Considerations for Regulating Installation and Performance of

Heavy Vehicle Event Data Recorders

(HVEDRs)

National Highway Traffic Safety Administration

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# **Executive Summary**

 The purpose of this technical document is to discuss the background, technical aspects, and policy considerations for regulating installation and performance of heavy vehicle event data recorders (HVEDRs). By way of background, the document reviews past standardization efforts by the National Highway Traffic Safety Administration (NHTSA), SAE International, and other Federal agencies. It reviews safety recommendations from the National Transportation Safety Board (NTSB) and reflects upon the Department of Transportation’s Safety Action Plan for improved motorcoach safety that includes consideration for the installation and performance characteristics of HVEDRs on motorcoaches.

 The main technical issues under consideration in the document include: data element types to be captured that are not already captured by traditional means or by existing engine/powertrain control modules, trigger mechanisms to capture data elements during a particular event, storage issues (bigger storage due to longer duration crashes in heavy vehicle crashes), survivability characteristics, and data extraction methods. The document also explores the types of vehicles for which HVEDR requirements might apply (e.g., large trucks, buses, school buses) and incorporates discussion of lessons learned from light vehicle event data recorder (EDR) regulation.

The document also discusses regulatory and enforcement considerations such as the merits of mandatory versus voluntary approaches. NHTSA includes other associated policy issues such as impacts on the agency’s other crash data collection activities and whether the HVEDR data will be sufficiently collected in the field such that it would justify fleet-wide consideration.

This document also discusses issues associated with HVEDR hardware/implementation costs. Although this document briefly mentions privacy issues the privacy impact of HVEDRs are considerably different from light vehicle EDRs. Heavy vehicles are typically commercial motor vehicles and may entail workplace personal privacy considerations.

Ultimately, NHTSA concludes in this document that the agency is not yet ready to develop regulations for the HVEDRs as significant informational gaps exist in the areas of operator privacy, system costs, and data elements required for agency crash analysis, and because of the difficulty in estimating the benefits of HVEDRs it may be hard to justify the costs associated with mandating HVEDRs.

The analysis herein and the conclusions of this document relate to a conventional EDR approach that would record a consistent set of baseline data in crashes involving heavy vehicles focusing on data elements currently commonly available on heavy vehicles or those that could be available with the addition of common accelerometer technology. However, this document does not contain intended or implied conclusions related to the potential data recording opportunities and/or needs to support analyses of crashes that may occur involving heavy vehicles equipped with emerging and/or future technologies such as advanced driver assistance systems (ADAS) and Automated Driving Systems (ADS).

NHTSA believes that as heavy vehicles begin and/or expand the adoption of new crash avoidance technologies and ADAS, the data availability and system cost considerations may change. Further, NHTSA continues to research, and also engage in international activities surrounding expanded data logging approaches, and data recording triggers that may appropriately support analyses of incidents that could occur while emerging driving automation systems, including future ADSs, are engaged. The agency will continue to monitor the issues surrounding HVEDRs, related data standards, and emerging technologies and revisit the possibility of developing a regulatory proposal at a future date.

# **1.0 Introduction**

In January 2012, the National Highway Traffic Safety Administration (NHTSA) published a final rule amending 49 CFR Part 563, “Event data recorders,” (Part 563), which regulates voluntarily installed event data recorders (EDR) in light passenger vehicles up to a 3,855 kilograms (kg) (8,500 pounds (lb)) gross vehicle weight rating (GVWR). The final rule amended a set of minimum standardized data elements, content format, and retrieval methods for EDRs installed voluntarily by vehicle manufacturers in light vehicles. These requirements apply to vehicles manufactured on or after September 1, 2012, if the vehicle is equipped with an EDR. We note that the crash characteristics and relevant measurements that an EDR would need to capture for heavy vehicles (vehicles with GVWR 4,536 kg (10,000 lb) and greater)[[1]](#footnote-2) would be considerably different from those of light vehicle EDRs.

 Currently, NHTSA does not regulate the installation of heavy vehicle event data recorders (HVEDRs). However, the collection of data from HVEDRs could provide additional information on vehicle performance just before and during a crash. These data, in turn, may be used to examine improvements to heavy vehicle safety systems such as occupant and impact protection, assess the efficacy of heavy vehicle crash avoidance systems such as antilock braking systems (ABS), electronic stability control (ESC), and potentially other advanced driver assistance systems (ADAS), depending on the recorded data content.

For the purposes of the following discussions, a heavy vehicle is considered to be any vehicle with a GVWR greater than 4,536 kg (10,000 lb) and buses designed to carry more than 10 persons.[[2]](#footnote-3),[[3]](#footnote-4) Additionally, this document examines the potential costs associated with HVEDRs on heavy vehicles of varying capabilities as well as the costs of implementing a mandate for installation of EDRs on heavy vehicles, and policy issues surrounding such a mandate.

In this document NHTSA examines the technical and developmental requirements necessary to install EDRs in heavy vehicles such as large trucks and buses that would record a consistent set of baseline data in crashes involving any heavy vehicles focusing on data elements currently commonly available on heavy vehicles or those that could be available with the addition of common accelerometer technology. This document does not broach issues related to the potential data recording opportunities and/or needs to support analyses of crashes that may occur involving heavy vehicles equipped with emerging and/or future technologies such as ADAS and ADS.

# **2.0 Background**

## 2.1 General EDR Background

In the light vehicle context, the EDR is a function or device installed in a motor vehicle to record technical information about the status and operation of vehicle systems for a very brief period of time (i.e., a few seconds) and in very limited circumstances (immediately before and during a crash), primarily for the purpose of post-crash assessment of vehicle safety system performance. EDR data are used to improve crash and defect investigation and crash data collection quality to assist safety researchers, vehicle manufacturers, and the agency to understand vehicle crashes better and more precisely. Additionally, vehicle manufacturers utilize EDR data in improving vehicle designs and developing more effective vehicle safety countermeasures. EDR data can also be used by Advanced Automatic Crash Notification (AACN) systems to aid emergency response teams in assessing the severity of a crash and estimating the probability of serious injury before they reach the site of the crash.

There has been increased activity in the area of light vehicle EDRs over the past three decades. In the early 1990s, General Motors (GM) began installing limited-capability EDRs on their new air bag-equipped vehicles. Around the mid-1990s, there was increased interest in aftermarket EDRs for fleet application, especially in Europe. By the late 1990s, GM and Ford had developed more sophisticated EDRs and were installing these devices on their newly designed vehicles. NHTSA's internal analysis shows that, for Model Year (MY) 2021, 99.5 percent of new light vehicles produced were equipped with EDRs that meet Part 563's requirements. Some EDRs in light vehicles today collect the optional data elements listed in Part 563 such as driver inputs (e.g., steering) and vehicle system status.

The focus of EDR related functionality in heavy vehicles during the same period was mostly on collecting data from engine and powertrain systems to monitor efficiency and performance of these systems. In the past two decades, the development of HVEDRs has expanded to other areas such as in the aftermarket audio/video data for fleet management, driver training and liability protection.

Today, HVEDRs are offered as original equipment and aftermarket systems, ranging in complexity from simple compact standalone devices that measure crash pulses, to complex devices that are integrated into the vehicle, to devices that can automatically capture audio and video on commercial vehicles. Most of these systems are installed by either the vehicle manufacturer or the engine supplier[[4]](#footnote-5) and monitor basic engine performance, vehicle system performance, and maintenance data. Some of the more complex systems track trip activity (operator performance), vehicle crash and crash avoidance data, and video data.[[5]](#footnote-6)

## 2.2 Background on NTSB and NHTSA Interest in EDRs

EDRs have been a focus of activity within several agencies of the Federal Government. In 1997, the National Transportation Safety Board (NTSB) issued recommendations to NHTSA to pursue crash information collection using EDRs for buses with a GVWR above 4,536 kg (10,000 lb).[[6]](#footnote-7) In 1999, the NTSB conducted a review[[7]](#footnote-8) of bus crashworthiness issues and published a report that included two HVEDR data collection recommendations (H-99-53 and -54) for aiding future crash investigations and improving the data to support future occupant safety improvements. In 2010, the NTSB superseded the H-99-53 recommendation with recommendation H-10-07. Similarly, NTSB issued two more recommendations (H-10-014 and -015) focusing on the development and implementation of minimum performance standards for event data recorders on heavy trucks. In July 2019, the NTSB closed H-99-54 and H-10-07. The remaining open recommendations are provided below.

**H-10-14:** Develop and implement minimum performance standards for event data recorders for trucks with gross vehicle weight ratings over 10,000 pounds that address, at a minimum, the following elements: data parameters to be recorded; data sampling rates; duration of recorded event; standardized or universal data imaging interface; data storage format; and device and data survivability for crush, impact, fluid exposure and immersion, and thermal exposure. The standards should also require that the event data recorder be capable of capturing and preserving data in the case of a power interruption or loss, and of accommodating future requirements and technological advances, such as flashable and/or reprogrammable operating system software and/or firmware updates.

**H-10-15:** After establishing performance standards for event data recorders for trucks with gross vehicle weight ratings over 10,000 pounds, require that all such vehicles be equipped with event data recorders meeting the standards.

NHTSA’s interest in light vehicle EDRs sprang from its crash investigation program in the early 1990s, where early EDRs were used to better understand crashes. This interest has grown over the years from EDRs being used to enhance a few crash investigations to their widespread use in NHTSA’s crash investigation programs – Special Crash Investigation (SCI) program, Crash Investigation Sampling System (CISS) (a replacement of the National Automotive Sampling System Crashworthiness Data System (NASS-CDS)), and Crash Injury Research and Engineering Network (CIREN). To further the understanding of EDRs, in 2001, NHTSA launched an EDR research web page. The site provides lists of EDR reports, articles, news stories, patents, and other material (<https://www.nhtsa.gov/research-data/event-data-recorder#overview-10516>).

Through the mid-2000s, the agency coordinated efforts with the Federal Motor Carrier Safety Administration (FMCSA) and the Federal Highway Administration (FHWA), outlining recommendations on parameters for HVEDRs to measure. Both the FMCSA and FHWA published follow-on works building upon the basic recommendations contained in the NHTSA report. This work is further examined in section 2.3 below.

For light passenger vehicles (up to a 3,855 kg (8,500 lb) GVWR), NHTSA’s interest in EDRs culminated in the August 2006[[8]](#footnote-9) publication of a final rule regulating voluntarily installed EDRs. The final rule established a set of minimum standardized data elements, content format and retrieval methods for EDRs installed voluntarily by vehicle manufacturers in light vehicles. These requirements became effective on September 1, 2012.[[9]](#footnote-10) In this regulation, the agency attempted to devise an approach that would encourage broad application of EDR technologies in motor vehicles and maximize the usefulness of EDR data for the medical community, researchers, vehicle manufacturers, and regulators, without imposing unnecessary burdens or hampering future improvements. The final rule also discussed the reasons for which we deferred consideration of EDR requirements for heavier vehicles.

In the area of heavy vehicles (those with a GVWR of 4,536 kg (10,000 lb) or more), NHTSA published a comprehensive plan in 2007 to research improvements to motorcoach safety. This plan was prepared in response to several NTSB recommendations and to motorcoach crashes that occurred since the recommendations were issued. The plan focused on areas such as requiring seat belts, improved roof strength, emergency evacuation, and fire safety. It also worked to address the two (now superseded) 1999 NTSB recommendations that call for school buses, motorcoaches, and buses to be equipped with HVEDRs.

 The 2007 motorcoach safety plan noted that the agency had recently established requirements for voluntarily installed EDRs in light duty vehicles,[[10]](#footnote-11) and also that the crash characteristics and relevant measurements for motorcoaches (and similarly for heavy trucks) would be considerably different. As an outgrowth of this plan, NHTSA worked with the Society of Automotive Engineers (SAE) Truck and Bus Committee in the development of the 2010 SAE Recommended Practice J2728, “Heavy Vehicle Event Data Recorder (HVEDR) Standard – Tier 1.” This Recommended Practice (RP) was developed to define specifications and functional requirements for the reliable and accurate recording of crash parameters relevant to heavy trucks. In the 2007 motorcoach safety plan, NHTSA indicated that upon completion of SAE J2728, it would consider requiring the installation of HVEDRs into motorcoaches and other heavy vehicles.

Subsequently, on April 30, 2009, Transportation Secretary Raymond LaHood announced a full Departmental review of motorcoach safety. The findings from this review resulted in a Departmental Motorcoach Safety Action Plan (MSAP), which was released November 16, 2009,[[11]](#footnote-12) and subsequently updated on December 12, 2012.[[12]](#footnote-13) The departmental agencies that helped create the Action Plan included: NHTSA, FMCSA, FHWA and the Pipeline and Hazardous Materials Safety Administration. The plan outlined the additional steps needed to improve motorcoach safety[[13]](#footnote-14) and it also considered outstanding recommendations to the DOT from the NTSB. One of the NHTSA actions to be taken to address the root cause of fatalities and injuries was to consider the installation and performance characteristics of HVEDRs on motorcoaches.

## 2.3 Heavy Vehicle Event Data Recorder Standardization Efforts

#### 2.3.1 NHTSA Truck and Bus Event Data Recorder Working Group

In May 2002, the NHTSA-sponsored Truck and Bus Event Data Recorder Working Group (T&B EDR WG) published a report[[14]](#footnote-15) supplementing the findings of NHTSA’s first EDR report,[[15]](#footnote-16) published in August 2001, with findings related to heavy vehicle applications. The May 2002 report was the final product of a 1998 NHTSA effort which utilized the collective efforts of industry, academia, and other government organizations to study HVEDRs.

 The T&B EDR WG report recommended data elements to collect, prioritized the data elements for their usefulness in investigating the causes of crashes, proposed requirements for HVEDR survivability and retrievability, and identified areas for further research. The core data elements to be captured by a HVEDR that were recommended in the report included:

* longitudinal (x-direction) acceleration,
* lateral (y-direction) acceleration,
* vertical (z-direction) acceleration,
* throttle position,
* antilock brake system (ABS) status,
* automatic transmission gear selection,
* seat belt status (driver only),
* brake pedal position,
* engine revolutions per minute (RPM),
* vehicle and engine identification numbers (VIN and EIN respectively),
* event time and date,
* vehicle speed, and
* wheel speeds.

The report also recommended secondary and optional HVEDR data elements such as:

* safety systems status and deployment times,
* battery status,
* cruise control status,
* auxiliary brake system status,
* vehicle heading/location,
* steering input,
* traction/stability control status,
* video/audio data, and
* vehicle load status.

However, the report concluded that these data elements, although valuable for better event reconstruction, require more careful consideration for inclusion in HVEDR systems. The report notes the complexities in determining parameters for crash data for heavy vehicle crash reconstructions given the widely varied uses of heavy vehicles and identifies where additional research is needed.

#### 2.3.2 Federal Highway Administration

In December 2004, the FHWA published a report titled “Development of Requirements and Functional Specifications for Crash Event Data Recorders – Final Report.”[[16]](#footnote-17) This report summarized the results of joint research between the FHWA and the Truck Manufacturers Association on the functional requirements and specifications needed to facilitate the reconstruction of crashes involving large trucks. This report examined existing and on-going EDR work, as well as commercial vehicle crash data, to produce recommendations on HVEDR performance requirements and potential test methods.

The FHWA project defined specific HVEDR requirements and functional specifications for investigation and reconstruction of crashes involving large trucks. Like the NHTSA effort, the FHWA project ranked specific HVEDR data elements into three tiers:

Tier 1 – The minimum required data elements for a crash HVEDR on commercial motor vehicles (CMVs).

Tier 2 – The data elements, in addition to Tier 1, that would permit further analysis of crashes involving CMVs.

