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6. AUTHOR(S) Christopher Armstrong, Bradley Higgins, Krystina M. Engleman, John Grindey, Kristina Lombardi, Jacobo Pardo, Henry Ramirez, Henry Schmoker and John Steiner		7. SUPPLEMENTARY NOTES There are 5 individual reports that make up the full report for this Feasibility Study (Deliverable No. 3 thru Deliverable No. 7)
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12. ABSTRACT

As outlined in the T8080-160062 Feasibility Study of Event Data Recorders for Commercial Buses contract, the following report presents a summarized history of standards activities related to event data recorders (EDRs) and heavy vehicle event data recorders (HVEDRs) that have taken place or are currently in progress. All standards activities related to EDR and HVEDR that were found or in which Mecanica's research team participated have occurred in the United States. The SAE J1698 (light-duty) EDR and the SAE J2728 HVEDR Recommended Practices focus on defining the specifications, minimum performance requirements and data elements leveraging vehicle OEM ECUs, sensors, data networks and data messages. To define EDR/HVEDR functionality on OEM ECUs, networks and data, there are several technical Recommended Practices/Standards publications that are foundational to both the J1698 light-duty EDR and J2728 HVEDR Recommended Practices. Those foundational Recommended Practices and Standards are also discussed in this report.

13. ACKNOWLEDGEMENTS

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14. KEY WORDS

EDR, HVEDR, Event Data Recorder, bus, school bus, motorcoach

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Transport Canada Commercial Bus HVEDR Feasibility Study (File No. T8080-160062) Deliverable No. 5:

Summary Report of International Commercial Vehicle EDR Industry Standards and Recommended Practices. Includes Interview Notes with Key Government Stakeholders (e.g. NHTSA, TSB…)

5. Submission of a summary report of all available international commercial vehicle EDR industry standards and recommended practices including interviews notes with key government stakeholders such as NHTSA and TSB in the US.
Deadline: Within 8 weeks of deliverable # 4

Mecanica Scientific Services Corporation

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1.0 INTRODUCTION

The following report for *T8080-160062 Feasibility Study of Event Data Recorders for Commercial Buses*, Deliverable No. 5, "Summary Report of International Commercial Vehicle EDR Industry Standards and Recommended Practices," presents a summarized history of standards activities related to **event data recorders (EDRs)** and **heavy vehicle event data recorders (HVEDRs)** that have taken place or are currently in progress. All standards activities related to EDR and HVEDR that were found or in which Mecanica's research team participated have occurred in the United States.

Several members of the Mecanica research team have been active members and served in leadership roles for some of the following standards committees on EDR and HVEDR functionality.

In addition to reporting on EDR and HVEDR standards activity, the Mecanica research team was tasked with reaching out to organize meetings with key government stakeholders focused on highway safety research or regulatory work on HVEDR and EDR.

2.0 EXECUTIVE SUMMARY

The active and inactive EDR/HVEDR standards activities that have been discovered have largely taken place in the United States and organized within the internationally recognized standards organization, Society of Automotive Engineers (SAE) International.

The "SAE J1698, Event Data Recorders" Committee focuses on standardizing common terminology; defining data elements; standardizing data access, communications protocols and reporting formats; and achieving industry consensus. During the open comments period for the National Highway Traffic Safety Administration's (NHTSA) Notice for Proposed Rulemaking (NPRM) for Title 49, Code of Federal Regulations (CFR), Part 563, "Event Data Recorders" (69 FR 32932), the SAE J1698 Committee submitted the contemporaneously published J1698 Recommended Practice as technical guidance to NHTSA on the now final Part 563 rule.

Since 2002, Mecanica Scientific's John C. Steiner has served as a member and currently serves as a liaison between the SAE J1698 Committee and the SAE J2728, "Heavy Vehicle Event Data Recorders" Committee. The J1698 Committee remains active in addressing new challenges and updating EDR recommended practices to keep up with new vehicle technologies, especially currently available automated driving systems (ADS) and future advanced driver assistance systems (ADAS).

The SAE J2728, "Heavy Vehicle Event Data Recorders" Committee works in parallel to the SAE J1698 passenger vehicle EDR Committee and focuses on HVEDR functions for heavy-duty (HD) ground-wheeled vehicles with Gross Vehicle Weight Ratings (GVWR) of over 4,545 kg (10,000 lbs.). SAE published the J2728 Recommended Practice (RP) for HVEDR in June of 2010. In early

2017, the SAE J2728 committee reconvened and is once again active. Similar to the SAE J1698 Committee, the SAE J2728 Committee currently looks to address new challenges and update HVEDR Recommended Practices to keep up with new vehicle technologies, especially ADAS.

It is important to note that the SAE J1698 (light-duty) EDR and the SAE J2728 HVEDR Recommended Practices focus on defining the specifications, minimum performance requirements and data elements leveraging vehicle OEM ECUs, sensors, data networks and data messages. To define EDR/HVEDR functionality on OEM ECUs, networks and data, there are several technical Recommended Practices/Standards publications that are foundational to both the J1698 light-duty EDR and J2728 HVEDR Recommended Practices. Those foundational Recommended Practices and Standards are discussed in this report.

The National Fire Protection Association (NFPA) committee on fire apparatus published the 1901 Standard defining the vehicle data recorder (VDR) specific to fire apparatus.

The American Trucking Association's (ATA) Technology & Maintenance Council (TMC) maintains a well-organized list of technical committees addressing trucking and industry collaboration and consensus on best practices for commercial fleet maintenance, repair and modifications. The ATA/TMC features two committees related to HVEDR. These are the RP 1214, "Guidelines for Event Data Collection, Storage and Retrieval" Committee and the SAE J2728 Standards Committee for establishing common data elements and data-element definitions for heavy commercial vehicle event data recording.

Finally, there has been additional committee activity related to EDR/HVEDR but focused on the end use of EDR/HVEDR-type data. In the early 2000s, American Society for Testing and Materials (ASTM) International organized an active standards committee, WK4150, "Practice for the Investigation of Non-Volatile Memory Data in Evidentiary Electronic Control Units."

Another potential end-user standards committee which serves as an authority on the formatting and incorporating of EDR/HVEDR data into large-scale highway statistical databases, such as the National Automotive Sampling System (NASS), is the SAE Data Collection and Archiving Standards Committee.

Contact by telephone, email and in-person communication was attempted to organize discussions and interviews pertaining to EDR/HVEDR with key stakeholders in regulatory or investigative agencies, such as the United States' Department of Transportation (DOT), NHTSA, Federal Motor Carrier Safety Administration (FMCSA) and National Transportation Safety Board (NTSB), and Mexico's *Instituto Mexicano del Transporte* (Mexican Transport Institute) and *Secretaría de Comunicaciones y Transportes* (Secretary of Communications & Transportation). The Mecanica research team also attempted to reach key stakeholders in Japan, China, Europe, Israel and Australia regarding EDR/HVEDR highway safety research or regulatory activity, but no "on the record" interviews with key stakeholders of the aforementioned government agencies were secured.

3.0 RECOMMENDED PRACTICES & STANDARDS

Some of the literature presented and reported here are referred to as *Recommended Practices* or *Standards*. SAE International defines both Recommended Practices and Standards as technical reports. SAE International respectively defines these documents as follows:

- *SAE Standards: These Technical Reports are a documentation of broadly accepted engineering practices or specifications for a material, product, process, procedure or test method.*
- *SAE Recommended Practices: These Technical Reports are documentations of practice, procedures and technology that are intended as guides to standard engineering practice. Their content may be of a more general nature, or they may propound data that have not yet gained broad acceptance.*[1]

There are generally three categories of Recommended Practices (RPs) and Standards committees that have been or are currently active and focused on light-, medium- and heavy-duty EDR/HVEDR. These three categories and the involved standards organizations include:

- EDR/HVEDR Technical Functionality (SAE, NFPA)
- EDR/HVEDR Technical Fleet Installation/Integration (ATA/TMC)
- EDR/HVEDR Data End User (SAE, ASTM)

Some of the Recommended Practices and Standards committees identified and discussed here are no longer active or are completely disbanded. These committees played significant roles in the seminal RPs and Standards work of the early 2000s, however, and are reviewed in the following report.

