

IEEE Standard for Data Storage Systems for Automated Driving

IEEE Vehicular Technology Society

Developed by the
Intelligent Transportation Systems Committee

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STANDARDS

IEEE Standard for Data Storage Systems for Automated Driving

Developed by the

Intelligent Transportation Systems Committee
of the
IEEE Vehicular Technology Society

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Recognized as an American National Standard

Abstract: The goals and metrics of a data storage system for automated driving (DSSAD) are defined in this standard. Functions and common technical requirements for data storage are identified. Data elements relevant to automated driving system (ADS) Level 3, Level 4 and Level 5 are defined. The usage of data among diverse end users is also defined. A compendium of data elements used in vehicles of categories M1 and N1 regarding their EDR and DSSAD for partial and fully automated vehicles is provided in this standard. An on-board diagnostic (OBD) port lockout/near field communication (NFC) protocol for protection against data manipulation via the vehicle diagnostic port is provided. This standard is made available without prejudice to national and regional laws related to data privacy, protection, and personal data processing. Users are responsible for compliance with all such laws and regulations. This standard may be frequently updated to include relevant data definitions and data elements toward the development of automated vehicles. The overall goal is to create a data collection standard for automated driving that includes functional requirements for automated vehicle gateways and security guidelines for cloud-based automotive data recorder requirements.

Keywords: ADS, ADS-operated vehicle, assumption, automated driving system, autonomous vehicles, cloud, cloud-based DSSAD, cloud-based event, data elements data recorder, data recorders, data storage system automated driving, decision making, DSSAD, EDR, EDR-DSSAD, EDR security threats, EDDR-DSSAD definitions, functional requirements, gateway architecture, IEEE 1616.1™, interfaces, near field communication protocol, NFC, ODD, OES, operating envelope specification, operational design domain, safety measurement, security requirements, vehicle gateway

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Participants

At the time this standard was completed, the Motor Vehicle Event Data Recorder Working Group had the following membership:

Thomas M. Kowalick, *Chair*
Paul Kostek, *Secretary*
Mark Limond, *Technical Editor*

Minjin Baek
Jun Li

Meng Lu
Thomas Kurihara

Ben Levitan
Michelangelo Mazzucco

The following members of the individual Standards Association balloting group voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

Minjin Baek
Bill Brown
Kevin Cameron
Zhiman Chen
Marco Hernandez
Werner Hoelzl
Chen-Hui Hu

Ming Jiang
Piotr Karocki
Thomas M. Kowalick
Thomas Kurihara
Jun Li
Russell Mohr

Rajesh Murthy
Bansi Patel
Cam Posani
Eugene Stoudenmire
Walter Struppler
John Vergis
Alan Winfield

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Ted Burse, *Vice Chair*
Gary Hoffman, *Past Chair*
Konstantinos Karachalios, *Secretary*

Sara R. Biyabani
Doug Edwards
Ramy Ahmed Fathy
Guido R. Hiertz
Yousef Kimiagar
Joseph L. Koepfinger*
Thomas Koshy
John D. Kulick

Joseph S. Levy
Howard Li
Johnny Daozhuang Lin
Gui Lin
Xiaohui Liu
Kevin W. Lu
Daleep C. Mohla
Andrew Myles

Paul Nikolich
Annette D. Reilly
Robby Robson
Lei Wang
F. Keith Waters
Karl Weber
Philip B. Winston
Don Wright

*Member Emeritus

Introduction

This introduction is not part of IEEE Std 1616.1™-2023, IEEE Standard for Data Storage Systems for Automated Driving.

Vehicle and highway safety experts agree that the potential benefits of driverless vehicles are significant—comfort, safety, and efficiency are claimed. Yet, among motorists, there is skepticism about the actual safety and security of automated driving systems (ADS).

It is one thing to promise enormous benefits to society and another to achieve such benefits when the challenges to achieve them are underestimated. This standard provides evidence of usage to a wide variety of end users. Without sufficient evidence adequately supporting the safety claims, ADS would not exist.

The need to create a standard to address data storage system automated driving (DSSAD) is overdue. There are enormous investments in ADS, and the ecosystem exceeds 600 entities (see Pricewaterhouse Coopers’ “Autonomous ecosystem” website [B3]⁶).

The mantra of this standards initiative is best described by Albert Einstein’s quotation, which is set in stone at the National Academies of Science building in Washington, DC: “The right to search for truth also implies a duty; one must not conceal any part of what one has recognized to be true.”

The truth is that, despite the best intentions of promises made by numerous high-profile automakers, it has become abundantly clear that to achieve the challenges involved in the deployment of ADS, more evidence is required. However, it has been difficult to compile more evidence without a complete and predictive safety case. DSSAD crash site evidence is needed to complete the predictive safety case.