Tier 3 – A complete set of data crash elements to thoroughly analyze crashes involving CMVs, including the data elements listed in Tiers 1 and 2 above.

The report also examined: the cost effectiveness of the data elements in each of the three tiers and overall costs of installing a HVEDR; requirements for HVEDR components, hardware, software, sensors, and databases; physical attributes of the device; crash/environmental survivability; availability of appropriate sensors; data storage and retrieval; crash event trigger algorithms; accuracy and reliability; calibration; and maintainability.

#### 2.3.3 Federal Motor Carrier Safety Administration Commercial Motor Vehicle Technology Diagnostics and Performance Enhancement Program

 In December 2005, the FMCSA published a report[[17]](#footnote-18) as part of its Commercial Motor Vehicle Technology Diagnostics and Performance Enhancement Program. The report focused on a project that explored the potential for the development of cost-effective vehicle data recorder (VDR) solutions tailored to various applications or market segments. Through a combination of technical research and analysis, including fleet-related cost-benefit, potential VDR configurations ranging from a fundamental to comprehensive system were explored.

 The project was centered around four tasks. Task 1 focused on capturing the available results of the research (e.g., the FHWA and T&B WG reports, industry standards, etc.) and synthesizing information from the commercial vehicle user, OEM, equipment supplier, and recorder manufacturer communities. The results of this task formed the foundation for the development of VDR alternative concepts and the evaluation of their potential benefits and costs.

Task 2 focused on the identification of specific features and capabilities available and

incorporated in commercially available VDRs, and the estimation of the costs associated with

those features. Task 3 focused on the development of several VDR concepts with different levels of functional sophistication in order to understand the costs and benefits associated with different implementations of a VDR. The concepts were developed to represent practical combinations of features and capabilities that would address requirements for different stakeholders (e.g., enforcement/litigation communities, fleet operators, vehicle manufacturers, government researchers, etc.). The following VDR concepts were developed:

Concept 1. A low-cost event-triggered data recorder for recording baseline crash data

Concept 2. A more advanced event-triggered data recorder incorporating advanced sensor technologies

Concept 3. A baseline continuous data recorder that records maintenance and operational data meant to improve fleet operations

Concept 4. An advanced continuous data recorder that includes additional driver-monitoring parameters

Concept 5. A “full-featured” VDR that might include crash data and operational-efficiency data.

Task 4 focused on understanding the benefits of the developed operational concepts. In addition, estimated costs (e.g., for engineering development, application programming, and hardware) were developed for these same concepts.

To better understand the costs and benefits associated of a single-purpose crash EDR, Concept 1 was analyzed. To understand the costs and benefits of VDRs targeted at improving operational efficiency (including driver and vehicle monitoring, vehicle tracking, and maintenance management), Concept 3 was analyzed. Concept 5 was also profiled in order to

develop a cost-benefit analysis for a “full-featured” VDR that would record both the crash event as well as provide more traditional operational data used by fleets.

In general, this project found that although VDR devices will benefit the commercial vehicle industry and society as a whole, these benefits will likely be spread across three primary stakeholder groups: (1) benefits to fleets (e.g., improving operational efficiency and reducing costs), (2) benefits to OEMs (e.g., reducing liability costs and improving vehicle designs and safety), and (3) benefits to the public sector (e.g., fewer crashes, injuries, and fatalities; and improved inspection capabilities). The following table provides a summary of the estimated costs for the concepts evaluated.

**Table 2.3.3 – FMCSA VDR Concept Cost Estimate Summary**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Estimated Piece Cost (±15%)** | **One-Time Tooling and Layout Cost** | **Software Development Cost** | **Amortized Per Unit Cost (based on 10,000 units)** |
| **Concept #1** – Core EDR | $260 | $20,000 | $15,000 to $30,000 | $265 (assuming $25,000 for SW) |
| **Concept #3** – Core VDR | $140 | $20,000 | $15,000 to $30,000 | $145 (assuming $25,000 for SW) |
| **Concept #5** – Comprehensive EDR and VDR | $450 | $20,000 | $20,000 to $40,000 | $460 (assuming $25,000 for SW) |

In conducting the cost-benefit analysis, FMCSA stated that it became clear that return-on-investment calculations for VDRs (from the fleet operator’s perspective) are challenging for two main reasons. First, benefits are often defined in terms of increased productivity, efficiency, competitiveness and/or improved safety, and these measures will vary depending on a particular fleet’s situation—and even for a specific fleet’s situation, they are very difficult to quantify. Second, costs are difficult to obtain from commercial suppliers of VDR equipment and services.

#### 2.3.4 SAE Recommended Practice J2728, “Heavy Vehicle Event Data Recorder (HVEDR).”

SAE J2728 was developed through the SAE Truck and Bus Event Data Recorder Committee, a subcommittee of the SAE Truck and Bus Council. The committee is responsible for recommending, developing, and reviewing Recommended Practices, Standards, Draft Technical Reports, and Information Reports related to EDRs utilized on trucks, buses and truck-trailers. Participants in the SAE Truck and Bus Event Data Recorder Committee include representatives from OEMs, suppliers, consulting firms, government, and others across the heavy vehicle, construction, and agriculture industries.

Work on SAE J2728 Recommended Practice began when the Truck and Bus Event Data Recorder Committee was formed in 2004. The first draft of the recommended practice was circulated in June 2007, and published in its final form in June 2010. This version of the recommended practice described a common set of design and performance requirements for recording, storing, and retrieving data surrounding well-defined events that can occur during the operation of a heavy vehicle.

It stated to apply to vehicles with GVWRs over 4,536 kg (10,000 lb)[[18]](#footnote-19) and established a common set of definitions, data sets, data formats, data extraction requirements, and performance requirements for HVEDRs. As with the NHTSA and FHWA efforts, the original SAE recommended practice ranked HVEDR data elements into three tiers:

Tier 1 – The minimum required data elements for functional HVEDRs.

Tier 2 – Data elements, in addition to Tier 1, that would include additional non-proprietary data contained on the vehicle data network as defined in SAE J1587, “Electronic Data Interchange Between Microcomputer Systems in Heavy-Duty Vehicle Applications” and SAE J1939, “Recommended Practice for a Serial Control and Communications Vehicle Network.”

Tier 3 – Data elements, in addition to Tiers 1 and 2, that would include additional proprietary data on manufacturer-specific safety systems as those technologies develop.

The June 2010 version of SAE J2728 only addressed Tier 1 data elements. In 2020, a revised version of SAE J2728 was issued in order to reflect the current market situation and future expected developments as well as to organize information previously contained in SAE J2728 into separate documents that are topically focused. The SAE J2728 series of documents now consists of a base document SAE J2728 and the first of a series of documents SAE J2728-1, which provides a list of recommended data elements, as a minimum, as well as heavy vehicle specific triggers for data recording. The list of data elements is grouped by various vehicle systems (e.g., ABS, cruise control system, collision warning system, etc.) and provides the intent, possible source, and format of the recommended data elements.[[19]](#footnote-20) SAE J2728-1 also implements new safety system triggers, such as, a safety restraint system trigger, ABS activation trigger, automatic emergency braking event trigger, and an ESC intervention trigger. It is important to note that the 2020 version of SAE J2728 no longer uses the data element tier categories. Appendix A contains the J2728-1 list of recommended data elements.

#### 2.3.5 ATA Recommended Practice 1214 – Guidelines for Event Data Collection, Storage and Retrieval.

 In 2001, the Technology and Maintenance Council (TMC) of the American Trucking Association (ATA) published guidelines (Recommended Practice 1214 (T)) to define and collect event related data onboard commercial vehicles. This “Recommend Practice 1214 (T)” identifies several data parameters based on SAE J1587 (which is a communication protocol for use between microprocessors in commercial vehicles as a diagnostic tool), sample rate, and minimum recording interval time. Unlike the light duty vehicle approach of storing the event related data elements in the EDR associated with the air bag control module (ACM), the RP 1214(T) recommends that the data be stored in the existing Engine Control Module (ECU). In 2020, TMC/ATA issued a revision of this recommended practice titled RP 1214A that includes updated SAE references and an additional table of SAE J1939 parameter group numbers and suspect parameters number[[20]](#footnote-21) for each of the data parameters.

## 2.4 Technical Background

There are many complex technical issues associated with potentially regulating EDRs on heavy vehicles. Many of these issues are shared with light vehicle EDRs. However, some are unique to HVEDRs. Data elements are one example of that. Chapter 4 will explore data element needs in more detail. Here we provide a brief background on some of the other key technical issues that warrant background information and will also be explored in more detail later in this document.

#### 2.4.1 Application and Scope of Target Vehicles

 Heavy vehicles encompass a wide range of weights, occupants, and end uses. GVWRs can range from 4,536 kg (10,000 lb) pickups and work trucks to Class VIII trucks and buses well over the 14,969 kg (33,000 lb) lower limit for that vehicle class. End uses are as varied as multi-passenger transport carrying more than 50 occupants (e.g., motorcoaches) to freight (e.g., tractor-trailers) and construction (e.g., dump trucks) carrying one or two occupants. In addition, vehicles may use similar platforms in vastly different roles (e.g., a dump truck may be built on a similar frame as a box truck) or use a unique structure to accomplish a specific task (e.g., motorcoaches). This complicates the selection of a target group of vehicles. In the case of large passenger transport vehicles, there is a greater potential for loss of life in a single crash. Accordingly, these crashes generate a great deal of public interest. In the case of heavy trucks, there is a greater frequency of crashes in which the agency may have an interest, and the agency may get more useful information (e.g., estimates of crash compatibility with light vehicles) and garner better data collection results with vehicles other than buses.

 Thus, the agency will need to examine further the scope of vehicles it intends to cover during any process to promulgate a proposed rule for HVEDRs. Some of the options available to the agency would include limiting applicability to motorcoaches and other buses, limiting the scope to Class VII and VIII vehicles and buses, and the inclusion of all heavy vehicles (GVWR 4,536 kg (10,000 lb) or more). All of these address large bus safety. Some of the opportunities and challenges of each of these strategies are briefly listed below.

Motorcoaches and other Buses

*Opportunities:*

* Focuses heavy vehicle data capture on high occupancy vehicles
* Existing vehicle controller area network structure required for EPA controls conducive to imaging crash data
* Narrow scope of vehicles
	+ Can ensure that proposed data elements are tailored to investigative needs and crash conditions

*Challenges:*

* Would not cover other heavy vehicle types that may benefit from the technology
* Small number of fatal crashes to investigate
* May require installation of additional sensors to capture some of the data elements

Class VII and VIII Heavy Vehicles (GVWR of 11,794 kg (26,001 lb) and up)

 Class VII and VIII vehicles are the heaviest classes of highway transport. Additionally, they represent the most common heavy vehicles on the road.

*Opportunities:*

* Potential for capturing crash information from a larger number of vehicle crashes
* Existing SAE J1939 vehicle controller area network structure required for EPA controls conducive to imaging crash data
* Broad scope of vehicles
	+ Can ensure that proposed data elements are tailored to investigative needs and crash conditions
	+ Includes the largest motorcoaches, buses, and trucks

*Challenges:*

* Would not cover other heavy vehicle types that may benefit from the technology
* Additional tools (e.g. data collection tools and guidelines for first responders and crash investigators) needed to collect additional heavy vehicle crash information

All Vehicles with GVWRs of 4,536 kg (10,000 lb) and Greater

*Opportunities:*

* Potential for capturing crash information from all heavy vehicle crashes
* May encompass some vehicles equipped with SAE J1939 controller area network
* May encompass some vehicles equipped with air bag controllers or based on light duty structures that already have EDRs

*Challenges:*

* Varied end uses of vehicle types may warrant development of a complex rule to ensure that HVEDR installations capture the types of data the agency most needs
* May adversely impact small businesses
* Even more tools needed to collect all additional heavy vehicle crash information

#### 2.4.2 Heavy Vehicle EDR Triggers

 EDRs capture data by continuously monitoring sensor systems to determine if a crash, or other event deemed important, has occurred. Once sensor data meets or exceeds an event threshold, the EDR “triggers” a recording function to capture data related to the event. In light duty vehicles this trigger is typically related to deployment of an air bag or deceleration threshold. However, large trucks and buses present some unique challenges in determining appropriate trigger thresholds and mechanisms to begin recording data. The relative size of the vehicles could make crash detection difficult if relying solely on accelerometer-based data, especially when considering the largest heavy vehicles whose crash partners are relatively small light vehicles or any heavy vehicle which strikes pedestrians or pedalcyclists. Additional sensors or other methods will need to be explored to detect certain types of crashes.

#### 2.4.3 Survivability

 In many instances, HVEDRs will not be accessed immediately after a crash has occurred. For this reason, it is important to protect stored data for an extended period of time to ensure the availability of the data. The NHTSA EDR working group recommended that the data (and internal clocks) for heavy vehicles must be maintained without use of a power source external to the EDR for up to 30 days.

 In addition to the ability to store data without power, the HVEDR must be capable of surviving certain environmental conditions during a crash event. For example, the NTSB recommended that a fire survivability requirement be considered for light vehicle EDRs.[[21]](#footnote-22) Other crash factors that relate to HVEDR survivability include:

* Location of the HVEDR in the vehicle to provide the maximum protection
* Impact resistance to protect HVEDR components
* Fluid resistance
* Penetration resistance
* Internal power supply
* Data storage methodology

#### 2.4.4 Data accessibility

After the crash event is completed, a tool will be needed to retrieve recorded HVEDR data. Because of the diversity of heavy vehicle types and crash conditions, it is important that the HVEDR data be accessible in both a standardized format and with a standardized tool. Additionally, because access to the HVEDR may be limited due to crash conditions, the agency may wish to consider data access through multiple sources (for example, from both the HVEDR itself as well as from the On-Board Diagnostic (OBDII) connection).

# **3.0 Safety Problem**

Data collected by HVEDRs could be used to improve highway safety. HVEDR data can provide information to enhance our understanding of crash events and safety system performance, thereby potentially contributing to safer vehicle designs and more effective safety regulations. However, this success is highly predicated upon whether: a) the data is collected; and b) the collected data is useful for improving safety. The following sections provide a general overview of the safety problem in heavy vehicles and discuss the potential areas where HVEDRs may or may not be of benefit.

## 3.1 Large Truck Crashes

According to the Fatality Analysis Reporting System,[[22]](#footnote-23) there were 4,479 fatal crashes involving large trucks (greater than 4,536 kg (10,000 lb)) in 2019. These crashes resulted in a total of 5,005 fatalities accounting for 13.9 percent of all fatalities in traffic crashes. It is important to note that the fatality in the majority of these crashes occurred in the large truck’s collision partner, and not the large truck itself. Of these 5,005 fatalities involving large trucks in 2019, 71 percent (3,544) were occupants of other vehicles, 11 percent (569) were non-occupants, and 18 percent (892) were occupants of large trucks. Truck occupant fatalities by itself account for 2.5 percent [[23]](#footnote-24) of all traffic fatalities in 2019.

In the 4,479 fatal large truck crashes, many of the collision partners were light vehicles. These light vehicles will likely be equipped with EDRs. So, data from a HVEDR in a large truck-passenger vehicle crash may only provide incremental benefit in a crash reconstruction over that provided by the light vehicle EDR. It could, for example, provide insight on the large truck brake application, travelling speed prior to impact, and velocity change (delta-V). However, such data is only helpful if the large truck HVEDR is available for download after the crash. In cases where a fatality occurs, it is more likely that the vehicles involved will be available for some time after the crash. In cases where there is no fatality or where the damage to the heavy vehicle is limited to a trailer or the rear of the vehicle, a large truck may not necessarily have significant enough damage to prevent it from leaving the scene after any general crash investigation has been conducted by first responders. Similar circumstances are likely to occur with large truck crashes involving motorcycles, pedestrians, cyclists, etc.