Also discussed and identified in the following research are several key foundational Standards or RPs regarding the light-, medium- and heavy-duty EDR/HVEDR devices that are built on original equipment manufacturer (OEM) electronic control units (ECUs) and leverage the vehicle's native closed-loop control systems, data networks and sensors. The EDR/HVEDR functions as defined by SAE J1698 ("Light-Duty Event Data Recorders"), SAE J2728 ("Heavy Vehicle Event Data Recorders") and NFPA 1901 ("Fire Apparatus Vehicle Data Recorder") specifically define and rely on standardized (and regulated) Controller Area Network (CAN) vehicle data networks, such as SAE J1939 for heavy-duty vehicles and SAE J1850 for light-duty vehicles.

3.1 EDR & HVEDR Technical Functionality Recommended Practices/Standards

EDR/HVEDR functionality, as defined over the past 18 years by the Standards committees at SAE International, is specifically designed as *functions* (software algorithms) that are added to one of a vehicle's numerous native OEM ECUs installed at the factory and are required for the

[1]Source: https://www.sae.org/standardsdev/devprocess.htm.

proper (and safe) operation of the vehicle. These EDR/HVEDR functions leverage the vehicles' OEM closed-loop controllers, data networks and sensors.

In response to NTSB's repeated Safety Recommendations and congressional testimony, industry leadership initiated the Heavy Vehicle Event Data Recorder Committee under the SAE International Truck & Bus Council in late 2005.

On a separate but parallel track, the industry professionals and experts actively involved in the NFPA Committee for Standard 1901, "Standard for Automotive Fire Apparatus" worked to publish their first requirements for an add-on VDR that leveraged the fire apparatus's standardized (SAE J1939, J1708) data networks, addressed vehicle messages and sensors.

EDR/HVEDR-related publications and work are reviewed in the following sections.

3.1.1 Light-Vehicle EDR Standards

The Event Data Recorder Committee, who reports to the Electrical Systems Group of the Motor Vehicle Council, is responsible for developing and maintaining SAE Standards, Recommended Practices and Information Reports that generate common data output formats and define a variety of data elements that make up an EDR record. These records may be useful for analyzing vehicle crash and collision-like events that meet specified trigger criteria. These standards are intended to control the EDR data-element definitions, record retrieval methodologies and recommend tests for validating EDR functionality as applicable for light-duty original equipment applications. The following sections outline development and revision activities for the SAE J1698 standard.

3.1.1.1 SAE J1698, "Event Data Recorders"

In 2003, the focus and energy directed at passenger-vehicle EDRs started to increase due to the membership and volunteer work contributed to SAE J1698 "Vehicle Event Data Interface" (VEDI).

The J1698 Recommended Practice provides common definitions and operational components of light-duty EDRs. In December 2003, the initial J1698 RP version, SAE J1698/1 "Event Data Recorder - Output Data Definition," focused on establishing a common format for displaying and presenting light-duty vehicle post-downloaded data and did not intend to standardize the format of data stored on any on-board storage unit or the method of data recording, storing or extraction.

Crash data-recording technology in light-duty vehicles had developed and evolved from various technical needs of manufacturers and customers without industry standards or government regulation. This explains the wide variation in the scope and the extent of recorded data among vehicle manufacturers. Intending to compile data elements and parameters that various manufacturers currently recorded, J1698/1 established the common format for displaying and presenting this recorded data. This initial version of the Recommended Practice was limited in application to single-event, frontal-impact vehicular data recordings.

It is important to note ongoing EDR-related activities prior to 2003 in the United States, as previously discussed in *T8080-160062 Feasibility Study of Event Data Recorders for Commercial Buses,* Deliverable No. 3. These included NHTSA's numerous activities regarding EDR and included technical assistance from the U.S. National Aeronautical & Space Administration (NASA) Jet Propulsion Laboratory (JPL), who conducted extensive research into passenger vehicle airbag systems and recommended in their April 1998 *Advanced Air Bag Technology Assessment, Final Report* that technology (such as EDR) be developed to collect data from the tens of thousands of fatal highway accidents that occur on U.S. highways every year. In August 2001, the NHTSA Event Data Recorder Working Group published their *Final Report* (No. NHTSA-1999- 5218-9) on passenger vehicle EDR and subsequently published a second supplemental report, *Volume II Supplemental Findings for Trucks, Motorcoaches, and School Buses*, *Final Report* (No. DOT HS 809432). The U.S. NTSB had also previously published two Safety Recommendations for EDRs in July 1997[2] and November 1999.[3]

These developments laid the foundation for the organization of the SAE J1698 VEDI committee by 2003. The SAE J1698 Committee has historically featured a diverse, active membership of participants representing OEM suppliers, consulting firms, academia and government liaisons.

Prior to NHTSA's publishing of the Part 563 "Event Data Recorder" final rule (71 FR 50998), NHTSA received the SAE J1698 Committee Recommended Practice, which proposed technical guidelines outlining EDR specifications, such as recommended data elements for recording and what kind of data was technologically possible to record based on then-current vehicle CAN and serial data capabilities.

The J1698 Committee reconvened in 2010 to reorganize itself from the formerly titled "Vehicle Event Data Interface" Committee, renaming itself the "Event Data Recorder" Committee. The newly reinstated J1698 EDR Committee focused on addressing recently proposed legislation responding to a series of reported unattended acceleration claims. Nearly all the proposed legislation featured some degree of an EDR requirement. Additionally, in keeping with SAE standards work requirements, the J1698 Committee had reconvened to conduct a five-year review of the Recommended Practice previously completed and published in 2005. The EDR Committee took this opportunity to update the J1698 document in accordance with in-progress and changing technologies.

During the 2010 reorganization, the SAE J1698, "Event Data Recorder" Recommended Practice was restructured as a series of three documents:

- "J1698-1, Event Data Recorder - Output Data Definition"
- "J1698-2, Event Data Recorder - Retrieval Tool Protocol"
- "J1698-3, Event Data Recorder - Compliance Assessment"

[2]NTSB Safety Recommendation H-97- 10 through -18, July 1997, which called for electronic recording of crash data.

[3]NTSB Safety Recommendation H-99- 45 through -54, Nov. 1999.

To date, the SAE J1698 Committee has worked to issue new RPs and revise previously published ones. These redrafts include the updated J1698 (base document), revised on March 17, 2017, as well as J1698-1, “Event Data Recorder - Output Data Definition,” updated as of May 2018. The J1698-1A, “Pedestrian Protection EDR Output Data Definition Appendix” addendum to SAE J1698-1 was issued on March 2, 2016. The J1698-2, “Event Data Recorder - Retrieval Tool Protocol” was revised on January 14, 2013 and reaffirmed on March 18, 2018. The J1698-3, “Event Data Recorder - Compliance Assessment” was last revised on December 17, 2015.

The SAE J1698 Committee has been working to maintain commonality of data element terms, definitions and parameter outputs with the current United States federal regulations for light-duty vehicle EDRs as defined in 49 CFR Part 563, which is implemented on a voluntary basis.

The current J1698-1 “Event Data Recorders - Output Data Definition” RP lists relevant data elements for vehicle-specific sensors and/or the vehicle system and the system status received by the EDR via the vehicle communication bus. To characterize the general availability of the data elements, all data elements are classified using three different classifications, namely Classification I, II or III. Classification I entails those data elements found either in the ECU(s) or on the communications bus in most vehicles across the industry, with the exception of some volumetrically smaller vehicles. Data elements currently found on either ECU(s) or the communications bus in some vehicles but are not industry-wide are considered Classification II. Classification III lastly includes the data elements either not found in the ECU(s) or on the communications bus in any current vehicles or found only in a small percentage of vehicles.

Furthermore, these data elements may be proprietary or irretrievable. The current J1698-1 standard specifies a minimum reporting frequency of 100 Hz (100 samples/second) for change in vehicle speed. Table 3.1.1.1 displays an excerpt of the output data elements for the latest J1698-1 RP.

