems—Verification of the Communication between Vehicle and OBD II Scan Tool.

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[17]ISO/IEC publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembé, CH-1211, Genève 20, Switzerland/Suisse (http://www.iso.ch/). ISO/IEC publications are also available in the United States from Global Engineering Documents, 15 Inverness Way East, Englewood, CO 80112, USA (http://global.ihs.com/). Electronic copies are available in the United States from the American National Standards Institute, 25 West 43rd Street, 4th Floor, New York, NY 10036, USA (http://www.ansi.org/).

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[21]As this standard goes to press, any SAE publication identified as a “work in progress” was not yet available. Consult the SAE Web site for more information (www.sae.org).

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NOTES

1—Examples of Crash Injury Triage Guidelines from: Massachusetts Statewide Trauma Triage Guidelines for Air Medical Services, November 1997 and the American College of Surgeons, are as follows:

- — High impact speed
- — Intrusion
- — Patient ejected from automobile
- — Major auto deformity
- — Rollover

2—Examples of the Types of Situations that MVEDR Data Will Help Avoid are as follows:

- — Transporting a seriously injured person (from a night crash) who needs emergency surgery to a hospital that does not have a surgeon/surgical team available at night.
- — Transporting a person with a potentially life-threatening head injury to a hospital that does not have a neurosurgeon

3—Medical Community/Research Support for MVEDR Variables for Emergency Medical Response Use at the Scene of Crashes, prepared by Elizabeth Garthe, M.H.S., Ricardo Martinez, M.D., Nicholas Mango, BSME [posted on P1616 Web site (http://grouper.ieee.org/groups/1616/home.htm) as document #129]

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