Consequently, gathering the HVEDR data from large trucks in crashes with light passenger vehicles could be challenging, particularly when considering the timing between the crash and any crash investigation the agency may conduct, and the ability to correlate any captured data to a particular crash. These challenges help define the potential requirements for HVEDRs, such as increased storage for crash data, increased number of locked events, increased sensor sensitivity, additional event triggers, and time stamps to correlate data to a particular crash, but invoke additional challenges such as operator privacy and access to the HVEDR after the fact.

For the crashes where the fatality was the truck occupant (892 fatalities in 2019), an HVEDR may be more insightful because approximately 55 percent of these crashes are single vehicle crashes. As in other crashes, information from a HVEDR might be insightful as to the speed, brake/throttle position, steering wheel angle, etc. Unlike the majority of large truck collisions with passenger vehicles, crashes with a large truck occupant fatality would likely cause the large truck to be significantly damaged, and not driven away from the scene immediately. As a result, assuming the HVEDR survives the crash, there would be a longer window of opportunity for NHTSA’s crash investigators to image the HVEDR data and to correlate the data with the crash in question.

Another source of information on the value of HVEDRs is in crash reconstruction of heavy trucks in fatal crashes. The agency initiated a research program in November 2012 in response to a Congressional mandate set forth in the “Moving Ahead for Progress in the 21st Century Act” (MAP-21), which requires NHTSA to study and help identify crash characteristics, the related injury types and injury origin within heavy vehicle crashes. The finding(s) from this research study[[24]](#footnote-25) showed that truck occupants are often fatally injured by blunt force trauma or by positional asphyxiation related to rollover crashes. This study also showed that, unlike light duty vehicles, large trucks often do not exhibit sudden longitudinal deceleration. (EDRs in light duty vehicles use sudden deceleration as a trigger to record the required data elements or deployment of an air bag.)

## 3.2 Large Bus Crashes

Motorcoach travel remains one of the safest modes of highway transportation in the United States, transporting approximately 750 million passengers per year in over-the-road buses. During the ten-year period of 2001 through 2010, motorcoach crashes resulted in an average of 17 motorcoach occupant fatalities per year. Approximately 61 percent of the annual number of motorcoach fatalities occurred in rollover events. In 2009, DOT issued a Departmental Motorcoach Safety Action Plan, which outlined a Department-wide strategy to enhance motorcoach safety.[[25]](#footnote-26) This plan culminated in multiple rulemaking actions. The agency issued a final rule[[26]](#footnote-27) on November 25, 2013, requiring seat belts in motorcoaches to prevent occupants from ejection during rollover crashes. To further reduce the fatalities in large buses, on June 23, 2015, the agency issued a final rule requiring ESC systems for truck tractors and large buses to reduce untripped rollovers and to mitigate understeer or oversteer conditions that can lead to loss of control.[[27]](#footnote-28) The agency has also proposed a new Federal motor vehicle safety standard (FMVSS) to enhance the rollover structural integrity of certain types of large buses greater than 11,793 kg (26,000 lb).[[28]](#footnote-29) The agency proposed performance requirements for these new large buses greater than 11,793 kg (26,000 lb) in a test where the vehicle is tipped over from an 800 millimeter (mm) (31.5 in.) raised platform onto a level ground surface. The performance requirements would ensure that these vehicles provide a sufficient level of survival space to restrained occupants in rollover crashes. On April 6, 2016, the agency proposed a new FMVSS that will help reduce fatalities and injuries in motorcoach and large bus crashes by mitigating occupant ejection. The notice of proposed rulemaking specifies a new impactor test on the glazing material of side and rear windows and glass panels on the roof of motorcoaches and large buses.[[29]](#footnote-30)

Transit and other large buses also have a good safety record. Large transit buses (over 11,793 kg (26,000 lb) GVWR) on average only result in 4.6 fatalities per year. Mid-size buses (between 4,536 – 11,793 kg (10,000 – 26,000 lb) GVWR) result in approximately 13.5 fatalities per year (combining transit buses, cross country buses,[[30]](#footnote-31) van based buses, other buses, large van,[[31]](#footnote-32) and unknown mid-size buses, and excluding school buses).[[32]](#footnote-33)

School buses are also one of the safest forms of transportation in the United States. For the 2018-2019 school year, approximately 480,000 yellow school buses traveled about 3.3 billion miles to transport over 26 million children to and from school and school-related activities.[[33]](#footnote-34) School buses have to meet more Federal motor vehicle safety standards than any other type of motor vehicle. On average, there are about 5.2 school-aged child bus passenger fatalities traveling to and from school in the U.S. annually (2009-2018). In contrast, over this same period, on average, there were 9.2 school-aged child fatalities in passenger vehicle crashes traveling to and from school in the U.S. annually.[[34]](#footnote-35)

Given the small target population for further improving large bus safety, the agency needs to consider the value of HVEDRs being applied fleet-wide. As previously mentioned, the DOT Safety Action Plan tasked the agency to consider the installation and performance characteristics of HVEDRs on motorcoaches, and the NTSB has reiterated its need for having HVEDRs to collect data. The NTSB found that 75 percent of the motorcoach crashes they investigated were caused by driver behavior (driver fatigue, medical condition, inattention, and recognition).[[35]](#footnote-36) HVEDRs could have the potential to provide insight into the cause of bus crashes (speed of the vehicle, whether and when the brakes were applied and steeling input angle); however, any decision to regulate the installation of HVEDRs for large buses must carefully consider the cost implications against the potential benefit of the additional information that would be provided. This is particularly the case for school buses, where additional costs to school districts could result in reduced ridership, and more students being forced to take less safe means of transportation to/from school.

## 3.3 Advanced Automatic Crash Notification

It is expected that light vehicle EDR data could play an increasing role in providing crash information to AACN systems in order to improve emergency medical services and crash response times. While the agency is not aware of AACN use on heavy vehicles, we see no reason why data from HVEDRs could not perform the same role. Specifically, crash data, regardless of vehicle platform, can help the safety community develop more robust triage algorithms and other emergency response systems to improve medical services to crash victims, particularly those of high occupancy vehicles.

While commercial motor vehicles and fixed-route buses would likely be more routinely tracked and monitored, and hence may not accrue as much value from an AACN system as an ordinary passenger vehicle, the high occupancy commercial motor vehicles, such as motorcoaches or school buses, may require larger volumes of emergency medical services personnel to provide triage at a crash scene. HVEDR data could provide an AACN system with information about the crash scenario, such as impact speed, rollover occurrence, principle direction of force, etc., but there are limitations. For example, it could not readily differentiate between a fully loaded bus and an empty bus. So, additional technology, such as voice transmittal would likely be needed in the interim. Finally, we note that an AACN system does not rely on the installation of a HVEDR; rather, both systems would presumably pull data from the same vehicle sensors. As such, the installation of an HVEDR may hasten the availability of such data for AACN use, but the implementation of AACN does not require it.

Notwithstanding the above, we believe that it is likely that light vehicles will lead the way in the development and implementation of AACN and their use in heavy vehicles will lag to some degree. This is supported by the information received from vehicle and engine manufacturers who stated that few had plans to incorporate automatic crash notification (ACN), much less AACN.[[36]](#footnote-37)

# **4.0 Data Elements**

While this document is intended only to discuss the issues relevant to the potential installation and regulatory requirements for HVEDRs, it is important to examine previous work on data element recommendations and existing data sets as guides to what future regulated HVEDRs might resemble. In some instances, we have provided our assessment of this previous work as it relates to what the agency could consider in any future rulemaking. We note that a much closer examination of data elements and characteristics and their place within both agency data collections and the scope of applicable vehicles would be necessary prior to establishment of any regulatory requirements, and that these are just the agency’s initial thoughts on the technical feasibility at the time this report was drafted.

Based on member input, the T&B WG established a set of data elements that would provide the agency with the most benefit in improving the crash reconstruction process, along with offering useful data to aid in injury prediction, vehicle defect analysis, crash causation, and other uses.[[37]](#footnote-38) The T&B WG identified three tiers of data elements that could be collected by HVEDRs. They are as follows:

* Tier 1 - Priority data elements (data of the most beneficial use towards agency goals);
* Tier 2 - Secondary data elements (data in addition to the Priority elements that also provide tangible benefits, but should be considered carefully prior to implementation); and
* Tier 3 - Optional data elements (data elements in addition to the Primary and Secondary elements that provide useful, but non-essential, information about the operation of a vehicle, or are simply too costly to implement as a requirement).

These tiers are structured in general agreement with those later used in the FHWA study and the 2010 SAE recommended practice.[[38]](#footnote-39) A comparison of recommended data elements from NHTSA T&B WG, FMCSA, FHWA, and SAE can be found in Table 4.0 below. Table 4.0 also identifies whether or not the data element was monitored at the time of this contract and the percentage of truck and engine manufacturers that monitored the data element (based on a survey of 8 manufacturers).[[39]](#footnote-40)

**Table 4.0 – Comparison of Data Element Priorities and Monitoring Status**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Data Element** | **NHTSA T&B WG** | **FHWA** | **FMCSA Concept** | **2010 SAE J2728** | **2020 SAE J2728-1** | **Monitored in 2012** | **% of Mfrs Monitoring in 2012** |
| Cumulative Delta-V, Longitudinal |  |  | 1,2,5 |  |  | N | 0 |
| Cumulative Delta-V, Lateral |  |  | 1,2,5 |  |  | N | 0 |
| Longitudinal Acceleration | T1 | T1 | 1,2,5 |  |  | N | 0 |
| Lateral Acceleration | T1 | T1 | 1,2,5 |  |  | N | 0 |
| Vertical Acceleration | T1 | T1 | 1,2,5 |  |  | N | 0 |
| Accelerator Pedal Position | T1 | T1 | 1,2,3,4,5 | T1 | Y | Y | 75 |
| ABS Status | T1 | T1 | 1,2,4,5 | T1 (Multiple locations) | Y (Multiple locations) | Y | 13 |
| Brake Pedal Position | T1 (Position history & Status) | T1(Status, Pressure & History) | 1,2,3,4,5 |  |  | N | 0 |
| Seat Belt Status | T1 (Driver only) | T1 | 1,2,5 (Driver & Passenger) |  | Y | N | 0 |
| Engine Speed | T1 | T1 | 1,2,3,4,5 | T1 | Y | Y | 100 |
| Service Brake Status | T1 | (May be part of Brake status element) | 1,2,5 | T1 (Multiple locations) | Y | Y | 75 |
| Trailer Brake Status | T1 | (May be part of Brake status element) | 1,2,5 | T1/ABS | Y | Y | 13 |
| Transmission Gear | T1 | T1 | 1,2,3,4,5 | T1 |  | Y | 25 |
| Vehicle Speed | T1 | T1 | 1,2,3,4,5 | T1 | Y | Y | 100 |
| Wheel Speeds | T1 | T1 | 2,5 | T1 (Multiple locations) | Y (Multiple locations) | Y | 100 |
| Steering Wheel Angle | T2 | T1 | 2,5 |  |  | N | 0 |
| Time/Date | T1 | T1 | 3,4,5 | T1 | Y | Y | 100 |
| Vehicle Identification Number (VIN) | T1 | T1 | 1,2,3,4,5 | T1 | Y | Y | 100 |
| Air Bag Status | T2 | T2 |  |  | Y | N\* | 0\* |
| Air Bag Deployment Time | T2 |  |  |  |  | N\* | 0\* |
| Battery Voltage | T2 | T2 | 2,4,5 |  |  |  |  |
| Cruise Control Status | T2 | T2 | 2,4,5 | T1 | Y | Y | 75 |
| Air Reservoir Pressure |  | T3 | 2,4,5 |  |  |  |  |
| Lamp Status (Headlamps, Brake Lamps, Warning Lamps, Marker Lamps) | T2 | T2 | 2,5 | T1 (Brake and Warning Lamp Status Only) | Y (Brake and warning lamps) |  |  |
| Retarder System Status | T2 | T2 | 2,4,5 | T1 | Y | Y | 63 |
| Clutch Position |  | T2 | 2,5 | T1 | Y | Y | 75 |
| Odometer |  |  | 2,3,4,5 | T1 | Y | Y | 100 |
| Stability Control System Status |  | T2 | 2,5 |  | Y |  |  |
| Traction Control System Status | T2 | T2 | 2,5 |  |  |  |  |
| Wiper Status | T2 | T2 | 2,5 |  |  |  |  |
| Turn/Hazard Signal | T2 | T2 | 2,5 |  |  |  |  |
| School Bus Warning Lamp | T2 |  |  |  |  |  |  |
| Tire Pressure |  | T3 | 4,5 |  |  |  |  |
| Tire Temperature |  | T3 |  |  |  |  |  |
| Tilt/ Yaw Angle† |  | T2 | 2,5 |  |  |  |  |
| Engine Hours |  |  |  | T1 | Y | Y | 100 |
| Detonation "Knock" |  |  | 4,5 |  |  | Y | 100 |
| Engine Idle Time |  |  | 3,4,5 |  |  | Y | 100 |
| Engine Temperature |  |  | 3,4,5 |  |  | Y | 100 |
| Engine Exhaust Temperature |  |  | 4,5 |  |  | Y | 100 |
| Fuel Consumption/  Level |  |  | 3,4,5 |  |  | Y | 100 |
| Fuel Pressure |  |  | 4,5 |  |  | Y | 100 |
| Intake/ Boost Pressure |  |  | 4,5 |  |  | Y | 100 |
| Oil Pressure |  |  | 4,5 |  |  | Y | 100 |
| Transmission Fluid Temperature |  |  |  | 4 |  | Y | 100 |
| Vehicle Load Status | T3 | T2 | 2,4,5 |  |  |  |  |
| Digital Video Capture[[40]](#footnote-41) | T3 | T3 (Driver & Roadside) |  |  |  |  |  |
| Global Positioning (Vehicle Path/Heading) | T2 | T1 |  |  | Y |  |  |
| Brake Stroke |  | T3 |  |  |  |  |  |
| Brake System Pressure |  | T3 |  |  |  |  |  |
| Distance to Intersection |  | T3 |  |  |  |  |  |
| Driver – Eye Glance Position |  | T3 |  |  |  |  |  |
| Driver – Fatigue Status |  | T3 |  |  |  |  |  |
| Roadway Surface Friction |  | T3 |  |  |  |  |  |
| Side Object Detector |  | T3 |  |  |  |  |  |
| Truck Headway |  | T3 |  |  |  |  |  |
| Truck Lane Position |  | T3 |  |  |  |  |  |
| Subsystem Fault Codes |  |  | 3,4,5 |  |  |  |  |
| Engine Load |  |  | 3,4,5 |  |  |  |  |
| Yaw Rate |  |  | 2,5 |  |  |  |  |
| Inertia Brake Status |  |  | 2,4,5 |  |  |  |  |
| Application Pressure |  |  | 2,5 |  |  |  |  |
| Brake System Faults |  |  | 2,3,4,5 |  |  |  |  |
| Door Latch/Lock Status |  |  | 2,5 |  |  |  |  |
| Seat Occupancy |  |  | 2,5 |  |  |  |  |
| Power-Take-Off (PTO) Status |  |  | 4,5 |  |  |  |  |
| Driver ID |  |  | 3,4,5 |  |  |  |  |
| Alternator Current |  |  | 4,5 |  |  |  |  |

\* The Volvo trucks at the time (2012) were equipped with driver and passenger air bag restraints. We could not verify whether or not Volvo was monitoring air bag status or deployment times, but are assuming they did collect crash data on these elements.

† Tilt/ Roll angle applied about the longitudinal axis.