Table 3.1.1.1. Excerpt from J1698-1-201703 RP Output Data Elements

Section No.	Data Element Description
7.1	Acceleration Data - Lateral, Longitude, Normal and Peripheral Acceleration
7.2	Accident Date - Year, Month, Day; time of the day when the event occurred.
7.3	Accident Time - Hour, Minute and Seconds
7.4	Adaptive Cruise Control - Operating status of the adaptive cruise control system.
7.5	Ambient Temperature - The estimated exterior ambient air temperature as measured by the vehicle system.
7.6	Anti-Lock Brake System Status - Operating status of the anti-lock brake system.
7.7	Blind Spot System - Operating status of the side blind spot system.
7.8	Brake Override - Parameter indicates that the brake and accelerator pedals have been depressed simultaneously for a specified period of time, thereby creating a control conflict.
7.9	Brake Application - Brake Pedal Position or Brake System Internal Pressure; either or both of the data elements may be used to indicate driver intended brake application. Service Brake, On and Off - Status of the switch that is used to detect whether or not the brake pedal was pressed by the driver.
7.10	Collision Warning System - Operating status of the collision warning system.
7.11	Cruise Control System Status - Operating status of the cruise control system.
7.xx	Additional RP Output Data Elements are available
7.50	Turn Signal Switch Status - Status of the switch that is used to indicate the driver's intention to make a turn or change lanes.
7.51	Vehicle Identification Number - The Vehicle Identification Number (VIN), assigned by the vehicle manufacturer.
7.52	Vehicle Mileage - Odometer reading of the vehicle at the beginning of the event.

Presently, the SAE J1698 Committee is working to keep the J1698 EDR RP documents current with ever-changing vehicle technologies foundational to passenger-vehicle EDRs. Special attention has been paid to the most disruptive and advanced technologies, those being the varying degrees of ADAS. ADS can be as simple as a lane departure warning (LDW) system that either warns a driver when the vehicle nears departure of its lane, or otherwise intercedes by applying wheel brakes or ADAS autonomously steering the vehicle (without driver input) to maintain the vehicle's lane position, such as can be done by General Motors' Cadillac Division's *SuperCruise*®. These disruptive technologies span from automatic emergency braking (AEB)

systems to fully autonomous vehicles requiring no driver, such as Google's Waymo (an autonomous car development company and subsidiary of Alphabet, Google's parent company).

Additionally, current committee projects are working to incorporate and harmonize EDR with the intelligent transportation system (ITS) infrastructure in support of vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I) and vehicle-to-X (future system expansion) to monitor how these advanced systems perform.

There are foundational standards for the SAE J1698, "Event Data Recorder" Recommended Practice that outline how to take advantage of a vehicle's OEM data network, closed-loop controllers, sensors and data. The first foundational standard is the common method of physical connectivity to access the vehicle's EDR data via the SAE J1962, "Diagnostic Connector," which is equivalent to ISO/DIS 15031-2 (December 14, 2001).

Other standards regarding data output definitions for a J1698-compliant EDR would be SAE J211-1, "Instrumentation for Impact Test - Part 1 - Electronic Instrumentation"; SAE J670, "Vehicle Dynamics Terminology"; and SAE J2948, "Keyless Ignition Control Design."

3.1.1.2 LV37, European EDRs

Contact has been made with a key resource for information regarding European EDR in the European OEM market. At the time of writing, this information is not available.

3.1.2 Heavy-Vehicle EDR Standards

HVEDR standards refer to any type of electronic function with capability of storing data for a defined event within a heavy truck or bus ECU that communicates on the SAE J1939 or J1587/J1708 data communications protocol. What some have called a "black box" is properly termed HVEDR as defined by the SAE J2728, "Heavy Vehicle Event Data Recorders" Recommended Practice.

3.1.2.1 SAE J2728, "Heavy Vehicle Event Data Recorders"

This RP document applies to HVEDRs for HD ground-wheeled vehicles over 4,545 kg (10,000 lbs.), commonly referred to as Classes 3-8, and which are intended to be compliant with current Federal Motor Vehicle Safety Standards (FMVSS) and/or Federal Motor Carrier Safety Regulations (FMCSR). In the context of the J2728 RP, the term *heavy vehicle* refers to motor vehicles equipped with one or both of two vehicle communication networks, SAE J1708/J1587 or SAE J1939.

This document focuses primarily on wheeled vehicles with standard on-board power supplies (e.g., batteries). It intends to address the needs of OEM original, OEM modified/additive and aftermarket systems. The document does not specifically exclude trailers and similar non-engine

powered vehicles although the current lack of standardized methodologies and processes for inter-vehicular communication and power supply interconnections remains unresolved.

SAE J2728 attempts to standardize HVEDR, categorized into three tiers. Tier 1 represents the basic functionality of an HVEDR, Tier 2 includes non-proprietary data available on the vehicle communication networks and Tier 3 addresses relevant proprietary data as technology and practices evolve. The J2728 RP addresses the minimum performance specification for a Tier 1 HVEDR.

A glossary of terms are also defined in this RP and include “electronic control unit” (ECU), “vehicle speed sensor” (VSS) and “heavy vehicle event data recorder” (HVEDR). An ECU is defined as an electronic subsystem that manages the functions of a vehicle system or components. ECUs are commonly referred to as “electronic control modules” (ECMs) or “modules.” The VSS is a sensor that determines the approximate longitudinal velocity of a vehicle during operation. This sensor is generally mounted near the rear of the transmission above the tone ring. HVEDR is defined as an electronic system that captures and records electronic information related to an event during vehicle operation.

J2728 lays out the foundation for a minimum-specification HVEDR system. This begins with the technical requirements for the system, including event triggers, data elements and event duration.

The RP lists and defines three different types of events and their trigger threshold. The first is an “Acceleration Triggered Event.” An Acceleration Triggered Event can be thought of as a “hard brake” or “harsh brake” event. This type of event is triggered by a reported vehicle velocity change figured to be in the range of 5 to 14 mph/s. The default recommendation for this velocity change value is 7 mph/s. To avoid multiple triggerings of an Acceleration Triggered Event during a single hard brake event that is cycling the anti-lock brake system (ABS), the velocity change should persist beyond the threshold for at least 0.5 seconds before triggering.

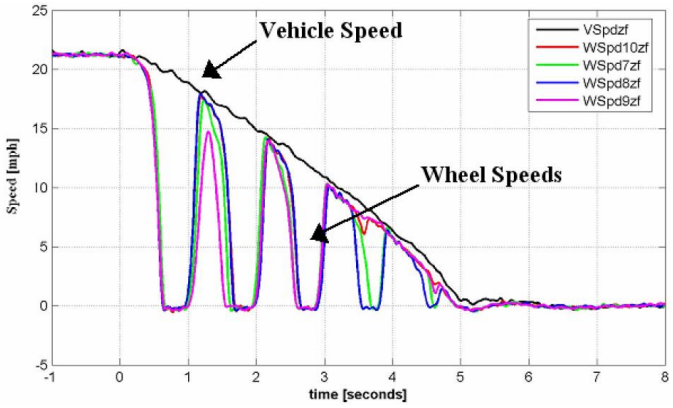

Figure 3.1.2.1-1. Wheel speed changes[4]

[4]Source: Shurtz, M., Heydinger, G., Guenther, D., and Zagorski, S., "Effects of ABS Controller Parameters on Heavy Truck Model Braking Performance," SAE Technical Paper 2006-01-3482, 2006.

Note that in Figure 3.1.2.1-1 there are five ABS-induced wheel slip cycles at various vehicle speeds that should not be recorded in order to avoid misinterpreting the invalid acceleration triggered events.

The next defined event is a “Last Stop Event.” This event should trigger once the vehicle speed falls below 1.9 mph for 15 seconds or more. This event should also be unable to trigger again until the vehicle speed exceeds 14.9 mph for 6 seconds. It is further suggested that switching the ignition off will not trigger an event.

The last specified event is a “Safety Restraint System [SRS] Event.” This event will trigger upon any safety system deployment event, such as a driver-side frontal supplemental restraint system, if equipped.

Upon any of these three events triggering, several data elements are recorded and stored in memory. J2728 lists the data elements that should be recorded by an HVEDR. Figure 3.1.2.1-2 below is excerpted directly from the J2728 RP document and describes each data element required for an HVEDR to be RP-compliant.