In previous generations, automotive systems had a standard design, deployment, verification, and validation of safety systems. The modern electronics-intensive connected vehicle changed everything. Current and future vehicles are increasingly complex, and operational uncertainties of ADS present many issues, the least of which is public awareness and acceptance.

The IEEE TechRxiv paper “Holistic Perspectives on Safety of Automated Driving Systems-Methods for Provision of Evidence” [B22] highlights this as follows:

uncertainties imposed by the operating environment and cites the ADS’s interaction with other road users requires a complex set of interwoven functions and subsystems to achieve the entire strategic, tactical and operational responsibilities of the driving task.

This standard seeks to identify associated challenges and gaps in determining what happens when a vehicle crashes. For example, the event data recorder (EDR) provides “what happened info,” and the DSSAD for ADS provides “why it happened info” at the crash site.

Significant challenges need to be addressed before driverless vehicles are ready and accepted by the public for widespread use.

The DSSAD reports and verifies two key fields, summarizing the status of the vehicles ADS and who was in control at a specific point in time. In addition, this standard references DSSAD and EDR data sets required for the actual crash event.

Unlike the EDR, the DSSAD would provide persistent storage to the limited size of the data involved. This would allow an investigator to determine who was in control during a collision with a smaller vehicle or pedestrian, a traffic offense, or an unsafe maneuver.

⁶The numbers in brackets correspond to those of the bibliography in Annex A.

The DSSAD includes a timestamp between the driver and the system (e.g., who/what was requested to be in control and who/what was in control), including the fields needed to record the automated data in Modern Minimum Uniform Crash Criteria (MMUCC)⁷ compliant crash reports. The specific recommended areas include the date and time, on/off, status of automation, the transition period, and the time of the takeover/transition.

This standard is for global consumption realizing differences exist between the regulatory environments. For example, there is a difference between the regulatory requirements in Europe and those in the United States. In Europe, certification is overseen by national regulators whereas in the United States, manufacturers are responsible for self-certifying their own products.

The primary goal of this standard is to contribute to developing ADS-equipped vehicles that are safe, secure, and ready for the marketplace.

Acknowledgments

The IEEE Intelligent Transportation Systems Committee of the IEEE Vehicular Technology Society P1616.1: Data Storage System for Automated Driving (DSSAD) Working Group extends its gratitude to the following:

- The UNECE World Forum for Harmonization of Vehicle Regulations (WP.29) is a unique worldwide regulatory forum within the institutional framework of the UNECE Inland Transport Committee. Three UN Agreements, adopted in 1958, 1997 and 1998, provide the legal framework allowing Contracting Parties (member countries) attending the WP.29 sessions to establish regulatory instruments concerning motor vehicles and motor vehicle equipment. Overall, the regulatory framework developed by the World Forum WP.29 allows the market introduction of innovative vehicle technologies, while continuously improving global vehicle safety. The framework enables decreasing environmental pollution and energy consumption, as well as the improvement of anti-theft capabilities.
- UN Regulations contain provisions (for vehicles, their systems, parts and equipment) related to safety and environmental aspects. They include performance-oriented test requirements, as well as administrative procedures. The latter address the type approval (TA) (of vehicle systems, parts and equipment), the conformity of production (i.e., the means to prove the ability, for manufacturers, to produce a series of products that exactly match the TA specifications) and the mutual recognition of the TAs granted by Contracting Parties.
- Specifically for usage of ECE/TRANS/WP.29/2020/81- AGREEMENT concerning the adoption of Harmonized Technical United Nations Regulations for Wheeled Vehicles, Equipment and Parts which can be fitted and/or be Used on Wheeled Vehicles and the Conditions for Reciprocal Recognition of Approvals Granted on the Basis of these United Nations Regulations and ECE/TRANS/WP.29/2020/123/Rev1: ADDENDUM 159 -UN Regulation No.160:Uniform Provisions concerning the approval of motor vehicles with regard to the Event data Recorder.

⁷The MMUCC is a minimum, standardized data set used to determine motor vehicle crashes and the vehicles and persons involved.

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IEEE Standard for Data Storage Systems for Automated Driving

1. Overview

1.1 Scope

This standard defines requirements and metrics for data storage in a data storage system for automated driving (DSSAD), as well as related functions and common technical requirements. A DSSAD is a device or function that records and stores a data set (“timestamped flags”) during the automated driving sequences of any vehicle equipped with Level 3, Level 4, or Level 5 automated driving systems (ADS). The standard conforms to a compendium of data elements used in vehicles of categories M1 (used for the carriage of passengers) and N1 [used for the carriage of goods (trucks)] regarding their event data recorder (EDR) and DSSAD for partial and fully automated vehicles, including relevant data elements to ADS Level 3, Level 4, and Level 5 (see [Figure 1](#) for all ADS levels). This standard explains the means by whereby an EDR and a DSSAD interact. This standard is made available without prejudice to national, local, and regional laws and regulations related