There were some minor differences between the recommendations in how and what data elements are captured. Also, there were some significant differences between recommendations on what data elements are considered top priorities (Tier 1) versus secondary priorities (Tiers 2 and 3). Definitions of most of the data elements can be found in the NHTSA T&B WG Report.[[41]](#footnote-42)

## 4.1 Priority Elements

 The first tier of data elements consists of the various types of onboard data that might be used to assist in crash reconstruction, crash causation, and injury mitigation. This tier of data includes elements recorded prior to, during, and immediately after an event triggers the HVEDR. Most of the data would be sourced from existing electronic control modules (ECUs) and sensors already located on large trucks and buses. However, unless the vehicle is equipped with an air bag, it is likely that manufacturers would need to install certain sensors (e.g. accelerometers) or incorporate them into the HVEDR to capture the remaining data. The NHTSA T&B WG and FHWA Tier 1 recommendations match closely since these two agencies are mainly concerned with crash reconstruction. The 2020 SAE J2728-1 no longer uses tier categories for the data elements it simply outlines a recommended set of data elements, but the majority of the recommended data elements would be considered Tier 1 data elements. The SAE recommendations prioritize the elements that relate to crash reconstructions with the new addition of crash avoidance technology data elements. However, the SAE elements still do not include items such as vehicle accelerations that may assist both NHTSA and FHWA in understanding the crash scenario.[[42]](#footnote-43)

 Table 4.1 lists the priority data elements of Tier 1 as recommended by the NHTSA T&B WG. Also shown is the minimum required range, sampling rate and accuracy for the recorded data recommended by the T&B WG. We note that the T&B working group provide rationale for the data element parameters.[[43]](#footnote-44)

**Table 4.1 - Tier 1 Minimum Required Data Elements and**

**Minimum Characteristics of Recorded Data**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Data Element** | **Unit** | **Range** | **Sampling Rate** | **Accuracy** | **Source** |
| Longitudinal Acceleration | G | ± 100 g | 1800 Hz | ± 5% | Accelerometer |
| Lateral Acceleration | G | ± 100 g | 1800 Hz | ± 5% | Accelerometer |
| Vertical Acceleration | G | ± 50 g | 1800 Hz | ± 5% | Accelerometer |
| Accelerator Pedal Position | % | 0 to 100% | 2 Hz | ± 2% | Pedal Position Sensor |
| ABS Status | On/Off | On/Off | 2 Hz | N/A | ABS ECU |
| Brake Pedal Status | Alpha-numeric | On/Off | 2 Hz | N/A | Pedal Position Sensor |
| Service Brake Status | On/Off | On/Off | 2 Hz | N/A | ABS ECU |
| Trailer Brake Status | On/Off | On/Off | 2 Hz | N/A | ABS ECU |
| Seat Belt Status (Driver)[[44]](#footnote-45) | On/Off | On/Off | 2 Hz | N/A | Latch Sensor |
| Engine Speed | RPM | 0 to 4,000 | 2 Hz | 10 RPM | Engine ECU |
| Transmission Gear | Alpha-numeric | Five states | 2 Hz | N/A | Transmission ECU |
| Vehicle Speed | km/h | 0 to 100 mph | 2 Hz | 1 mph | Transmission ECU/ ABS ECU |
| Wheel Speeds | km/h | 0 to 100 mph | 100 Hz | 2 mph | ABS ECU |
| Time/Date | Time: Decimal HourDate: Digital Day and Year | Time: 24 HoursDate: 366 Day | N/A | ± 5 s | Internal Clock |
| Vehicle Identification Number (VIN) | Alpha-numeric | 20 Characters | N/A | N/A | Engine ECU |

 We note that certain priority HVEDR data elements are similar to the data elements specified in Part 563. However, there are some significant differences between the element needs for HVEDRs when compared to light vehicle EDRs that warrant discussion here. The following section discusses some of the differences between data element types for acceleration, time/date/VIN, transmission gear, wheel speeds and steering input between light vehicle EDRs and HVEDRs.

 *Acceleration*: Longitudinal, lateral, and vertical accelerations are not considered priority data elements in Part 563.[[45]](#footnote-46) We do, however, consider them valuable for heavy vehicle crash reconstructions in the absence of other data. While accelerometers are primarily used in light vehicles for air bag deployment purposes, acceleration measurements in light vehicles are also used to derive the vehicle delta-V and provide a clearer picture of the forces acting on the vehicle during a crash. Because heavy vehicles are not required to install air bags, accelerometers for detecting heavy vehicle crashes are less common.

 For the agency to compare heavy and light vehicle crashes, heavy vehicles would need to capture some form of crash pulse data that could be correlated to that collected by light vehicles. Therefore, heavy vehicle manufacturers that do not currently install air bags, or accelerometers for other purposes, would need to design and install sensor systems to measure vehicle accelerations under the proposed priority data element tier. One strategy, the use of simple three-axis accelerometers, may be the most economically viable option for heavy vehicle manufacturers that have not already incorporated such designs.

 As with acceleration data for light vehicle EDRs, there may be technical challenges associated with confirming sensor accuracy. There are many factors that contribute to the relative accuracy of vehicle mounted accelerometers, and we believe that this would hold true for truck and bus mounted accelerometers as well. However, despite these challenges, we believe that accelerometers can provide crash reconstructionists with valuable information regarding crash forces. One strategy for HVEDRs may be to take an approach similar to that for light vehicle EDRs and permit manufacturers to specify range and accuracy requirements.

 *Time/Date and VIN*: Like Part 563 for light vehicles, any future HVEDR requirement would need to address the issue of capturing multiple events. To distinguish events, the HVEDRs would need to record the time and date of each event. In light vehicles, this is accomplished via the ignition cycle and event number data elements. If multiple events were to be captured it may be more appropriate for HVEDRs to record the time and date for each event and VIN to ensure data is correctly associated with a particular event and vehicle. Trucks and buses may often be left running between certain triggering events. In addition, we note that heavy vehicles already have internal clock systems installed to provide the data for this element. None of the data elements in Part 563 include the VIN.

 *Transmission Gear, Wheel Speeds, and Steering Input*: Transmission gear, individual wheel speed, and steering input are three data element sets that are important supplementary data for road conditions and operator avoidance maneuvers during heavy vehicle crash reconstructions.[[46]](#footnote-47) Prioritizing these data elements may aid crash investigators and may aid in determining the effectiveness of emerging crash avoidance technologies (e.g. crash imminent braking, stability control, etc.) that utilize data systems currently available on most heavy vehicles.

## 4.2 Secondary Elements

 The second tier of data elements consists of the various types of onboard data that, in addition to the Tier 1 data elements, might allow for more detailed crash reconstructions. Like the Tier 1 elements, this tier of data includes elements recorded prior to, during, and immediately after an event triggers the HVEDR. Some of the data would be sourced from existing ECUs and sensors already located on large trucks and buses. However, it is likely that some manufacturers would need to install certain safety features and/or sensors (e.g. air bags, stability control systems) to capture the remaining data. It is not intended that all of the safety features identified in Tier 2 will be available on all large trucks and buses. Rather, if such safety features are available, the agency would likely consider that the HVEDR capture data regarding those safety features. As with the Tier 1 data elements, the NHTSA T&B WG and FHWA Tier 2 recommendations match closely[[47]](#footnote-48) (see Table 4.0). The 2020 version of SAE J2728-1 includes data elements that would be considered Tier 2 data (i.e., cruise control systems, stability control systems, occupant safety systems, etc.)

 Table 4.2 lists the data elements of Tier 2 and the minimum required range, sampling rate and accuracy if the data are recorded as recommended by the T&B WG.

**Table 4.2 - Tier 2 Optional Data Elements and Minimum Characteristics if Recorded**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Data Element** | **Unit** | **Range** | **Sampling Rate** | **Accuracy** | **Source** |
| Air Bag Status | On/Off | On/Off | 2 Hz | N/A | Air Bag Readiness Indicator |
| Air Bag Deployment Time (Time to Deploy First Stage in Multi-stage Air Bag)[[48]](#footnote-49)  | Ms | 0 to 3000 ms | N/A | ± 2 ms | Air Bag ECU |
| Battery Voltage | V | 10 to 16 Volts (for 12 Volt Systems) | 1 Hz | ± 1 V | Engine ECU |
| Cruise Control Status | On/Off | On/Off | 2 Hz | N/A | Engine ECU |
| Steering Wheel Angle | Degrees | 0-720 deg CW and CCW | 2 Hz | ± 10 deg | Steering Position Sensor |
| Lamp Status (Headlamps, Brake Lamps, Warning Lamps, Marker Lamps) | On/Off | On/Off | 1 Hz | N/A | Switch Sensor |
| Retarder System Status[[49]](#footnote-50) | On/Off | On/Off | 2 Hz | N/A | Engine ECU |
| Traction Control System Status | On/Off | On/Off | 2 Hz | N/A | ABS ECU |
| Wiper Status | On/Off | On/Off | 1 Hz | N/A | Vehicle ECU |

 As indicated above, many of these data elements are currently available on heavy vehicles for collection by HVEDRs. They are used primarily to determine the operational and fuel efficiency of heavy vehicles. Certain systems such as Stability Control, Traction Control, Tilt/Roll Angle sensors, and air bags[[50]](#footnote-51) equate roughly to similar data elements regulated under Part 563. However, the sampling rates and ranges shown in Table 4.2 are more appropriate for heavy vehicle crash data.

## 4.3 Optional Elements

The third tier of data elements consist of the various types of optional onboard data in addition to the Tier 1 and Tier 2 data elements. These data elements are typically used for fleet management purposes rather than the crash investigative purposes of concern to the agency, but can provide additional insight into the vehicle dynamics, overall vehicle health, and occupant behaviors during an event. Like the two previous tiers, this tier of data includes elements recorded prior to, during, and immediately after an event triggers the HVEDR. Most of the data would be sourced from optional ECUs and sensors. We note that the 2020 version of SAE J2728-1 has included some data elements that would be considered Tier 3 data elements (e.g., engine hours and GPS coordinates).

Table 4.3 lists the priority data elements of Tier 3 as recommended by the T&B WG. We note that the Tier 3 data elements do not equate to any existing data elements covered under Part 563 for light vehicle EDRs, but are required for emissions monitoring purposes under the environmental regulations in 40 CFR Part 86, “Control of emissions from new and in-use highway vehicles and engines.”

**Table 4.3 - Tier 3 Optional Data Elements**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Data Element** | **Unit** | **Range** | **Sampling Rate** | **Accuracy** | **Source** |
| Vehicle Load | Alpha-numeric | Yes/No | 1 Hz | N/A | Axle Load Sensors |
| Digital Video Capture[[51]](#footnote-52) | N/A | N/A | N/A | N/A | On Board Cameras |

##

#### 4.3.1 Digital Video Capture[[52]](#footnote-53)

Digital video capture technology (Dash Cam) provides a unique approach for recording and analyzing vehicle crash events as it can often be difficult to understand crash dynamics by only interpreting data from sensors. Operators are beginning to look to video as a way of supplementing or even replacing the need for recording onboard sensors. With the development of low-cost and reliable digital video cameras and developments in video compression technology, it has become economical to install digital video capture and recording systems onboard both commercial and private vehicles. The Dash Cam market in 2020 was valued at $67 million and expected to grow to $169 million by 2026.[[53]](#footnote-54) Cameras can be mounted on the front, sides, or rear of the vehicle, or even facing the driver to record all aspects of an event. Video information collected on the environment and the driver can play a significant role in determining the causes and effects of crashes. Showing actual footage of a crash or other event along with the other sensor information can be an effective way to review causal factors and outcomes of crashes and other safety-critical events.

Storage memory size is an issue, but with the latest MPEG-4 compression technology, video can be stored at varying levels of resolution. In addition, local storage may be augmented or replaced by cloud storage solutions. Video recording could be done on a continuous loop that overwrites itself when memory space is exhausted. Video recorded data could be captured (locked) based on a triggered event. Since it is difficult to design software to discern objects or events in video directly, a sensor (e.g. accelerometer and brake pedal) would have to be integrated with the recording system to trigger the video capture or the captured video could be locked manually. Currently available optional services from third parties can have these video data pushed to central servers once the video is activated due to certain triggering factors. (These may require monthly or yearly subscription services. The videos from these data trigger events are used for commercial driver training purposes and to protect the commercial motor vehicle operator firms from liability.)

## 4.4 Data Collection

 In order for the HVEDR to provide useful information, it must function properly during an event in which data collection is triggered. If that triggering event is a crash, the data must survive the crash.[[54]](#footnote-55) HVEDRs, as we are discussing them here, operate in two modes. One mode continuously monitors pre-crash data, while the second mode determines when an event of interest has occurred and if that event should be recorded for subsequent download. In the pre-crash mode, HVEDRs continuously capture[[55]](#footnote-56) the steady-state operating conditions of the vehicle. This process allows momentary recording[[56]](#footnote-57) of the pre-crash data. In the crash mode, the HVEDR first analyzes the captured pre-crash data and determines if an event of interest has occurred through a comparative process. Based on the outcome of this process, the data are then either recorded in non-volatile memory, or deleted.

During its deliberations, the NHTSA T&B WG recommended that HVEDRs capture 10 seconds of pre-crash information at low resolutions, and up to 10 seconds of crash data at higher resolutions to ensure that the most valuable set of crash information is collected for reconstruction. FMCSA, on the other hand, recommended 20 seconds of pre-crash and 5 seconds of crash data. SAE J2728 standardized 30 total seconds of data, 15 seconds of pre-crash and 15 seconds of crash data at a 10 Hz rate, to be collected by an HVEDR.

Any future HVEDR regulation would need to carefully consider the amount of pre- and post-crash data, as well as the resolution in each phase. We note that the light duty vehicle EDR rule (Part 563) only requires 5 seconds of pre-crash data and 300 ms of crash data. However, currently Part 563 is not focused on crash avoidance technology. Higher recording frequencies and a longer pre-crash time period of data may be warranted to understand the pre-crash conditions and avoidance maneuvers. In addition, due to the increased momentum of heavy vehicles, a longer crash time period may be warranted to fully capture the events during and after the HVEDR has been triggered to begin recording.

To collect pre-crash data, such as engine RPM and pedal applications, HVEDRs need to continuously sample data from sensors associated with each system. Similarly, pre-crash accelerations need to be continuously sampled. These data are stored in a temporary circular buffer that has enough storage capacity to capture the entire pre-crash data interval and is continuously updated as new data are generated. These data aid the HVEDR in determining whether or not a trigger threshold has been met or exceeded, indicating that a crash has occurred.

A trigger threshold can be associated with any number of pre-crash (or non-crash) circumstances. For example, the trigger threshold may be associated with the activation of a safety system, a minimum vehicle deceleration, or even through manual recording by direct action of the vehicle operator. The HVEDR may monitor for the occurrence of any single, or any combination of thresholds. Once a trigger threshold has been met or exceeded, the data are to be recorded in the permanent memory of the HVEDR, if appropriate.

Both the NHTSA T&B WG and the FMCSA reports considered event triggers based on vehicle deceleration and restraint deployment. The FMCSA report also noted manually operated triggers for certain aftermarket data recorders. In addition, to a vehicle deceleration trigger SAE J2728-1 outlines a safety system trigger that encompasses a range of safety systems (e.g., safety restraint system, ABS, and cruise control system triggers) and a trigger based on the last stop of the vehicle. These trigger mechanisms are discussed further in Section 6 of this document.