Data Element	Description	Comment / Example / Alternate element names	Config Item	Recorded
Alternate Vehicle ID	Vehicle-unique, alpha-numeric identifier substitute for the VIN.	For those situations where a standard VIN is unavailable, not accessible, not required, or has been changed (e.g.,as can happen with a "salvage" title), then the HVEDR System shall utilize a vehicle-unique, alphanumeric identifier substitute for the VIN.	User	Header
Event Data Recording Complete	This data indicates whether or not a complete set of data that the event data recording device is designed to capture was successfully recorded by and stored in the device.		No	Header
Event Date	The date when the event occurred.	Date MM/DD/YYYY	No	Header
Event Time	The time when the event occurred.	Time HH:MM:SS GMT: 24-hour clock The HVEDR must provide its own real-time clock capability, including battery backup	No	Header
HVEDR Make	Manufacturer name for HVEDR.		Mfr	Header
HVEDR Model	Model number for HVEDR.		Mfr	Header
HVEDR Serial Number	Serial number for HVEDR.		Mfr	Header
Pre-event Buffer Size (Samples)	Defines how many data samples are stored in the pre-event buffer.	Tier 1 minimum sample rate is 10 Hz, for total of 15 s, therefore 150 samples	Mfr	Header
Post-Event Buffer Size (Samples)	Defines how many data samples are stored in the post-event buffer.	Tier 1 minimum sample rate is 10 Hz, for total of 15 s, therefore 150 samples	Mfr	Header
Rear Axle Ratio	Ratio of Transmission output shaft speed to Tire revolution rate.		User	Header
Tire Size	Tire size in Revolutions per km.		User	Header
Total Event Records HVEDR Supports	Total number of event records the HVEDR supports in non-volatile memory.		Mfr	Header
Trigger Thresholds	Lists the currently configured trigger threshold(s).	2 or more sub-strings containing the following data items [Trigger Data Item Trigger Comparison ('<', '>', etc.) Trigger Threshold Value] Trigger thresholds formatted as semicolon (;) delimited list. At minimum, will contain one threshold for acceleration trigger, and one threshold for last stop trigger.	Mfr / User	Header
Trigger Threshold Activated	Indicates which Trigger Threshold was activated to cause the recording the event.	Substring from Trigger Thresholds for activated trigger	No	Header
Trigger Threshold Count	Indicates how many trigger thresholds the device has been configured with.	Calculated value based on Trigger Threshold(s). Count >= 2.	No	Header
VIN	Indicates the Vehicle Identification Number (VIN) assigned by the vehicle manufacturer.	PID: 237, MID: Varies by mfg. Transmission Rate: on request PGN: 65260 (pre-2010). Engine only for post-2010 Transmission Rate: on request VIN will not be reported to other ECUs by HVEDR, but will be provided by the HVEDR to the Extraction Tool	Mfr / User	Header
Vehicle Configuration	A free-form text field for vehicle configuration.		Mfr / User	Footer
ABS Retarder Status	Indicates the status of the ABS Retarder.	ABS Retarder Status	No	Pre-event Post-event
ABS Brake Control Status – Tractor	Indicates the status of the ABS Brake control system on the vehicle/tractor, active or not active.	ABS Brake Control ABS Retarder Control (SAE J1587 only)	No	Pre-event Post-event
ABS Warning Lamp Status – Tractor	Indicates the status of the ABS warning light on the vehicle/tractor, on or off.	ABS Warning Lamp	No	Pre-event Post-event

Figure 3.1.2.1-2. Excerpt from SAE J2728 Data Elements[5]

[5]Source: SAE International Surface Vehicle Recommended Practice, "Heavy Vehicle Event Data Recorder (HVEDR) Standard - Tier 1," SAE Standard J2728, Rev. June 2010.

These collected data elements must also be recorded before and after an event trigger. To accomplish this, a pre-trigger circular data buffer must be continuously writing all required data elements to volatile memory. Upon an event trigger, the HVEDR must store the pre-trigger event data and begin recording trigger and post-trigger data. The minimum recording duration for an event is 15 seconds pre-trigger and 15 seconds post-trigger, captured at 10 Hz for a total of 30 seconds of event-related data. It should be noted that this is a minimum recording duration and is not intended to preclude devices with greater duration-recording capabilities.

The J2728 RP further identifies the protocol by which this data is extracted and saved from the HVEDR. It specifies that the data-imaging tool is to use the SAE J1939 or J1587 protocols to image (download) the HVEDR data. It should be noted that J1939 supersedes J1587 due to the former's ability to operate at higher speeds. SAE J1587 is no longer updated and increasingly phased out of use. Leveraging the OEM's standardized communications data bus and system components, including the ECU and VSS, facilitated the implementation of HVEDR capabilities in heavy vehicles.

As previously discussed, the SAE J2728 HVEDR Committee is in the process of reconvening to reorganize the recommended practices document structure and to update the recommended practice with new technologies and systems found on today's commercial vehicles. One of those updates is to address a request made by NHTSA to all SAE EDR-related committees to address and identify data elements that EDR/HVEDR should capture in order to accomplish the following:

1. *Standard data elements for crash reconstruction purposes;*
2. *Clear and concise definitions of parameters regarding operational design domain; and*
3. *Performance tests suitable for variable performance ADS testing.*

As ADS and ADAS enter major transportation systems, stakeholders such as regulatory agencies and OEMs will require the ability to test and validate these advanced systems. Accidents will additionally necessitate the ability to evaluate the readiness of the ADS or ADAS function and assess to what level the ADS or ADAS was in control versus the actions (or inactions) of the driver.

In outlining how to capture ADS or ADAS system performance data by use of EDR/HVEDR, attention need be placed on respecting the proprietary nature of the decision-making algorithms and related data of these ADS or ADAS technologies. A finite list of data elements for accident reconstructionists (private, government agency crash investigators, or law enforcement investigators) will need to determine how a driver's actions (or inactions) contributed to a highway crash and to what level the ADS or ADAS technology was engaged or intervened.

Additional data, including proprietary decision-making data, can be captured outside of the publicly accessible EDR/HVEDR function in a type of data logger for the ADS or ADAS OEM to recover and analyze.

Similar hurdles to ensuring proprietary algorithms and data elements do not become public record were encountered in the development and introduction of light-duty vehicle EDRs, as defined by

SAE J1698 and 49 CFR Part 563. Since light-duty EDR functionality is built on the occupant restraint system controller (the airbag control module; ACM) to meet FMVSS 208 and 214, there were concerns that proprietary algorithms and data on the deployment of these technologies not be made publicly available. The amount of engineering research and development put into these advanced systems by the vehicle manufacturer (and restraint system supplier) is exceptionally significant, and that proprietary intellectual property should be respected.

The proprietary intelligent algorithms and data that are the core of the performance of occupant restraint systems meeting FMVSS 208 and 214 are therefore well protected and are not a part of the SAE J1698 light-duty EDR functionality. The same can be accomplished to protect the proprietary nature of the ADS and ADAS technologies found in medium- and heavy-duty commercial vehicles.

3.1.2.2 NFPA 1901 Standard

NFPA 1901, “Standard for Automotive Fire Apparatus” published by the National Fire Protection Association, outlines the standard for firefighting apparatus. NFPA 1901 defines necessary requirements for new automotive fire apparatus and trailers for transporting personnel and equipment. This listing sets the minimum standards for mechanical, cosmetic, lighting and all equipment included with fire apparatus to meet U.S. compliance.

The NFPA 1901 Standard has evolved over several revisions from its original recommended safety and design practice. Of particular note, the 2009 revision specified the addition of a VDR to capture data that would promote safe driving and riding practices. The current 2016 revision to this standard did not modify these VDR stipulations and mainly addressed the testing of high-pressure pumps.

The 2009 NFPA 1901 Standard defined data elements similar to typical HVEDR data, such as vehicle speed, engine speed and throttle position. Additional data elements specific to fire apparatus include emergency lights (and sirens) status, seat/occupant presence data and restraint system use data. The 1901 Standard requires data be recorded in a 48-hour loop at a sample rate of 1 Hz. Data imaging is obtained through the vehicle’s J1939 network, with connection via a standard USB type-A connector. Table 3.1.2.2 summarizes the data elements required by NFPA 1901.

Table 3.1.2.2. NFPA 1901 Standard VDR Data

Data	**Unit of Measure**
Vehicle Speed	mph
Acceleration (from speedometer)	mph/sec
Deceleration (from speedometer)	mph/sec
Engine Speed	rpm
Engine Throttle Position	% of full throttle
Anti-lock braking system event	On/Off
Seat Occupied Status	Occupied: Yes/No by position
Seat Belt Status	Buckled: Yes/No by position at 30 sec into minute
Master optical warning device switch	On/Off at 30 sec into minute
Time	24-hour clock
Date	Year/Month/Day

Additionally, NFPA 1901 requires VDR memory with capacity to record 100 hours of minute-by-minute summary. When the memory capacity is reached, the system erases the oldest data in the first-in, first-out (FIFO) format. All data stored in the VDR must be uploadable by the user to a computer and importable into a data management software package. Data is required to be password-protected, with access controlled by the purchaser.