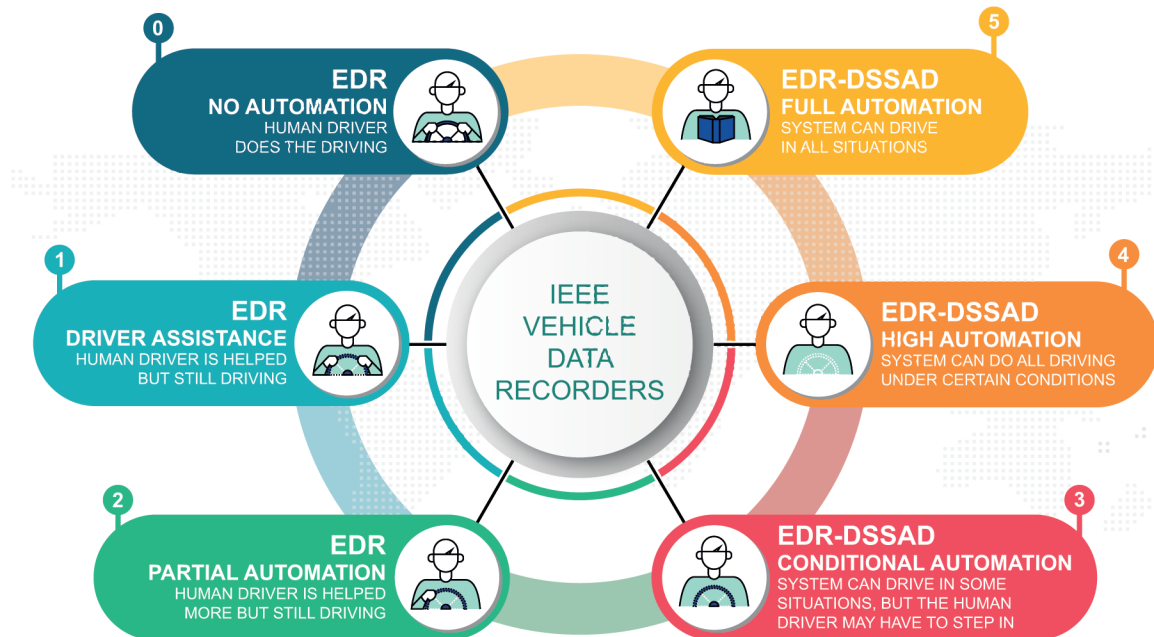


Figure 1—Levels of driving automation and data recorders

to data privacy, data protection, and personal data processing. Users are responsible for compliance with all such laws and regulations. This standard defines an onboard diagnostic connector (OBD-II) port lockout and near field communication (NFC) protocol for protection against data manipulation of EDR and DSSAD data via the vehicle diagnostic link connector (DLC). This standard does not include specifications for data retrieval tools and methods as that is subject to national and regional requirements.

1.2 Word usage

The word *shall* indicates mandatory requirements strictly to be followed to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*)^{8,9}

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

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

1.3 General

Crash data is critical to understanding causation leading up to the crash, occupant kinematics and vehicle performance during a crash and post-crash event. In addition, manufacturers, engineers, policymakers, 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, capturing a subset of vehicle data on a motor vehicle event data recorder (MVEDR) and a DSSAD makes essential information readily available for medical responders, crash investigators, and researchers. The degree of societal benefit from MVEDR/DSSADs is directly related to the number of vehicles operating with an MVEDR/DSSAD and the ability to retrieve and utilize these data. In addition, having standardized data definitions and formats allows the capture of vehicle crash information.

The IEEE P1616.1 Working Group recognizes the value of improved crash information in enhancing the knowledge of what happens before, during, and after a motor vehicle crash. Such insights shall greatly benefit 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 and DSSAD data elements. The impact of improved crash data goes beyond just understanding the dynamics of a crash; it affects a myriad of critical societal and business functions. With that in mind, the working group solicited input from various end users to help identify essential data elements and necessary uses of motor vehicle crash data. Depending on the application and data used, both individual crash events and aggregate data have value for end users.

For an overview of the magnitude of the problems that automated/autonomous vehicles will hopefully reduce, see NHTSA’s “The Economic and Social Impact of Motor Vehicle Crashes” [B51].

1.4 Preliminary considerations

The preliminary considerations for this standard are based on the widely accepted principle that EDR and DSSAD should not be mixed or overlapping in terms of functions and terms of concepts as well.

⁸The use of the word *must* is deprecated and cannot be used when stating mandatory requirements; *must* is used only to describe unavoidable situations.

⁹The use of *will* is deprecated and cannot be used when stating mandatory requirements; *will* is only used in statements of fact.