Certain crashes may encompass several events. For example, a vehicle may sideswipe a guardrail and then strike a second vehicle, or a vehicle may hit a car and subsequently be struck by a second vehicle from behind. Additionally, because heavy vehicles are typically operating on highways, over long distances, and over longer durations between stops, there may be several triggers that occur between vehicle stops that may be of interest during a crash investigation. Any future HVEDR regulation should consider requiring that HVEDRs be capable of measuring and storing a large number of events. We note that SAE J2728-1 recommends the capture of up to 5 events. The FHWA report suggests a different strategy. The FHWA recommendation is to capture up to 3 events, with an indicator light on the dash warning the operator to “empty” the data buffers of existing near-impact data prior to vehicle operation. At stated previously, a time and date stamp requirement will aid investigators in associating specific crashes or events with the corresponding event data and ensure that events of interest prior to a crash are captured in the memory cache.

## 4.5 Data Storage

#### 4.5.1 HVEDR Backup Power

 Because many of the critical data elements recorded occur both before and during the crash, an internal backup power system would need to be considered to ensure that the HVEDR is capable of capturing the short period of data immediately following each crash. The NHTSA T&B WG found that 60 seconds of reserve power would suffice to ensure data is recorded. FMCSA reported that IEEE P1616 MVEDR’s recommendation is that 30-60 seconds of reserve power would be needed to ensure that in extreme crashes, the HVEDR would be capable of recording data should the vehicle power become disconnected and the network shut down. The 2020 SAE recommended practice does not specify a specific timeframe.

On a practical level it is likely that the recording of multiple and/or simultaneous events may necessitate increased amounts of reserve power. Another important issue for consideration is the potential need for a backup power system for the download of HVEDR data. Operability of the vehicle power system may be problematic in crashes where there is significant vehicle damage. This should be less of a problem for heavy vehicles, than in light vehicles. One approach would be to require the data retrieval system to be capable of maintaining both its own power needs, and providing sufficient power to the HVEDR to retrieve data if the internal backup is drained, or the connection to the vehicle batteries is severed during a crash.

#### 4.5.2 Data Retrievability

 One important aspect of data storage is the ability of first responders, crash investigators, and researchers to have the capability to download crash data from the HVEDR. Part 563 requires that light vehicle manufacturers make available a commercial data-imaging tool for light passenger vehicles with an EDR. There is one supplier that provides imaging tools for the vast majority of vehicles. We recognize that because of the myriad of heavy vehicle configurations and data needs, HVEDRs will be optimized for the specific vehicle in which they are installed. Additionally, manufacturers may choose data recording products from any number of component suppliers and may draw data from any number of existing heavy vehicle components to be recorded in a HVEDR to economize on installation costs. This raises the issue of the future potential need for a standardized download interface for HVEDRs. An even higher level of standardization would be a standardized download tool. By comparison, the light vehicle EDR regulation does not have a standard download interface or download tool. What is required is the commercial availability of a download tool. Because of this, a large segment of the market has contracted Bosch to be their provider for the download tool. Our crash investigation experience on retrieving data from light duty vehicles suggests that a more universal retrieval tool may lead to a great probability of data retrieval at lower cost. However, it would remain to be seen if simply requiring commercially available download tools for HVEDRs would lead to a dominate supplier of tools as it did for light vehicles.

 Heavy-duty commercial vehicle OEMs often offer vehicles with multiple types and manufacturers of engines, transmissions, ABS, and other vehicle subsystems.[[57]](#footnote-58) As a result, a common communications method for subsystems was developed[[58]](#footnote-59) so that any engine could theoretically communicate with any transmission or ABS. In addition, there was a need for a common diagnostic interface to minimize cost and facilitate troubleshooting of vehicles with multiple subsystems. In North America, two main protocols have become standard, SAE J1708, *Serial Data Communications Between Microcomputer Systems in Heavy-Duty Vehicle Applications* /J1587, *Joint SAE/TMC Electronic Data Interchange Between Microcomputer Systems in Heavy-Duty Vehicle Applications*, and SAE J1939 *Recommended Practice for a Serial Control and Communications Vehicle Network* for Class B diagnostics and a high-speed Controller Area Network (CAN) for Class A communications. In addition, the International Organization for Standardization (ISO) 11898 CAN standard is a popular choice for Class A communications, along with ISO 11992 for tractor-to-trailer communications. A discussion of related network standards can be found in Appendix B.

 These wired onboard networks can be utilized to standardize a HVEDR data retrieval interface tool. In addition, a significant amount of vehicle operating data is already being broadcast through such networks.

 Most light vehicle manufacturers have opted to use the OBDII port as an access point for imaging EDR data. This port is also readily available on heavy vehicles and may be an appropriate port to access images of HVEDR data.

The convenience of accessing the EDR from the OBDII port is limited by the fact that it requires the vehicle power systems to be operable and the ignition key to be available. Operability of the vehicle power system may be problematic in severe crashes. Vehicle damage in severe crashes may prevent connection with the OBDII port. But field data indicate that even in light vehicles, crash damage to the OBDII port is not likely. Any future rulemaking could consider the need for a secondary access point whereby the HVEDR data may be imaged via a direct connection to the HVEDR. This could be in the form of a commercially available tool. One concern about such a secondary method is that each manufacturer could develop a proprietary set of connections for the HVEDR module. A potential way to mitigate the problem of proprietary connectors for direct access to HVEDR modules would be to specify a standardized secondary port.

 We note that a third potential means to access HVEDR data is through vehicle telematic systems. Telematic systems utilize cellular or wireless technologies to communicate data elements collected by a HVEDR to a central third-party provider. In addition, these systems offer such safety features as AACN. However, if the agency wishes to consider standardizing data access through such a telematic system, a feasibility and cost study would have to be conducted. We anticipate that designing telematic systems into vehicles that do not currently incorporate them would likely add significant costs.

#### 4.5.3 Crash Report Generation/Standardization

 Once the data is collected via the CAN system, it is ideal for the HVEDR to report data in a consistent format that is useful for comparison of data from one vehicle to another. An advantage of the current state of commercial vehicle multiplex communications systems is that, to a large extent, the format of certain data sets (ECU data, ABS data) of interest for crash reconstruction purposes have already been standardized.[[59]](#footnote-60) Since many of the data element sets have already been standardized, the addition of the few data channels that remain represents a minimal investment for manufacturers. The 2020 SAE J2728 recommends the use of SAE J1939-71 as a reference for formatting the recommended data elements, where applicable. Future HVEDR regulation could use SAE J1939-71 as the starting point for crash report format.

# **5.0 Survivability**

 The ability of the HVEDR memory to survive crashes is a key issue of consideration. Several factors to consider in the development of survivability requirements include the location of the device in the vehicle, impact shock, temperature, immersion, penetration, crush, fire, and independent power supply. In addition, the data sets should offer some protection from tampering, whether it is intentional or not. Below we present additional information for consideration related to each of these factors, but the extent to which any of these factors would require regulation would need additional study.

## 5.1 Location

 Location of the HVEDR in the vehicle is one important consideration. Proper placement of the device within the vehicle compartment will help minimize the likelihood that the data will be compromised by other survivability factors. Location within the vehicle compartment is likely to be more protective for heavy vehicles than it is for light vehicles, given their likely collision partners. We note that the EDR device location is not mandated for light duty passenger vehicles. Instead, the agency assumes that light vehicle manufacturers will locate voluntarily installed EDR devices in such a manner that the units are likely to be protected during a crash. In most cases, light vehicle EDR devices are located in the passenger compartment near the vehicle center of gravity.

Because of the breadth of different styles of heavy vehicles, the location of the HVEDR device may need to be optimized for each specific vehicle. Therefore, a mandate on a specific location for HVEDRs that are devices within a vehicle may not be possible. Heavy vehicle manufacturers, such as Volvo and Freightliner, report installing the HVEDR components in the occupant compartment, with the engine control data stored in a unit located on the engine. For the purposes of our discussions here, we are assuming that the HVEDR will be a device that will be mounted in a safe location (e.g. within the passenger compartment).[[60]](#footnote-61)

One strategy, recommended by FMCSA and SAE, may be to require that the HVEDR unit be contained within a separate electronic module. There are several advantages to requiring a separate module. First, the survivability of the HVEDR could be tested for compliance as a vehicle component rather than through vehicle testing, greatly reducing compliance test costs. Component testing is important given the myriad of potential vehicle end uses and designs. Such component testing would ensure that the HVEDR is capable of maintaining a data set under adverse environmental conditions. Second, the HVEDR could be located on the vehicle in an area that optimizes protection of the module from both environmental conditions, and crash conditions. Third, a modular format would facilitate data retrieval by enabling removal of the device for subsequent downloading in the severest of crashes. This subsequent downloading may be necessary if the crash conditions damage or restrict access the data port or make it unsafe to access the module at the scene.

Disadvantages of this strategy include increased development and manufacturing costs for heavy vehicle manufacturers as they prepare to incorporate HVEDRs, limitations on vehicle designs that may utilize a more distributed network of data collection and storage, increased visibility of HVEDR components for those who might tamper with or attempt to defeat the units, and limitations on potential areas in which to standardize installation given the breadth of vehicle end uses.

## 5.2 Impact

 To ensure that crash data are preserved, we believe that the HVEDR data storage function should be protected from impact damage. The two main sources of impact shock for HVEDRs installed in heavy vehicles are operational shock and crash shock. Operational shock is attributable to such minor events as curb strikes, potholes and other roadway conditions, load shift, and low speed impacts (e.g. collision with a loading dock ramp). These operational shocks vary widely in amplitude, duration, and frequency. Crash shock results from the rapid deceleration during a crash event or from strikes to the HVEDR from other vehicle components during the crash event.

The NHTSA T&B WG found that a 300 g, 50 ms component impact test would be sufficient to demonstrate that the HVEDR is resistant to crash impacts.[[61]](#footnote-62) They did not specify the shape of the impact pulse. If we assume a half-sine pulse with a peak of 300 g and a total duration of 50 ms, the velocity change (delta-V) of this pulse would be approximately 56 km/h (34.9 mph). FHWA recommended a half-sine pulse with a peak acceleration of 150 g and a 50 ms duration. Such a pulse would have a velocity change of 25 km/h (15.6 mph). It stated that the reduced impact force would be a more reasonable test for manufacturers to meet, and would better mimic the crash pulses in FMVSS Nos. 208[[62]](#footnote-63) and 214.[[63]](#footnote-64) We note that the crash characteristics of trucks and buses differ significantly from those of light duty vehicles. However, we do believe it is reasonable to assume that heavy vehicles would have similar crash speeds as other vehicles, even if the crash pulses are different. Any future regulation on HVEDRs would have to consider the need for crash impact requirements.

In addition to shock from crash impacts, FHWA recommended the impact resistance requirements of SAE J1455, “Recommended Environmental Practices for Electronic Equipment Design in Heavy-Duty Vehicle Applications,” to measure resistance to operational impacts such as stone strikes and vibrations. We note that the wide variety of heavy vehicle end uses greatly complicates the operational environments experienced by those vehicles. Because of this, it may be likely that the location of a HVEDR may necessitate exposure to hazards such as stone strikes, or elevated mechanical vibrations on a regular basis. Any future regulation would have to consider the need for operational impact and mechanical vibration requirements to ensure that HVEDRs will operate in such harsh conditions.

## 5.3 Temperature

 The NHTSA T&B WG found that fires occur in a small percentage of heavy vehicle crashes, so it did not recommend a test method for fire resistance. Additionally, agency crash data indicate that fires occur in less than one percent of real-world, tow-away crashes.[[64]](#footnote-65) However, recordings from crashes that result in fires may be important because other causal evidence may be destroyed.

Electronic modules are generally only rated to approximately 125 degrees Celsius (C),[[65]](#footnote-66) and are not designed to survive a fire. Agency research on fires within occupant compartments of GM vehicles[[66]](#footnote-67) indicates that temperatures near areas where EDRs and air bag control modules are typically located can be in excess of 600 degrees C.

 To address fires that occur as a result of crashes, FHWA proposed two additional temperature resistance tests. They estimated that intense fires may last up to 30 minutes. The first, a low-level fire resistance test, exposes the HVEDR to a temperature of 260 degrees C for 30 minutes. The second, a high-level fire resistance test, exposes the HVEDR to a temperature of 1,000 degrees C for 5 minutes. In both cases, the HVEDR would be required to retain crash data for the length of the test.

Interviews with OEM and suppliers performed as part of the agency research on EDR enclosures in light duty vehicles indicated that EDR enclosures are designed to meet the requirements of ANSI-IEC 60529-2004[[67]](#footnote-68) interior enclosure specifications.[[68]](#footnote-69) This specification provides guidance for dust and dripping water and the electronics are designed to withstand heat up to 100 degrees C. EDR component suppliers conduct additional tests by placing the EDR modules in an oven at temperatures between 120 degrees C and 150 degrees C. The agency research subjected 9 EDR modules to one hour exposures at temperatures of 100, 150, and 200 degrees C, and all survived. During pilot tests at 250 degrees C plastic enclosure components melted and board level components desoldered.

Currently, Part 563 has no fire protection or temperature resistance requirements for light vehicle EDRs. Since commercial trucks carry flammable materials and fuel tank capacity is much larger than light duty vehicles, the temperatures from fire resulting from a crash can quickly rise beyond the EDR designed enclosure specifications and temperature from fire can last for longer duration. Any future HVEDR regulation might need to carefully consider the need for a fire resistance performance requirement in the context of the field risk related to heavy vehicles and the practicability and cost of potential countermeasures.

On an operational basis, both FHWA and SAE recommended the operational temperature requirements of SAE J1455, which specifies tests to determine electronics performance at the typical temperature extremes experienced by heavy vehicles (-400 to +1250C).

Any future HVEDR regulation could look to previously established operational temperature requirements as a starting point for operational temperature resistance.

## 5.4 Immersion

 Sources of damage from fluid immersion include crashes resulting in the vehicle being immersed (e.g. in a lake), fluid leaks from other vehicle components, normal environmental operating conditions, vehicle power washing, and fluids used to extinguish a fire. Agency investigations of light duty vehicle crashes have anecdotally indicated that EDRs which have been immersed in water have retained and reported data after they were carefully dried prior to data retrieval (i.e. water immersion did not erase EDR data). In addition, we note that EDR circuit boards appear to have some minimal levels of protection from moisture. However, our experience is not such that we can draw broad conclusions about the general immersion protection of all EDRs. The agency has no requirements for fluid immersion resistance in Part 563 for light duty EDRs.

The T&B WG found that a shallow immersion of the HVEDR would suffice in demonstrating immersion resistance. At the time the T&B WG developed its recommendations, the agency was unaware of an industry test procedure that could potentially be evaluated and modified for its purposes. We note that FHWA has since recommended the fluid immersion test procedures in SAE J1455 to demonstrate resistance to moisture.

The agency research on EDR enclosures in light duty vehicles involved submerging EDR enclosures in either tap water or salt water for the period of 96 hours at a depth of 3 meters.[[69]](#footnote-70) This research showed that EDR data was extracted after extensive drying. Whether the tested conditions are representative of what a HVEDR would have to endure when submerged has not been determined. Any future regulation on HVEDRs could consider the need for immersion resistance consistent with the risk and potential practicability and cost of countermeasures. SAE J1455 could provide a starting point for such an analysis.

## 5.5 Penetration

 Penetration damage may occur when other vehicle components or objects from outside of the vehicle impact the HVEDR component housing over a narrow area during a crash. The principal direction of the impact during a crash event can vary widely. There are no specific penetration resistant requirements for light vehicle EDRs. However, it may be reasonable to consider such requirements for heavy vehicles because of differences from light vehicles in design and usage. For example, penetration damage from unsecured cargo or road debris is more likely to occur in a heavy vehicle than in a light vehicle, particularly for HVEDRs installed in a location outside of the protected passenger cabin. Additionally, we note that light vehicle EDRs are required to function after several crash tests, which provide some degree of assurance that they are protected. There are currently no crash test requirements for heavy vehicles. Therefore, physical protection of the HVEDR cannot be readily assessed as part of a crash test. For these reasons, a penetration resistance test may reasonably ensure that HVEDRs would survive such a narrow impact.