The NFPA 1901 Standard applies to all new fire apparatus meeting the following criteria:

1. Have 10,000 lbs. (4,545 kg) or greater GVWR, or are trailers intended to be towed by a fire apparatus under emergency response conditions.
2. Are designed for use under emergency conditions to transport personnel and equipment and to support the suppression of fires and mitigation of other hazardous situations.
3. Are contracted on or after January 1, 2009.

Fire apparatus contracted on or prior to January 1, 2009 may be retrofitted with a NFPA 1901 VDR. However, the NFPA 1901 Standard does not require retroactive installation to older vehicles. The NFPA 1901 standard also does not apply to wildland fire apparatus as those are addressed by NFPA 1906, “Standard for Wildland Fire Apparatus.”

3.2 ATA/TMC Fleet Integration Recommended Practices

The American Trucking Association is the largest national trade association for the trucking industry and consists of a federation of 50 affiliated state trucking associations and industry-related conferences and councils. Its Technology & Maintenance Council is a technical body that serves as the only industry association focused solely on truck technology and maintenance. TMC membership includes a broad collection of experienced fleets, equipment suppliers and service providers.

TMC regularly produces the *Recommended Practice Manual*, recognized as one of the trucking industry's most authoritative resources for commercial vehicle maintenance, testing, specification information and maintenance-shop management knowledge. TMC's RPs are specifications, routines or procedures intended to help with the design, performance, purchase and maintenance of commercial vehicles and equipment. The updated manual, ATA'S TMC *2016-2017 Recommended Practices Manual*, is available in print or electronically and contains over 3,100 pages of technical information representing the consensus and experience of the TMC members.

The ATA/TMC *2016-2017 Recommended Practices Manual* is focused on the installation and use of automatic on-board recorders (AOBRs) and electronic logging devices (ELDs), both for the electronic logging of driver hours of service (HOS). The TMC RP1210 Recommended Practice is discussed in more detail below.

3.3 EDR/HVEDR End User Recommended Practices/Standards

Considerably little work focused on the EDR/HVEDR end user has been discovered. In the early 2000s, ASTM International organized an active standards committee for WK4150, "Practice for the Investigation of Non-Volatile Memory Data in Evidentiary Electronic Control Units."

The ASTM WK4150 subcommittee drafted guidelines for forensic engineers and investigators and outlined methodologies for the handling of vehicle ECUs and ECU-associated EDR/HVEDR data in a forensically neutral fashion. The WK4150 Committee convened in February 2004 and published a final document. However, there are no active links or information from ASTM making the WK4150 document accessible nor indicating that the WK4150 subcommittee is still active.

Additionally, the Mecanica research team searched for standards committee work specific to highway safety databases, such as NHTSA's NASS. The SAE Data Collection and Archiving Standards Committee has held some discussion addressing the incorporation of EDR/HVEDR-type data into large databases, but no action has been taken on this work to date.

3.4 Foundational Standards

The HVEDR is typically found in the vehicle's engine or cab/chassis ECU, with the exact configuration dependent on the OEM engine. HVEDR was originally based on the older serial communication network defined by the J1587 and J1708 SAE standards. To meet more stringent emissions requirements mandated by the U.S. Environmental Protection Agency (EPA), the

California Air Resources Board (CARB) and other international regulatory agencies, the industry moved toward the higher-speed CAN and ISO (International Standardization Organization) networks defined by SAE J1939 and ISO 15765.

3.4.1 SAE J1587/J1708

The SAE J1587 RP document, “Electronic Data Interchange Between Microcomputer Systems in Heavy-Duty Vehicle Applications,” defines the format of messages and data that are generally of value to modules on the data communications link, namely field descriptions, size, scale, internal data representation and position within a message. This standard also establishes guidelines for frequency of messages and in which circumstances they are transmitted. In collaboration with other industry groups, the SAE Truck & Bus Low-Speed Communications Network Subcommittee intended to develop recommended message formats for basic vehicle data in addition to component identification and performance data. These defined data messages serve as the foundation of an EDR/HVEDR function.

SAE has officially retired the J1587 and J1708 serial bus communications standard, with no new message updates. The SAE J1587/J1708 serial communications protocol will eventually be superseded by SAE J1939 CAN communications.
SAE J1708 RP document “Serial Data Communications Between Microcomputer Systems in Heavy-Duty Vehicle Applications” defines the implementation for bidirectional, serial communication link among modules containing microcomputers in heavy-duty vehicle applications. It defines those parameters of the serial link that relate primarily to hardware and basic software compatibility, such as interface requirements, system protocol and message format.

The objective of the J1708 document was to define a general-purpose serial data communication link that could be utilized in heavy-duty vehicle applications to promote serial communications compatible among microcomputer-based modules. Data was expected to be shared among stand-alone modules to enhance their operations in a cost-effective manner.

Other dedicated communication links between specific modules may deviate from the RP document; it was therefore recommended that manufacturers publish separate documents for each device using the serial link. The manufacturer-published document should define data format, message identifiers (MIDs), message priorities, error detection (and correction), maximum message length, percent bus utilization and methods of physically adding/removing units to and from the line for the particular application.

3.4.2 ATA/TMC RP1210

The RP1210 document was produced through a joint effort by the ATA/TMC and SAE International. ATA/TMC RP1210A describes a standardized interface for a Windows™-based application program interface (API) to facilitate communication between a personal computer (PC) and the vehicle’s physical data link (J1587/1708, CAN J1939, or J1850).

Standardization of the communication protocol facilitated access to the HVEDR event data from the vehicle using off-the-shelf PCs. It also facilitated the development of software tools to extract and examine HVEDR event data. The RP1210 API is the foundation for several competing vehicle interfaces allowing diagnostic and control software running on Windows™- based PCs to communicate with the ECUs of a medium- or heavy-duty vehicle equipped with J1587/J1708, J1939 or other heavy- duty communications protocols.

TMC outlines three main priorities for the Communication API, namely the need to:

1. Allow transparency of hardware adapters to the application programmer,
2. Maintain consistency between hardware vendors when software products differentiate on a proprietary basis, and
3. Support the SAE J1708, CAN/J1939 and J1850 network protocols.

The PC can be connected to the vehicle data link to a variety of hardware devices in simultaneous communication. Refer to Figure 3.4.2 for an architectural overview of potential communications software/hardware interfaces from the original SAE and AMA/TMC joint-produced RP.