The T&B WG found that a 0.914 m (3 ft.) drop of 90.7 kg (200 lb) with a 12.7 mm (0.5 inch) diameter point would suffice in demonstrating penetration resistance. The FHWA proposed a 1.524 m (5 ft.) drop of 45.4 (100 lb) on a 6.4 mm (0.25 inch) diameter point. The FHWA proposal would result in reduced impact energy (678 J versus 813 J for the NHTSA T&B WG proposed test). However, because of the narrower point of contact, we estimate that the FHWA proposed test would exert a pressure over the point of contact of approximately 3.7 times greater than the NHTSA T&B WG proposal.[[70]](#footnote-71) SAE J2728-1 makes no recommendation for penetration resistance.

The FHWA proposal is based on an examination of similar requirements in various other transportation modes (aviation, light rail, automotive). It rationalized that the proposed 45.4 kg drop would produce about twice the energy of that required for light rail data recorders, and the reduced weight would be easier to implement than either the aviation requirement (227 kg), or the NHTSA T&B WG proposal (90.7 kg).

Any future regulation on HVEDRs could consider the need for penetration resistance requirements consistent with the risk and potential practicability and cost of countermeasures. The NHTSA T&B WG and FHWA test procedures could provide a starting point for such an analysis.

## 5.6 Crush

 In a similar manner as penetration damage, crush damage may occur when other vehicle components or objects from outside of the vehicle impact the HVEDR component housing during a crash. There are two main modes of failure associated with crush. First, when the load is applied perpendicular to a surface, the component housing may deflect and impact the more fragile electronics inside. Second, when the load is applied perpendicular to the “diagonals” or corners of the component, the housing may splay open creating a pathway for fluids or other environmental influences to enter the component and damage the electronics. We believe that resistance to crush is important for heavy vehicles because of the nature of how these vehicles are designed and used. Again, we note that light vehicles are crash tested, providing a minimal assessment of how the vehicle protects the EDR, whereas heavy vehicles are not required to be crash tested.

During a crash, crush may occur very quickly. However, because the EDR housing is typically metal, there is no time dependency associated with crush damage. Thus, a quasi-static test might be sufficient to replicate the dynamic crush. The NHTSA T&B WG found that a load of 500 lb applied perpendicular to the largest outward surface would suffice in demonstrating crush resistance. FHWA proposed a 1,500 lb load applied for 5 minutes to each face and each diagonal of the HVEDR. It believes that the 500 lb proposed by the NHTSA T&B WG may not be sufficient given the weight of a large truck, and instead estimated its proposal from the requirements for light rail data recorders (25,000 lb). In addition, FHWA estimates that the application duration and directions add greater consistency to the recommendation.

The agency research on EDR enclosures in light duty vehicles involved static crush tests that subjected the enclosures to 2500 lb to 6000 lb loads on either the top or side of the enclosure.[[71]](#footnote-72) The results indicated that side loading led to EDR enclosure failure and significant bending of the printed circuit board at 6000 lb. Depending on the location of HVEDR module and type of crash, the HVEDR enclosures could be subjected to much higher loads at different angles.

Any future regulation on HVEDRs could consider the need for crush resistance consistent with the risk and potential practicability and cost of countermeasures. The NHTSA T&B WG and FHWA test procedures could provide a starting point for such an analysis.

## 5.7 Tamper Resistance

 For the purpose of the following discussions, we are defining “tampering” to mean the deliberate altering or destroying of HVEDR data or the HVEDR itself, such that the data can no longer be retrieved. While the agency does not have any evidence that HVEDR modules are currently being physically compromised by tampering, we believe that it is theoretically possible for heavy vehicle operators to overwrite engine performance data related to a specific crash by continually cycling[[72]](#footnote-73) their vehicle on and off, assuming the vehicle is still in a condition where such cycling could occur. Also, it is possible that operators wishing to override other vehicle features could alter inputs to engine control modules, effectively falsifying the data collected by those units.

 While we have differentiated the HVEDR function from that of the ELDs[[73]](#footnote-74) regulated by FMCSA, we believe there is some synergy available to vehicle manufacturers to co-locate or correlate information between the two systems. To that end, any regulatory approach to minimizing tamper resistance of HVEDRs would be closely coordinated with FMCSA and FHWA requirements.

# **6.0 Event Description**

 In general, a crash is the type of event in which the agency has the greatest interest. It is from crash events that we can realize the greatest returns on vehicle safety from HVEDR data analysis. However, there are a myriad of crash-related events, such as high brake force applications, aggressive driving, driver controlled manual triggers, and vehicle monitoring situations, where the agency may wish to consider collecting data. Each of these scenarios will involve its own set of criteria that would trigger a HVEDR to begin recording data. The following paragraph details some of the conditions under which the agency may have an interest in a HVEDR recording crash data.

## 6.1 Event Trigger

 In light vehicles, sensors associated with air bag deployment have been used to trigger the initiation of EDR data capture. Typically, the vehicle air bag processor starts to collect data after a deceleration threshold of 8 km/h over 150 ms is measured for several samples.[[74]](#footnote-75) The initiation of data collection is often referred to as “algorithm enable.” After the event is over, the data are stored into the permanent memory modules.

 Aftermarket systems are used to capture data using various triggers to define the onset of an event. One such aftermarket system, Lytx DriveCam, uses an acceleration threshold to automatically record video (or lock an active recording loop) and other data. The system also incorporates a button for recording files at the discretion of the driver.[[75]](#footnote-76) For example, if the driver was cut off by another vehicle (s)he could press the button to collect the data related to the event. In a similar manner, some aftermarket data recorders can be triggered automatically, using predetermined acceleration thresholds or by other evasive maneuvers like sudden steering input beyond a few degrees of turn, rapid braking, sudden lane departure, etc., using other data channels and appropriate thresholds. The exact threshold is user specified, and can be set high (approximately 2-3g) to limit the collection to crash-related events or lower (approximately 1g) to collect both crash-related events and driving-related events, such as hard braking.

 There appears to be two prominent methods of determining an event – automatic and driver controlled. For automatic systems, thresholds are set to predetermined levels, which are dependent on two major considerations – the data parameter which is monitored (brake application, deceleration, etc.) and the class of events which are being recorded (crash, driver actions, etc.).

 The 2002 report from the NHTSA T&B WG focused on HVEDRs used for collecting data related to crashes. Thus, the WG found that basing the trigger for the event on vehicle deceleration would be most appropriate. The NHTSA T&B WG also determined through discussions with its members, that heavy vehicles act differently than light vehicles in a crash scenario. The NHTSA T&B WG found that a threshold in the range of 2 to 4g could be used to determine whether a crash has occurred for heavy vehicles.

 Additionally, in examination of two crash tests of full-sized school buses – one full-frontal into a rigid wall and the other a lateral hit near the front wheel by a large straight truck, the NHTSA T&B WG found that in a frontal crash, the acceleration profile throughout a vehicle is fairly constant. This was not true in a side crash, where the crash pulse varied significantly along the length of the bus. The highest acceleration measured was aligned with the impacting vehicle, whereas at the furthest position from the impact the lateral acceleration was dramatically diminished. The NHTSA T&B WG found that vehicle rotation significantly confounds the crash pulse measured by the linear accelerometers.

 The FHWA report[[76]](#footnote-77) found that crash events involving a large delta-V or a large acceleration/deceleration pulse over a short period of time would be relatively easy to detect and trigger EDR data storage on large trucks. However, many crashes involving large trucks where the collision partner is a light vehicle may not be easily detected due to weight differences between light and heavy vehicles. Also, vehicle dynamics are important when articulated vehicles are involved in crashes. For example, if a light vehicle hits a truck’s trailer perpendicular to the long axis of the trailer at the trailer’s rear axle, a HVEDR on the tractor may not detect the impact. In order to detect trailer impacts, a second EDR could be mounted in the trailer. As a result, additional crashes may be detected with two EDRs that could record the acceleration and angular rotation of both the tractor and trailer. FHWA proposed that an EDR on the trailer could be set up to only record trailer dynamics and communicate with the primary EDR.

 FHWA noted that a false trigger may occur when an event is incorrectly recorded as a crash if the crash detection parameters are not adjusted properly. Also, crash-like events that occur during normal truck operations may be difficult to filter out. For example, coupling a tractor to a fully loaded trailer may be recorded as a rear-impact to the tractor. They believe that in order to minimize the number of false triggers, reliable data pertaining to large truck vehicle dynamics and operating parameters in various types of crashes, such as magnitude, duration, and frequency, should be used for the development of crash detection algorithms.

 Lastly, FHWA stated that a manual feature could also be used to trigger an HVEDR recording. A driver-initiated event could be recorded when a driver presses a manual record button. A HVEDR would record the time that the button was pressed and store all vehicle dynamics and operational data in its memory for the time surrounding the event. Since EDR data are stored in a circular buffer, the recorded “pre-trigger” data would capture the event.

 NHTSA believes that several types of vehicle sensor/system failures could also be used to trigger a vehicle-initiated event on an HVEDR. For example, a sudden loss of brake system air pressure could trigger an HVEDR recording event. These failures could potentially indicate a crash causation factor if the system failure event occurs relatively close to the time an actual crash event occurs. Similarly, a tire blowout may trigger the HVEDR to begin recording data. NHTSA can envision a scenario where the vehicle operator might try to bring the vehicle to a controlled stop but lose control. In such a case, the loss of control, potential flagged by a variety of sensors, may be the triggering event and regardless of whether this results in a vehicle crash, the post-trigger interval (event interval) may be much longer than when the trigger is an air bag deployment or vehicle deceleration associated with a crash.[[77]](#footnote-78) Thus, such a sensor trigger, relatively far in advance of a potential crash necessitates the consideration of longer crash (event interval) recording. Section 4.4 above discusses considerations of pre-crash and crash recording intervals.

 Since many different types of system failure event triggers could overcomplicate the overall HVEDR system, the types of events that trigger HVEDR data capture should be considered against their relationship to safe operation of the vehicle.

 As noted above, SAE J2728-1 identified three event trigger criteria. Like the NHTSA T&B WG, FHWA, and FMCSA, SAE adopted an acceleration trigger with a threshold around 2 to 3 g. Alternate triggers identified in J2728-1 include a safety system trigger and a last stop trigger. The safety system trigger would signal the HVEDR to record data upon activation of alerts from safety systems (e.g. safety restraint system, ABS system, adaptive cruise control/automated braking, and electronic stability control). The last stop trigger would signal the HVEDR to capture data once the vehicle speed falls below 3.0 km/h for 15 seconds or more.

#### 6.1.1 Acceleration Trigger

 Vehicle accelerations are widely recognized as early indicators of crash occurrences. As such, HVEDRs could record data once a deceleration limit has been met. Based on the T&B WG, FHWA, FMCSA, and SAE recommendations, an acceleration trigger threshold in the 2-4 g range might be appropriate for HVEDRs. Some crash types will be difficult for the HVEDR to trigger because of low crash pulses. Therefore, it may be appropriate to consider a wide range of trigger threshold levels so that manufacturers may design HVEDRs for the specific needs of each vehicle end use. In addition, in consideration of any type of requirement, the agency should ask for public comment on whether or not this minimum range is appropriate, if there are alternatives to this trigger that should be considered, and if we need additional data (e.g. an element identifying the minimum trigger threshold) to ensure that HVEDRs are appropriately capturing crashes.

#### 6.1.2 Occupant Restraint System Deployment Trigger

 As with light duty vehicles, NHTSA remains interested in the safety system performance of heavy vehicles. Because of this interest, it may be appropriate for HVEDRs to capture data upon deployment of any occupant restraint system in heavy vehicles, regardless of if the deployment was the result of a crash. A deployment trigger might afford the agency valuable data with which to assess the performance of active heavy vehicle restraint systems such as air bags, seat belt pretensioners, and inflatable knee bolsters, if available.

#### 6.1.3 Last Stop Trigger

 One triggering mechanism commonly used in HVEDRs to track operator and vehicle performance is the “last stop trigger.” This trigger signals the data recorder to capture data once the vehicle is brought to a stop and the engine is shut off. For example, in a minor crash between a passenger vehicle and a large truck, the smaller vehicle could experience much more severe damage than the truck. Should the HVEDR not be triggered during the event, a “last stop” trigger could begin the capture of crash data of interest to the agency. One problematic aspect of a “last stop trigger” could be an event of interest being too far removed in time from engine shut off for the data recording loop to be able to capture the event. This could be mitigated by a manual trigger, as discussed below. The “last stop trigger” may merit consideration as a supplement to other event triggers.

#### 6.1.4 Manual Trigger

 A manual HVEDR trigger would essentially be a panic button so that the vehicle operator might capture data during pedestrian impacts, abnormal vehicle operations, minor vehicle-to-vehicle crashes, etc.[[78]](#footnote-79) Drivers may also initiate the recording of the vehicle state during an abnormal event, and can record events when witnesses are not present at the scene. Anecdotal evidence from users of aftermarket systems, such as Lytx DriveCam, indicates that such manual triggers are not only useful for capturing data regarding extremely low delta-V crashes or near misses, but provide operators with valuable training tools. Additionally, we envision that such data could be utilized by the agency for reducing pedestrian injuries or studying driver behaviors to promote best practices.

 Drawbacks of manual triggers would include the potential for other HVEDR events to be overwritten, missed data due to driver failure to remember to use an HVEDR recording button, driver unwillingness to admit fault when an event has occurred, or driver distraction due to the demands of properly operating the vehicle. While we recognize that such drawbacks exist, the potential benefits of a manual trigger could outweigh the drawbacks, and strategies exist for mitigating such drawbacks. In order to mitigate such drawbacks, manufacturers may wish to include alternate triggers such as heavy braking or dual pedal applications to signal HVEDRs to begin recording if an operator fails to manually trigger a minor event that is of interest to the fleet manager. Or, manufacturers may employ strategies for prioritizing which non-crash events are overwritten in the event that an operator manually triggers several events and the memory buffers have become full. Finally, manufacturers may employ a strategy whereby manual triggers could not overwrite an event triggered via vehicle deceleration or safety system deployment, but simply indicate if and when a manual trigger occurs during the event interval.

#### 6.1.5 Crash Avoidance System Trigger

With the introduction of crash avoidance system triggers in the 2020 SAE J2728 standard it may be appropriate for NHTSA to consider requiring that HVEDRs capture data upon the activation of any crash avoidance system (i.e., ESC, collision warning and automatic emergency braking systems) in heavy vehicles, regardless of if it was the result of a crash. With NHTSA’s interest in evaluating the potential benefits of new and existing in-vehicle crash avoidance technologies, a crash avoidance system trigger might provide the agency data with which to assess the performance of these systems in heavy vehicles.

# **7.0 Regulatory and Other Policy Issues**

 The following sections identify areas that the agency would need to address during the development of any future rule that regulates installation of HVEDRs.

## 7.1 Voluntary vs. Required HVEDRs

 When the light duty vehicle rulemaking was proposed, the agency opted to promulgate requirements for voluntarily installed EDRs in light vehicles at that time. Some of the concerns regarding the installation of EDRs in light vehicles included cost increases to consumers and potential consumer privacy concerns.[[79]](#footnote-80) These same concerns may not exist for heavy vehicles.

With regard to consumer privacy concerns, we note that heavy vehicles require commercial licenses to operate. The licensing requirements for operating and maintaining the affected vehicles are heavily regulated through State and Federal programs. These licensing and operation requirements, to a certain extent, limit the amount of privacy that the vehicle operator can expect. Further, consumer use of these vehicles is typically related to chartered or public transit, during which there exists a reduced expectation of privacy and a greater expectation of regulatory management and accountability. However, despite this, and based on FMCSA’s experience in attempting to establish rules for EOBRs,[[80]](#footnote-81) we believe a proposal to mandate installation could garner significant response seeking to limit the data collected and protect operator privacy. Privacy concerns also arise in the data element differences between HVEDRs, which may record VIN and global positioning, and light vehicle EDRs, which do not record any sensitive information such as the VIN and global positioning. NHTSA would need to carefully consider the legal and privacy concerns in choosing whether or not to mandate installation of HVEDRs.

With regard to cost concerns, we note that costs for commercial vehicles range much higher than the costs for consumer passenger vehicles. Therefore, as a percentage of the overall vehicle costs, a HVEDR represents a much smaller portion of the vehicle cost. However, because of the difficulty in estimating the benefits of HVEDRs, we are concerned about the societal cost of mandating HVEDRs. We note that the crash data available to the agency for heavy vehicles is more limited than for light vehicles, so the need for more robust crash data is greater.

Part of the justification to originally make EDRs optional for light vehicles was the fact that the vast majority of vehicles had them due to the integration with the air bag control systems. Given the fact that most heavy vehicles are not equipped with air bags, current levels of HVEDR installation are relatively low.[[81]](#footnote-82) Without a mandate for their installation, they are likely to remain low.

Important to any decision to mandate EDR installation would be the method by which they would be regulated. In early considerations for light duty EDRs, the agency chose not to mandate installation but remained open to considering this in the future. Subsequently, the agency proposed to mandate installation of light duty EDRs covered under Part 563 (77 FR 74144) to ensure that all vehicles include EDRs to improve crash and defect investigations and ensure robust data to assist safety researchers, vehicle manufacturers, and the agency to understand vehicle crashes better and more precisely. In 2019, NHTSA withdrew this proposal due to the near universal installation of EDRs on light vehicles (99.5 percent for MY 2021 vehicles) (84 FR 2804). Even so, any potential future regulatory proposal for HVEDRs would need to deal with some of the same enforcement issues as light vehicles.

## 7.2 Lead Time and Phase In

As with any other rulemaking action, any future HVEDR proposal would need to consider the lead time and phase-in appropriate to the requirements being proposed. To the extent data elements would be present in data collected by the ECU and/or transmitted through existing CAN system, less lead time and phase-in would be needed. Nonetheless, consideration of the time required for modifications to communication architecture will be necessary. It will also be important to consider the data that necessitates additional sensor and hardware installation and integration.

## 7.3 Costs

 In December 2005, FMCSA published cost estimates[[82]](#footnote-83) for implementation of heavy vehicle data recorders. The estimates were collected to better understand the development and production costs for various HVEDR concepts. The cost estimates were broken down into three categories – engineering development costs, application costs, and hardware costs.

 In the FMCSA report, three vehicle data recorder concepts were considered in the cost analysis – a “core event” recorder concept, a “core operational efficiency” concept, and a “full featured” recorder concept. For the purposes of discussion here, the core event recorder equates roughly to the Tier 1 elements identified above, and the full featured concept equates roughly to the combination of Tiers 1-3 identified above. In addition to the recorder estimates, the FMCSA further assessed costs associated with data storage and video capability.

We note that the agency would need to prepare a cost/benefit analysis for any future HVEDR rule to estimate the impact of HVEDR installation on manufacturers, operators, and small businesses. In the absence of a rigorous analysis, we will for the purposes of discussion use the FMCSA estimates to develop a general idea of the implementation cost range for installation of HVEDRs in large trucks and buses. However, NHTSA notes that these estimates may be on the high-end by the time this technical document is published because the cost of important components of an HVEDR, such as digital memory tends to decline rapidly.

#### 7.3.1 Estimated Data Storage Cost Range

 Based on the FMCSA data, we estimate that the Tier 1 data elements[[83]](#footnote-84) represent a low-cost event-triggered data recorder to be used for crash reconstruction purposes. It is envisioned that the bulk of the data will be drawn from existing subsystem ECUs and would be available over the existing vehicle communication networks. In addition to the existing data feeds, the HVEDR would need to incorporate a three-axis accelerometer (to record longitudinal, lateral, and vertical impulses), unless the vehicle is air bag equipped. It will also require the addition of several vehicle sensor systems not currently employed in all heavy vehicles (e.g. emergency brake status, seat belt status, and pedal position sensors).

 Similarly, we estimate that the combined Tier 1 through 3 data elements[[84]](#footnote-85) represent a full featured HVEDR that combines crash reconstruction capabilities with operational efficiency data and vehicle monitoring data. Again, such a full featured HVEDR would incorporate existing subsystem ECU data feeds with a three-axis accelerometer and other sensing/monitoring system data feeds to capture a fuller picture of the events shortly preceding and during a crash or triggering event. For the purposes of this analysis, the audio and video data cost estimates were not included but are included in the subsequent cost discussions on optional data elements.

The FMCSA report provided details on the memory requirements for each concept system. These data memory estimates were developed to provide a rough basis for determining the costs associated with data storage for each proposed concepts, but they do not include any anticipated programming, file structure, or other identifying data stored in the HVEDR memory.

**Table 7.1 – Summary of Estimated Data Element Memory Requirements**



 The FMCSA report estimated the cost for the different concepts to be between $145 and $460 per HVEDR unit in 2004 dollars. For the purposes of this document we will assume cost for EDR Concept #1 represents a system meeting the Tier 1 requirements and the higher end of the range, or Concept #5, represents a system meeting Tier 1 through Tier 3. Additional one-time costs in development of the HVEDRs would include tooling, software development, testing, and vehicle integration. Additionally, most manufacturers do not provide commercially available tools for access to the ECMs onboard. These one-time costs could range as high as $75,000 to $100,000 per vehicle model.

#### 7.3.2 HVEDR Internal Memory Costs

 Memory type and size selection for a video data recorder (VDR) is important and depends largely on the intended application. Based on the data element memory estimates identified in Table 7.1, it is expected that the Tier 1 data elements would require approximately 1 Megabytes (Mb) of space, whereas the combined Tiers 1 through 3 would require approximately 2 Mb of space (not including video data). Therefore, memory costs would range from $6 to $12 for EEPROM chips, and from $2 to $4 for flash memory.[[85]](#footnote-86)

#### 7.3.3 Digital Video Capture Costs

Digital video capture could range from as little as $50/camera to over $4000 depending upon the system complexity.[[86]](#footnote-87) Common format for video are 1280x720 and 1920x1080 pixels per frame at 30 Hertz (frames/sec).[[87]](#footnote-88) Assuming that the video is in 16 bits color (i.e., each pixel’s color is represented in binary by 16 bits), one second of video would require over 16 Megabits (Mbits) (16 bits/pixel x 1920 pixels x 1080 pixels x 30 frames/sec = 995 Mbits) or 125 Mb of memory. Therefore, a minute of uncompressed video would require 7.5 Gb, and a 90-minute movie requires 675 Gb.

Historically, when video cameras were analog, the most sophisticated hardware was the digital video recording (DVR) hardware. The DVR hardware is basically an analog-to-digital converter that converts the analog video signal from the camera into digital video. The hardware usually also included the necessary software to perform the video compression. DVR cards vary in complexity and cost based on the number of video inputs (usually 2 to 16), frame rate, resolution, and compression technology. With the advent of digital cameras, the raw digital video data is converted in the camera to some compressed file format.

Some large fleet operators are already using dash mounted cameras which record certain events based on some fixed triggers. The video is uploaded in real time to the central server of the fleet operator via an embedded cell phone device in each truck. Large trucking companies are making use of this service for training and to reduce driver-related errors.

## 7.4 Agency Databases and Information Collection Activities

 One area of careful consideration for the agency would be how the agency intends to collect and use data from HVEDRs. There are several policy considerations that fall under the information collection and database issue. Some of these issues are outlined here.

#### 7.4.1 HVEDR Data Collection Policy Considerations

One policy consideration is the usefulness of data collected from HVEDRs. We note that the agency has proposed[[88]](#footnote-89) and subsequently withdrew[[89]](#footnote-90) a notice to mandate installation of EDRs in passenger vehicles with GVWRs of 3,855 kg (8,500 lb) or less. Relatively recent data indicates that 99.5 percent of 2021 model year light vehicles with a GVWR of 3,855 kg (8,500 pounds) or less have EDRs compliant with Part 563. Given that 71 percent of fatalities in crashes involving large trucks were occupants of other vehicles, and that nearly all new light passenger vehicles have EDRs, in the future, crashes involving heavy vehicles will have EDR data available for at least the collision partner. That collision partner is much more likely to contain an occupant fatality. Given these facts, it would be reasonable and prudent for the agency to explore whether the inclusion of a HVEDR on commercial vehicles provides sufficient additional information that would be beneficial to the agency. A corollary to this question is whether the existing technical, or potential improvements to, capabilities of HVEDRs will provide a data set useful for improving occupant safety within the heavy vehicle.

#### 7.4.2 Crash Data Collections

Establishment of any HVEDR requirements would necessitate an agency review of existing crash investigation protocols under CISS and FARS to extend collection of crash information to the data contained in a HVEDR. Since much of this data is collected well after the fact, we rely mainly on police reports and photos from the scene. In many light vehicles to truck crashes, the truck drives away and we may only collect the truck’s VIN. The agency would then need to consider the benefit of tracking down the subject truck to download what might be minimally useful information.

Among the several comments received by the agency on the data modernization project[[90]](#footnote-91), several commentators agreed that collecting EDR data in light duty vehicles is important, but not a good substitute for on-scene crash data collection. The same argument can be extended for HVEDRs in trucks and buses. The future of HVEDR crash data collection also relies on an upgraded NHTSA crash data collection database design to incorporate electronic storing of HVEDR records, additional costs associated with Bosch Crash Data Retrieval (CDR) tools, training, staffing and linking of data extracts to other supporting on-scene crash data.

## 7.5 Enforcement

 If the agency were to move forward with requirements for HVEDRs, we would need to consider how we would intend to enforce those requirements. Heavy vehicles are not crash tested, so the agency currently has no means with which to ensure that HVEDRs would collect crash data within the ranges and accuracies specified without performing test for that express purpose. This may necessitate the need to explore the possibility of component testing to verify HVEDR performance to the extent possible.

## 7.6 Benefits of HVEDRs in Understanding Crash Modes and Injuries

As has been the case for light vehicle EDRs, it will be difficult to ascribe estimates of lives saved or injuries prevented to regulatory requirements for HVEDRs. Nonetheless, installation of HVEDRs has the potential of providing additional insight into crash causation, driver avoidance maneuvers, and crash dynamics, which will supplement agency investigations. As a whole, the crash investigation and supplemental HVEDR data could then be used to help reduce the nearly 3,800 fatalities per year in large truck and bus crashes. Similarly, these data could be used to aid the agency in further understanding the nature and severity of injuries incurred by occupants of other vehicles or pedestrians involved in crashes with heavy vehicles.

# **8.0 Agency Conclusions**

 Upon consideration of the issues identified above, the agency has tentatively concluded that it is not yet ready to develop regulations for HVEDRs. Significant informational gaps remain in the areas of operator privacy, system costs, and the data elements that would be important for agency crash analysis. We note that FMCSA’s revised EOBR rule, now termed an electronic logging device or ELD,[[91]](#footnote-92) may inform whether NHTSA has a sound regulatory and legal framework if it were to regulate the installation of HVEDRs. Further, many of the important crash characteristics are obtainable through a traditional crash investigation. For those data elements of most interest that are not available through investigative means, (e.g., vehicle acceleration or advanced safety technology activation), recording such data on an HVEDR would require installation of additional sensor systems. The added expense of installing sensors to collect these additional data and meet the requirements of a HVEDR rulemaking is likely to remain high for the foreseeable future and would make justification of a HVEDR mandate difficult through a cost-benefit analysis. We note that as heavy vehicles begin and/or expand the adoption of new crash avoidance technologies, and ADAS, these cost considerations may change. Further, NHTSA continues to research, and also engage in international activities surrounding expanded data logging approaches, and data recording triggers that may appropriately support analyses of incidents that could occur while emerging driving automation systems, including future ADSs, are engaged. We will continue to monitor the issues surrounding HVEDRs, related data standards, and emerging technologies and revisit the possibility of developing a regulatory proposal at a future date.

# **Appendices**

## **Appendix A – SAE J2728-1, Recommended data elements.**

Table A1: SAE recommended data elements

|  |  |  |  |
| --- | --- | --- | --- |
| **Data Element** | **Description** | **Comment** | **Use** |
| 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, alphanumericidentifier substitute for the VIN | Header |
| Event data recording complete | This data indicates whether a complete set of data that the event data recording device is designed to capture wassuccessfully recorded by and stored in the device. |  | Header |
| Event date | The date when the event occurred. | Date MM/DD/YYYY(PGN 65254 SPN 964,962,963) | Header |
| Engine hours | Number of hours that the engine has been operated from time of control unit first use to the time of the event trigger. | PGN 65253 SPN 247 | Header |
| Odometer | Total vehicle distance at the time of the event trigger. | PGN 65248 SPN 245 (or PGN 65217 SPN 917) | Header |
| Latitude | Vehicle position per GPS at the time of the event trigger. | PGN 65267 SPN 584 | Header |
| Longitude | Vehicle position per GPS at the time of the event trigger. | PGN 65267 SPN 585 | Header |
| Event time | The time when the event occurred. | Time HH:MM:SSGMT: 24-hour clockThe HVEDR should provide its own real-time clock capability, including battery backup, but may reference PGN 65254 SPN 961,960,959 | Header |
| HVEDR make | Manufacturer name for HVEDR. |  | Header |
| HVEDR model | Model number for HVEDR. |  | Header |
| HVEDR serial number | Serial number for HVEDR. |  | Header |
| Rear axle ratio | Ratio of transmission output shaft speed to tire revolution rate. |  | Header |
| Tire size | Tire size in revolutions per km. |  | Header |
| Trigger thresholds | Lists the currently configured trigger threshold(s). | This should show relevant thresholds for this event record, as defined in 3.1. | Header |
| Trigger threshold activated | Indicates which trigger threshold was activated to cause the recording the event. | Indicate what caused the record to be created | Header |
| VIN | Indicates the vehicle identification number (VIN) assigned by the vehicle manufacturer. | PGN 65260, SPN 237 | Header |
| Vehicle configuration | A free-form text field for vehicle configuration. | PGN 65259 and PGN 65242 for available ECU HW and SW part numbers | Header |
| Vehicle StateStandard Driver Controls and Vehicle State |
| Vehicle speed  | The longitudinal speed of the vehicle that is calculated or estimated from the vehicle speed sensor (VSS).  | PGN 65265 SPN 84 | Pre-event Post-event |