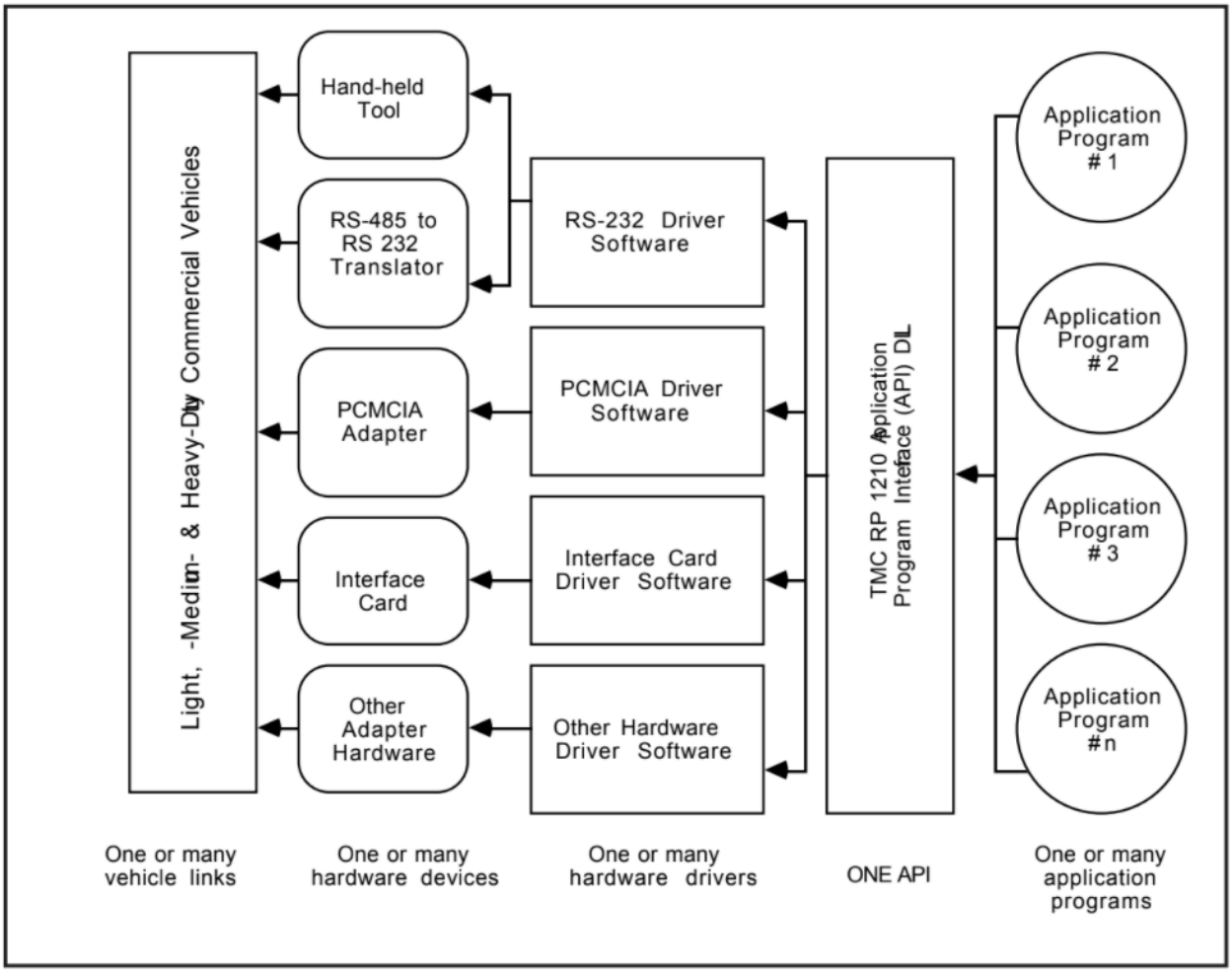

Figure 3.4.2. Architectural overview: potential communications software/hardware interfaces[6]

3.4.3 SAE J1939

The SAE J1939 series of Recommended Practices have addressed a spectrum of light-, medium- and heavy-duty vehicles, including both on- and off-highway trucks, trailers, construction equipment and agriculture equipment, and implementation of any devices that require communication between each other. A number of revisions have been made for this RP's standardized communications interface, whose purpose is to provide open, interconnecting communication channels for on-board electronic systems.

As aforementioned, the SAE J1587/J1708 standards have been superseded by the SAE J1939 standard due to the increased efficiency of CAN-based communication as opposed to RS-485 serial-based communication. The SAE J1939 is a communications protocol based on CAN that provides data communication between vehicle system ECUs. The J1939 Protocol allows two types of messages: peer-to-peer (direct node communication) and broadcast. Broadcast

[6]Source: ATA/TMC, "WINDOWS™ Communication API," TMC Recommended Practice 1210, June 2007.

messages are sent to all nodes and the nodes decide whether to use it. The messages exchanged between ECUs might include data such as engine temperature, road speed, throttle application and so on. This technology has become standard in the automotive and heavy-vehicle industry due to the need to increase the speed of data transfer from vehicle sensors to system ECUs and ECUs to ECUs for purposes such as increased fuel mileage, reduced exhaust emissions, fleet management and other requirements.

Table 3.4.3 below outlines the evolution of Recommended Practices for the J1939 standard interface.

Table 3.4.3. SAE J1939 Control & Communications Network Revision History

Version	**Version Description**
J1939	Serial Control and Communications Vehicle Network
J1939-01	Control and Communications Network for On-Highway Equipment
J1939-02	Agricultural and Forestry Off-Road Machinery Control and Communication Network
J1939-03	On-Board Diagnostics Implementation Guide
J1939-05	Marine Stern Drive and Inboard Spark-Ignition Engine On-Board Diagnostics Implementation Guide
J1939-11	Physical Layer - 250k bits/s, Twisted Shielded Pair
J1939-13	Off-Board Diagnostic Connector
J1939-15	Reduced Physical Layer, 250K bits/sec, Unshielded Twisted Pair (UTP)
J1939-21	Data Link Layer
J1939-31	Network Layer
J1939-71	Vehicle Application Layer
J1939-73	Application Layer - Diagnostics
J1939-74	Application - Configurable Messaging
J1939-75	Application - Generator Sets and Industrial
J1939-81	Network Management
J1939-82	Compliance - Truck and Bus
J1939-84	OBD Communications Compliance Test Cases for Heavy Duty Components and Vehicles

SAE J1939/84_201710, “OBD Communication Compliance Test Cases for Heavy Duty Components and Vehicles,” is the latest update to J1939 Standard 2017-10-18.

Certain data elements from the original SAE J1939 standards carried over to the current J2728 RP for heavy vehicles. Among them is the J1939 vehicle communications network. Part of the J2728 specifications were derived from specific SAE J1939 publications. SAE J1939-13 (“Off-Board Diagnostic Connector”) defines the data-port specification for the extraction of HVEDR event data. SAE J1939-71 (“Vehicle Application Layer”) and -73 (“Application Layer - Diagnostics”) define the messaging format for transmission of vehicle parameters to be used for diagnostics. J1939-73 also identifies the connector to be used for the vehicle service tool interface. Other data elements originating from the J1939 data network include the ABS warning and status, distance and speed, transmission gear and wheel-based vehicle speed, and cruise control status. The HVEDR must record data elements using the standard network messages from the available J1939 vehicle network. Additional J1939-derived elements to be recorded include the VIN, engine hours and trailer ABS status. Figure 3.4.3 illustrates how the J1939 communication network carries into the J2728 RP.

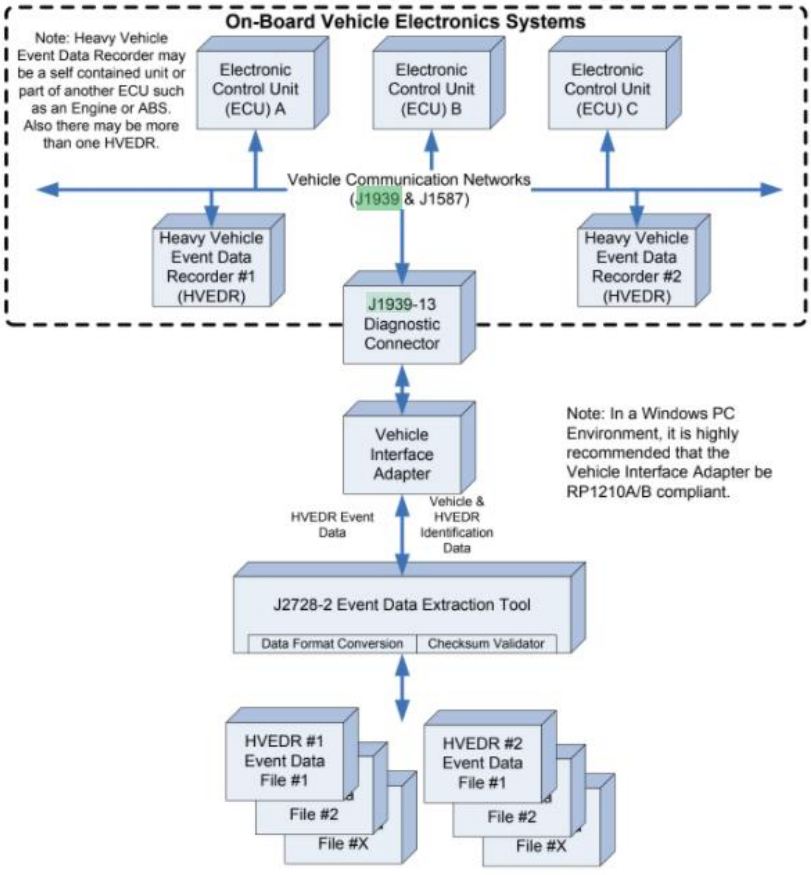

Figure 3.4.3 Example of data extraction from HVEDR via vehicle data bus[7]

[7]Source: SAE International Surface Vehicle Recommended Practice, “Heavy Vehicle Event Data Recorder (HVEDR) Standard - Tier 1,” SAE Standard J2728, Iss. June 2010.

3.4.4 ISO 15765

ISO 15765, “Diagnostic communication over Controller Area Network (DoCAN)” defines common requirements for vehicle diagnostic systems implemented on a CAN communication link as specified in ISO 11898-1.

Although primarily intended for diagnostic systems, ISO 15765 also meets the requirement from other CAN-based systems necessitating a network layer protocol. Data elements from ISO 15765 may be useful in future HVEDR data-elements definitions.

3.5 Key Stakeholder Interviews

As outlined in the original T8080-160062 contract, it was requested that the Mecanica research team make contact and arrange interviews with key stakeholders in regulatory or investigative agencies. Over the last 18 years, the Mecanica research team has collaborated on several projects related to highway-vehicle EDR, including Standards work and industry-collaborative technical symposiums with key researchers and representatives of NHTSA, FMCSA and NTSB. Utilizing these long-term acquaintances, the Mecanica team attempted to organize formal interviews to discuss this Transport Canada feasibility study specifically and HVEDR generally. Attempts to interview with Mecanica’s colleagues at the aforementioned agencies were also made in person during the SAE International Government/Industry Conference, held January 24-26, 2018 in Washington, D.C.

Attempts to contact key stakeholders at Mexico’s *Instituto Mexicano del Transporte* (IMT) or *Secretaría de Comunicaciones y Transportes* (SCT) for interviews were without success. The same attempts were made for contacts at the Chinese and Japanese federal governments. Due to diplomatic and procedural complications, the Mecanica research team was unsuccessful in arranging interviews with key government stakeholders at NHTSA, FMCSA, or NTSB.

4.0 CONCLUSION

This report has concluded *T8080-160062 Feasibility Study of Event Data Recorders for Commercial Buses*, Deliverable No. 5, “Summary Report of International Commercial Vehicle EDR Industry Standards and Recommended Practices.”

The principle industry standards addressing and defining the protocols for light-vehicle and heavy-vehicle network communication and ECU system management are detailed above. SAE Standard J1698 addresses the communication networks for light vehicles and the storage and extraction of their data. The SAE J1698 Standard Committee is an active body that is working to update the Standard so that it addresses changing technology, such as ADAS and ITS infrastructure.

SAE Standard J2728 is the document addressing and defining the protocols for heavy-vehicle network communication and ECU system management. Heavy vehicles, as defined by J2728, are ground-wheeled vehicles over 4,545 kg (10,000 lbs.), commonly referred to as Classes 3-8.

NFPA 1901 specifies the data elements recorded, similar to typical HVEDR data, and the use of a VDR device on fire apparatus conforming to weight of 10,000 lbs. (4,545 kg) or greater and designed for emergency conditions as well as the suppression of fires and other hazardous situations.

ATA/TMC RP1210 specifies guidelines for HVEDR data collection, storage and retrieval with a standard interface for Windows™-based PC and the J1587/1708 or J1939 protocols. ASTM WK4150 also addresses the issue of investigation of non-volatile memory data in ECUs.

Part of this deliverable was to include interviews with key government stakeholders. Attempts were made to conduct interviews with regulatory or investigative agencies of several countries, including the U.S., Mexico, Japan, China, Europe, Israel and Australia. While many representatives were willing to speak “off-the-record,” no on-the-record information was secured, and this document does not include these stakeholders’ views.

APPENDIX A - ACRONYMS

ABS	Anti-Lock Brakes System
ACCTYPE	Accident Type
ACM	Air Bag Control Module
ACN	Automatic Crash Notification
ACRS	Air Cushion Restraint System
ADAS	Advanced Driver Assistance Systems
ADEM	Advanced Diesel Engine Management (Caterpillar)
ADS	Automated Driver Systems
AEB	Automatic Emergency Braking
AORB	Automatic On-Board Recorders
API	Application Program Interface
APTA	American Public Transportation Association
ASTM	American Society for Testing and Materials
ATA	American Trucking Association
Ax, Ay	Longitudinal, Lateral Acceleration Change (g)
BAGDEPLY	airbag System Deployment
CADaS	Common Accident Data Set
CAN	Controller Area Network
CARB	California Air Resources Board
CARE	Community Road Accident Database
CCTV	Closed-Circuit Television Camera
CDC	Collision Deformation Classification
CDR	Crash Data Retrieval
CDS	Crashworthiness Data System
CFR	Code of Federal Regulations
CIREN	Crash Injury Research and Engineering Network
D	Deployment (event)
D/DL	Deployment and Deployment-Level (event)
D/N	Deployment and Non-Deployment (event)
DARR	Digital Accident Research Recorder (Volvo)
DDEC	Detroit Diesel Electronic Controls
Delta V (ΔV)	Change in Velocity (mph)
DERM	Diagnostic & Energy Reserve Module (General Motors specific)
DIS	Draft International Standard
DL	Deployment-Level (event)
DLC	Diagnostic Link Connector
DoCAN	Diagnostic Communication Over Controller Area Network
DOT	Department of Transportation
DTC	Diagnostic Trouble Code
DVLAT	Lateral component of delta V
DVLONG	Longitudinal component of delta V
EC	European Commission
ECBOS	Enhanced Coach and Bus Occupant Safety
ECM	Engine Control Module
ECU	Electronic Control Unit

EDR	Event Data Recorder
EDS	Electronic Data System
ELD	Electronic Logging Device
EPA	Environmental Protection Agency
ERSO	European Road Safety Observatory
ESC	Electronic Stability Control
FARS	Fatality Analysis Reporting System
FCW	Forward Collision Warning
FHWA	Federal Highway Administration
FIFO	First In, First Out
FMCSA	Federal Motor Carrier Safety Administration
FMCSR	Federal Motor Carrier Safety Regulations
FMVSS	Federal Motor Vehicle Safety Standard
GES	General Estimates System
GIT	Global Information Technology
GM	General Motors
GPS	Global Positioning System
GVWR	Gross Vehicle Weight Rating
HCV	Heavy Commercial Vehicle
HD	Heavy -Duty
HGV	Heavy Goods Vehicle
HVEDR	Heavy Vehicle Event Data Recorder
IMIT	Instituto Mexicano del Transporte (Mexico)
ISO	International Organization for Standardization
ITS	Intelligent Transportation System
JPL	Jet Propulsion Laboratory
kph	kilometers per hour
LCV	Light Commercial Vehicles
LDW	Lane Departure Warning
LER	Locomotive Event Recorder
LTCCS	Large Truck Crash Causation Study
MANEUVER	Attempted Avoidance Maneuver
MANUSE	Manual (Active) Belt System Use
MCMIS	Motor Carrier Management Information System
MID	Message Identifier
MMUCC	Model Minimum Uniform Crash Criteria
MOU	Memorandum of Understanding
mph	miles per hour
ms	milliseconds
MVEDRCLA	Motor Vehicle Event Data Recorder Connector Lockout Apparatus
MVEDRs	Motor Vehicle Event Data Recorders
MVSRAC	Motor Vehicle Safety Research Advisory Committee
MY	Model year
N	Non-Deployment (event)
NAFTA	North American Free Trade Agreement
NASA	National Aeronautics and Space Administration
NASS	National Automotive Sampling System
NASS-CDS	National Automotive Sampling System’s Crashworthiness Data System
NCHRP	National Cooperative Highway Research Program

NCSA	National Center for Statistics and Analysis
NFPA	National Fire Protection Association
NHTSA	National Highway Traffic Safety Administration
No.	Number
NOX	Nitrous Oxide
NPRM	Notice of Proposed Rulemaking
NTSB	National Transportation Safety Board
OBD	On-Board Diagnostic
OEM	Original Equipment Manufacturer
PACCAR	Pacific Car and Foundry Company
PDOF	Principal Direction of Force (1st)
PDOF1	Clock Direction for PDOF in Degrees (Highest CDC)
RCM	Restraint Control Module
RF	Right-Front
RP	Recommended Practice
rpm	revolutions per minute
SAE	Society of Automotive Engineers
SAMOVAR	Safety Assessment Monitoring On-Vehicle with Automatic Recording
SCI	Special Crash Investigations
SCT	Secretaría de Comunicaciones y Transportes (Mexico)
SDM	Sensing and Diagnostic Module (General Motors)
sec	seconds
SRS	Supplemental Restraint System
t	time (seconds)
TIFA	Trucks Involved in Fatal Accidents
TMC	Truck Maintenance Council
TPS	Throttle Position Sensor
TRB	Transportation Research Board
TSB	Transportation Safety Board (Canada)
UDS	Universal Documentation Service
USB	Universal Serial Bus
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
VDR	Vehicle Data Recorders
VEDI	Vehicle Event Data Interface
VERONICA	Vehicle Event Recording based on Intelligent Crash Assessment
VIN	Vehicle Identification Number
VRU	Vulnerable Road Users
VSS	Vehicle Speed Sensor
Vx (ΔVx)	Longitudinal delta V (mph)
Vy (ΔVy)	Lateral delta V (mph)
XML	Extensible Markup Language

APPENDIX B – HISTORY OF EDR/HVEDR-RELATED STANDARDS & RECOMMENDED PRACTICES

1986 ISSUED.
J1708 “Serial Data Communications between Microcomputer Systems in Heavy-Duty Vehicle Applications”

1988 ISSUED.
J1587 “Electronic Data Interchange between Microcomputer Systems in Heavy-Duty Vehicle Applications”

1992 ISSUED.
J1962 “Diagnostic Connector”

1994 ISSUED.
J1939-21 “Data Link Layer”
J1939-71 “Vehicle Application Later”
J1939-11 “Physical Layer, 250 Kbps, Twisted Shielded Pair”
J1939-31 “Network Layer”

1996 ISSUED.
J1939-73 “Application Layer – Diagnostics”

1997 ISSUED.
J1939-81 “Network Management”

1999 ISSUED.
J1939-13 “Off-Board Diagnostic Connector”

2000 ISSUED.
J1939 “Serial Control and Communications Heavy Duty Vehicle Network”
J1939-1 “On-Highway Equipment Control and Communication Network”

2002 REVISED.
J1587 “Electronic Data Interchange between Microcomputer Systems in Heavy-Duty Vehicle Applications”
Defined the format of messages and data that are generally of value to modules on the data communications link; established guidelines for message frequency and transmission circumstances.
J1962 “Diagnostic Connector”
Equivalent to ISO/DS 15031-2 (2001); foundational standard for SAE J1698 that outlined how to maximize a vehicle’s OEM data network, closed-loop controllers, sensors and data and was the first foundation for a common method of physical connectivity to access a vehicle’s EDR data.

2003 SAE J1698 “Vehicle Event Data Interface” (VEDI) Committee organized.
ISSUED.
J1939-15 “Physical Layer, 250 Kbps, Un-Shielded Twisted Pair (UTP)”
J1698 “Vehicle Event Data Interface – Vehicular Output Data Definition”
Established common format for displaying and presenting light-duty vehicle post-downloaded data.

2004 ISSUED.

J1698-2 “Vehicle Data Interface – Vehicular Data Extraction”

Defined a common method for extracting event data; aimed to utilize existing industry standards by using the J1962 physical interface and designating industry-standard diagnostic protocols for communications.

J1939-74 “Application – Configurable Messaging”

2005 REVISED.

J1698 “Vehicle Event Data Interface – Vehicular Output Data Definition”

ISSUED.

J1968-1 “Vehicle Event Data Interface – Output Data Definition”

Defined data items related to events.

2008 ISSUED.

J1939-82 “Compliance – Truck and Bus”

J1939-3 “On-Board Diagnostics Implementation Guide”

J1939-84 “OBD Communications Compliance Test Cases for Heavy Duty Components and Vehicles”

2009 REVISED.

NFPA 1901 “Standard for Automotive Fire Apparatus”

Specified the addition of a VDR for capturing data to promote safe driving and riding practices, defined data elements similar to typical HVEDR data and additional elements specific to fire apparatus.

2010 SAE J1698 “Vehicle Event Data Interface” Committee reconvened as the “Event Data Recorder” Committee

Addressed recently proposed legislation responding to a series of reported unattended acceleration claims and featuring some degree of an EDR requirement; conducted a five-year review of 2005 J1698 Recommended Practice to updated according to in-progress and changing technologies; restructured J1698 “Event Data Recorder” base document into a series of three documents: “J1698-1 Event Data Recorder – Output Data Definition,” “J1698-2 Event Data Recorder – Retrieval Tool Protocol,” and “J1698-3 Event Data Recorder – Compliance Assessment.” Committee remains active to date.

ISSUED.

J2728 “Heavy Vehicle Event Data Recorder (HVEDR) Standard – Tier 1”

Applied to HVEDRs for heavy-duty, ground-wheeled vehicles over 4,545 kg. (Class 3-8), equipped with one or both of the SAE J1587/1708 or SAE 1939 vehicle communication networks; attempted to standardize HVEDR by categorizing data into Tiers 1-3 and setting minimum perform specifications.

2012 REVISED.

J1939-1 “On-Highway Equipment Control and Communication Network,” **CURRENT**.

2013 STABILIZED.

J1587 “Electronic Data Interchange between Microcomputer Systems in Heavy-Duty Vehicle Applications”

Officially retired by SAE with no new message updates; superseded by SAE J1939 CAN communications.

REVISED.

J1698-2 “Event Data Recorder – Retrieval Tool Protocol.”

Previously “Vehicle Event Data Interface – Vehicular Data Extraction”

Identified common physical interface for intended development of EDR Retrieval Tools connecting to a light-duty vehicles; specified how to image, translate, and report EDR records through use of existing industry standards.

J1698-1 “Event Data Recorder – Output Data Definition”

Previously “Vehicle Event Data Interface – Output Data Definition”

Provided common data output formats for a variety of data elements (in light-duty vehicle OEM applications) useful for analyzing vehicle crash and crash-like events that meet specified trigger criteria.

J1939 “Serial Control and Communications Heavy Duty Vehicle Network,” **CURRENT. ISSUED.**

J1698-3 “Event Data Recorder – Compliance Assessment”

Defined procedures to be used for validating relevant EDR output records in compliance with reporting requirements outlined in Part 563, Table 1 during FMVSS-208, FMVSS-214, and other vehicle-level crash testing.

2014 **REVISED.**

J1939-31 “Network Layer,” **CURRENT.**

J1698 “Event Data Recorder”

Previously “Vehicle Event Data Interface” and structured into the J1698-1, -2, and -3 document series.

2015 **REVISED.**

J1939-82 “Compliance,” **CURRENT.**

J1939-15 “Physical Layer, 250 Kbps, Un-Shielded Twisted Pair (UTP)”

J1939-3 “On Board Diagnostics Implementation Guide,” **CURRENT.**

J1698-3 “Event Data Recorder – Compliance Assessment,” **CURRENT.**

REAFFIRMED.

J1939-74 “Application – Configurable Messaging,” **CURRENT.**

2016 **ISSUED.**

J1698-1A “Pedestrian Protection EDR output Data Definition Appendix,” **CURRENT.**

Appendix to J1698-1 containing EDR record parameters and definitions related to pedestrian protection systems in light-duty vehicles.

J1939-11 “Physical Layer, 250 Kbps, Twisted Shielded Pair”

REVISED.

J1939-21 “Data Link Layer,” **CURRENT.**

J1692 “Diagnostic Connector,” **CURRENT.**

NFPA “1901 Standard for Automotive Fire Apparatus,” **CURRENT**.

Did not modify 2009 VDR stipulations; mainly addressed testing of high-pressure pumps.

J1939-13 “Off-Board Diagnostic Connector,” **CURRENT**.

J1939-71 “Vehicle Application Layer,” **CURRENT**.

STABILIZED.

J1708 “Serial Data Communications between Microcomputer Systems in Heavy-Duty Vehicle Applications”

Officially retired by SAE with no new message updates; superseded by SAE J1939 CAN communications.

2017 SAE J2728 “Heavy Vehicle Event Data Recorders” Committee reconvened

Currently looks to update HVEDR Recommended Practices in accordance with new vehicle technologies, such as ADAS.

REVISED.

J1698-1 “Event Data Recorder – Output Data Definition”

Listed relevant data elements for vehicle-specific sensors and/or the vehicle system and the system status received by the EDR via the vehicle communication

bus, classified data elements into Classifications I-III and specified a minimum reporting frequency of 100 Hx (100 samples/second).
J1698 “Event Data Recorder,” **CURRENT.**
J1939-81 “Network Management,” **CURRENT.**
J1939-5 “OBD Communications Compliance Test Cases for Heavy Duty Components and Vehicles,” **CURRENT.**

2018 REAFFIRMED.
J1698-2 “Event Data Recorder – Retrieval Tool Protocol,” **CURRENT**.
REVISED.
J1698-1 “Event Data Recorder – Output Data Definition,” **CURRENT.**

SAE Standards Status Definitions[8]

ISSUED Initially published technical report; subject to a five-year review.

REVISED Updated and re-published active technical report; subject to a five-year review.

CURRENT Active version of technical report.

STABILIZED Technical report ‘frozen’ on last revision; five-year review not required.

REAFFIRMED Technical report reviewed by technical committee and determined current; subject to five-year review.

[8]Source: https://www.sae.org/standards/development/definitions

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