|  |  |  |  |
| --- | --- | --- | --- |
| **Data Element** | **Description** | **Comment** | **Use** |
| Front axle, left wheel speed | ABS wheel based vehicle speed. | PGN 65134 SPN 1592 (or PGN 65215 SPN 904 if HRWnot available) | Pre-event Post-event |
| Front axle, right wheel speed | ABS wheel based vehicle speed. | PGN 65134 SPN 1593 (or PGN 65215 SPN 904 if HRWnot available) | Pre-event Post-event |
| Rear axle, left wheel speed | ABS wheel based vehicle speed. | PGN 65134 SPN 1594 | Pre-event Post-event |
| Rear axle, right wheel speed | ABS wheel based vehicle speed. | PGN 65134 SPN 1595 | Pre-event Post-event |
| Retarder torque mode | State signal which indicates which retarder torque mode is currently generating, limiting, or controlling retarder torque. | PGN 61440 SPN 900 | Pre-event Post-event |
| Brake status - parking | Indicates the status of the switch that is installed to detect whether or not the parking brake has been applied. | PGN 65264 SPN 70 | Pre-event Post-event |
| Brake status - service | Indicates the status of the switch that is installed in brake system to detect whether the service brake has been applied. This switch is usually used toturn on the brake lamps. | PGN 65264 SPN 597 | Pre-event Post-event |
| Engine speed | Rotational speed of the engine output shaft. | PGN 61444 SPN 190 | Pre-event Post-event |
| Engine load | Percent of available engine torque being generated | PGN 61444 SPN 513 | Pre-event Post-event |
| Clutch switch | Indicates the status of the switch that is usually installed in or connected to theclutch pedal to detect whether or not the clutch pedal is depressed. | PGN 65264 SPN 598 | Pre-event Post-event |
| Accelerator pedal position | Ratio of the throttle pedal opening (driver’s operation) in percent. | PGN 61443 SPN 91 | Pre-event Post-event |
| Antilock Braking System |  |
| ABS brake control status - tractor | Indicates the status of the ABS brake control system on the vehicle/tractor, active or not active. | PGN 61441 SPN 563 | Pre-event Post-event |
| ABS warning lamp status - tractor | Indicates the status of the ABS warning light on the vehicle/tractor, on or off. | PGN 61441 SPN 1438 | Pre-event Post-event |
| ABS brake control status - trailer | Indicates the status of the ABS brake control system on trailer(s), active or not active.Active if ABS brake control is active for any trailer. | PGN 61441 SPN 1836 | Pre-event Post-event |
| ABS warning lamp status - trailer | Indicates the status of the ABS warning light on trailer(s), on or off.On if ABS warning light is on for any trailer. | PGN 61441 SPN 1792 | Pre-event Post-event |
| Cruise Control Systems |
| ACC mode | Control status of adaptive cruise control. | PGN 65135 SPN 1590 | Pre-event Post-event |
| ACC set distance mode | Driver setting of following distance sensitivity. | PGN 65135 SPN 1589 | Header |
| Cruise control set- speed | The speed to which the cruise control is set. | PGN 65265 SPN 86 | Pre-event Post-event |
| Cruise control states | The current state, or mode, of operation by the cruise control device. | PGN 65265 SPN 527 | Pre-event Post-event |
| Collision Warning and Automated Braking(Should include data about a relevant detected object, including: speed, distance, time to collision, any warning levels issued to driver, and automated brake intervention) |
| Time to collision with relevant object | The time to collision is the duration after which the predicted travelling paths of host vehicle and relevant object lead to a distance of 0 m between both. | PGN 61487 SPN 5680 | Pre-event Post-event |
| Collision warning level | Forward collision advanced emergency braking system state. | Human machine interface concepts, e.g., visual only, visual/audible, different warning tonesPGN 61487 SPN 5677 | Pre-event Post-event |
| Speed of forward vehicle | Absolute velocity of the preceding vehicle situated within 250 m in the same lane and moving in the samedirection. | PGN 65135 SPN 1586 | Pre-event Post-event |
| Distance to forward vehicle | Distance to the preceding vehicle situated within 250 m in the same laneand moving in the same direction. | PGN 65135 SPN 1587 | Pre-event Post-event |
| XBR control mode | ABS status indicating external brake request. | Shows drivers demand and automated demand signal PGN 64964 SPN 2918 | Pre-event Post-event |
| Lane Departure |
| Lane departure warning, right | Warning command from lane departure detection. | Use one or more of the following to indicate lane departurePGN 61447, SPN 3566, SPN 1701,SPN 8135, SPN 8137,or SPN 9749 | Pre-event Post-event |
| Lane departure warning, left | Warning command from lane departure detection. | Use one or more of the following to indicate lane departurePGN 61447 SPN 3565, SPN 1700, SPN 8136, SPN 8138or SPN 9750 | Pre-event Post-event |
| Lane departure warning system state | Indicates the status of lane departure warning system. | Lane departure warning system state PGN 65115 SPN 8141 | Pre-event Post-event |
| Stability Control |
| Steering wheel angle | Angle of the steering shaft connected to driver control. | PGN 61449 SPN 1807 | Pre-event Post-event |
| ROP engine control | Stability control of engine retarder for roll over protection. | PGN 65103 SPN 1816 | Pre-event Post-event |
| ROP brake control | Stability control of wheel brakes for roll over protection. | PGN 65103 SPN 1818 | Pre-event Post-event |
| YC engine control | Stability control of engine retarder for yaw control. | PGN 65103 SPN 1817 | Pre-event Post-event |
| YC brake control | Stability control of wheel brakes for yaw control. | PGN 65103 SPN 1819 | Pre-event Post-event |
| VDC system state | VDC fully operational. | Indicates whether VDC is fully operational or whether its functionality is reduced by a permanent or temporary condition or actionPGN 65103 SPN 1814 | Pre-event Post-event |
| Blind Spot |
| Blind spot system status | Operating status of system. | PGN 61958 SPN 12286 | Pre-event Post-event |
| Blind spot warning | Warning command to operator. | PGN 61958 SPN 12287 | Pre-event Post-event |
| Occupant Safety System |
| Crash notification | Indicates detection and type of crash by installed crash mitigation system. | PGN 61483 SPN 4973 | Pre-event Post-event |
| Seat belt status (driver) | Shows if buckled or not. | PGN 57344 SPN 1856orPGN 64791 SPN 4952 | Header |
| Seat belt status (passenger) | Shows if buckled or not. | PGN 64791 SPN 4953 | Header |
| Safety restraint system status | Operating status of system. | Warning to driver about system failure | Pre-event Post-event |

## **Appendix B – Vehicle Communications Networks Standards**

**SAE J1708, *Serial Data Communications Between Microcomputer Systems in Heavy-Duty Vehicle Applications***,[[92]](#footnote-93) defines a recommended practice for implementing a bi-directional, Class B serial communication link among vehicle ECUs. SAE J1708 defines the hardware and basic software compatibility such as the interface requirements, system protocol, and message format of the serial communications link. SAE J1708 does not define actual data to be transmitted by particular ECUs, which is an important aspect of communications compatibility, and is left to other standards and individual manufacturers to define.

**SAE J1587, *Joint SAE/TMC Electronic Data Interchange Between Microcomputer Systems in Heavy-Duty Vehicle Applications***, builds on J1708 to define the diagnostic serial communications link between onboard ECUs and offboard diagnostic equipment. It defines the format of messages and data to be transmitted including field descriptions, size, scale, internal data representation, and position within a message.

**SAE J1939, *Recommended Practice for a Serial Control and Communications Vehicle Network***,[[93]](#footnote-94) is intended for light-, medium-, and heavy-duty vehicles used on or off road as well as appropriate stationary applications that use vehicle-derived components (e.g., generator sets). Vehicles of interest include, but are not limited to, on and off highway trucks and their trailers; construction equipment; and agricultural equipment and implements. The purpose of J1939 is to provide an open interconnect system for electronic systems. J1939 is designed to allow ECUs to communicate with each other by providing a standard architecture.

**ISO 11898*, Road Vehicles: Interchange of Digital Information Controller Area Network (CAN)* *for High-Speed Communication***, describes the general architecture of CAN in terms of hierarchical layers according to the ISO reference model for Open System Interconnection (OSI), which is a standard for worldwide communications that defines a networking framework for implementing protocols in seven layers. The standard contains detailed specifications of aspects of CAN belonging to the physical layer and the data link layer. It specifies characteristics of setting up an interchange of digital information between electronic control units of road vehicles equipped with CAN at transmission rates above 125 kilobits per second up to 1 megabit per second. The CAN is a serial communication protocol that supports distributed real-time control and multiplexing.

**ISO 11992, *Road Vehicles: Interchange of Digital Information on Electrical Connections* *Between Towing and Towed Vehicles***, The ISO 11992 series specifies the interchange of digital information between road vehicles with a maximum authorized total mass greater than 3,500 kg. The series also specifies digital information interchange for towed vehicles, including communication between towed vehicles in terms of parameters and requirements of the lower OSI layers (physical and data link layer) of the electrical connection used to connect the electrical and electronic systems. ISO 11992-1 specifies the data link and physical layer requirements of the CAN communication bus between towing and towed vehicles. ISO 11992-2 specifies the parameters and messages for electronically controlled braking systems, including anti-lock braking systems (ABS) and vehicle dynamics control systems (VDC), as well as for running gear equipment (i.e. systems for steering, suspension, and tires), to ensure that the data communication interchange of information between road vehicles with a maximum authorized total mass greater than 3,500 kg and their towed vehicles, including the communication between (several) towed vehicles, on a dedicated network. ISO 11992-3 specifies the application layer, the payload of messages, and parameter groups for equipment other than brakes and running gears, to ensure the interchange of digital information between road vehicles with a maximum authorized total mass greater than 3,500 kg and their towed vehicles, including communication between towed vehicles. ISO 11992-4 specifies the diagnostic communication over a CAN between the towing and towed vehicle(s) of a commercial vehicle and its trailer(s), according to ISO 11992-2 or ISO 11992-3, which allows a diagnostic tester (client) to control diagnostic functions in an on-vehicle ECU (server) embedded in a road vehicle using the communication gateways between the vehicles.

1. In a separate rulemaking on EDRs for light passenger vehicles, the agency will consider expanding the scope of Part 563 to include vehicles with GVWRs between 3,855 kg (8,500 lb) and 4,536 kg (10,000 lb). We are, therefore, not considering vehicles in this weight range within this document. [↑](#footnote-ref-2)
2. Further clarification of vehicle applicability is discussed in Section 2.4.1. [↑](#footnote-ref-3)
3. Despite not being regulated, there are vehicles with a GVWR over 10,000 lbs equipped with light vehicle EDRs (e.g., large pickup trucks). [↑](#footnote-ref-4)
4. Examples of such systems include Detroit Assurance by Detroit Diesel, Vital Information Management System by Caterpillar, and Road Relay 4 by Cummins, among others. [↑](#footnote-ref-5)
5. Examples include Lytx DriveCam (www.lytx.com) and Safety Vision (www.safetyvision.com), among others. [↑](#footnote-ref-6)
6. NTSB recommendation H-97-18 recommended that NHTSA develop and implement, in conjunction with the domestic and international automobile manufacturers, a plan to gather better information on vehicle crash pulses and other crash parameters in actual crashes, utilizing current or augmented crash sensing and recording devices. This recommendation was closed by the NTSB in 2004. See www.ntsb.gov for more information. [↑](#footnote-ref-7)
7. National Transportation Safety Board. 1999. *Bus Crashworthiness Issues.* Highway Special Investigation Report NTSB/SIR-99/04. Washington, DC. [↑](#footnote-ref-8)
8. See 71 FR 50998. Docket No. NHTSA-2006-25666. We note that Part 563 was subsequently amended on January 14, 2008 (73 FR 8408) and August 5, 2011 (76 FR 47486). [↑](#footnote-ref-9)
9. We note that in a December 13, 2012 Federal Register notice (77 FR 74144), the agency proposed establishment of an FMVSS that would mandate installation of EDRs for light duty vehicles that fall under the scope of Part 563. [↑](#footnote-ref-10)
10. See Docket No. NHTSA-2007-28793. [↑](#footnote-ref-11)
11. http://www.fmcsa.dot.gov/documents/safety-security/MotorcoachSafetyActionPlan\_finalreport-508.pdf. [↑](#footnote-ref-12)
12. http://www.fmcsa.dot.gov/documents/safety-security/Motorcoach-Safety-Action-Plan-2012.pdf. [↑](#footnote-ref-13)
13. While the Motorcoach Safety Action Plan is specific to motorcoaches, we note that recommendations on event data recorder use for motorcoaches may equally be applied to other types of heavy vehicles. [↑](#footnote-ref-14)
14. See Report DOT HS 809432. [↑](#footnote-ref-15)
15. See Report DOT HS 043334. [↑](#footnote-ref-16)
16. FHWA-JPO-05-054 [↑](#footnote-ref-17)
17. FMCSA-PSV-06-001 [↑](#footnote-ref-18)
18. It appears that the conversion between pounds and kilograms stating the applicability of SAE J2728 was done incorrectly. A value of 4,545 kg is actually equal to 10,020 lb and a value of 10,000 lb is equal to 4,536 kg. We assume the correct value should be 4,536 kg (10,000 lb) as this would be consistent with the typical cutoff for heavy vehicles. [↑](#footnote-ref-19)
19. It recommends the use of SAE J1939-71 as a reference for formatting the data elements. [↑](#footnote-ref-20)
20. A suspect parameter number is assigned by the SAE to a specific parameter within a parameter group. It describes the parameter in detail by providing information such as data length, data type, resolution, etc. [↑](#footnote-ref-21)
21. We note that the agency undertook a limited research program that, in part, examined survivability needs, aspects, and hardening costs primarily for light vehicle EDRs. The applicability to HVEDRs would need to be more closely examined. [↑](#footnote-ref-22)
22. FARS is a census of fatal crashes involving motor vehicles traveling on public traffic ways. FARS is recognized as the most reliable national crash database, but it contains information only on fatal crashes. [↑](#footnote-ref-23)
23. There were a total of 36,096 traffic fatalities in 2019. (892 truck occupants / 36,096 = 2.5 percent) [↑](#footnote-ref-24)
24. See DOT HS 812 061. [↑](#footnote-ref-25)
25. See DOT HS 811 177 Motorcoach Safety Action Plan. [↑](#footnote-ref-26)
26. See 78 FR 70416. [↑](#footnote-ref-27)
27. See 80 FR 36050. [↑](#footnote-ref-28)
28. See 79 FR 46090. [↑](#footnote-ref-29)
29. See 81 FR 27903. [↑](#footnote-ref-30)
30. Cross country is a bus body type classification in NHTSA field data that means an over-the-road bus, which is a bus with a passenger deck over a luggage compartment. This body type is traditionally known as a motorcoach. [↑](#footnote-ref-31)
31. Large vans used as intercity, transit/commuter, charter/tour, etc. [↑](#footnote-ref-32)
32. FARS 2010-2019 data [↑](#footnote-ref-33)
33. U.S. State by State Transportation Statistics 2018-19; School bus fleet magazine, <https://www.schoolbusfleet.com/download?id=10131920&dl=1> [↑](#footnote-ref-34)
34. DOT HS 812 944 [↑](#footnote-ref-35)
35. See DOT, 2012 Update to the Motorcoach Safety Action Plan, December 12, 2012, page 7. [↑](#footnote-ref-36)
36. Based on surveys of eight major truck and engine manufacturers performed in 2012 through a NHTSA contract with Virginia Tech. [↑](#footnote-ref-37)
37. The report from the T&B WG provided limited justification for the included data elements, other than that they were data elements already captured in some heavy vehicle systems and data elements deemed important for crash reconstruction purposes. A future rulemaking action on HVEDRs may require additional justification for these data elements and/or a request for public comment. [↑](#footnote-ref-38)
38. We note that the recently published SAE J2728 recommended practice no longer uses tier categories for the data elements. [↑](#footnote-ref-39)
39. Based on surveys of eight major truck and engine manufacturers performed in 2012 through a NHTSA contract with Virginia Tech. [↑](#footnote-ref-40)
40. We note that the T&B WG and FMCSA reports refer to this as “Digital Video Imaging.” We have opted to term this “Digital Video Capture” here to avoid confusion with procedures for “imaging” data from HVEDRs for inclusion in agency databases. [↑](#footnote-ref-41)
41. See Report DOT HS 043334. [↑](#footnote-ref-42)
42. Vehicle acceleration data may assist the determination of the crash severity. [↑](#footnote-ref-43)
43. For example, for the acceleration sampling rate they stated that “[t]he necessary sampling rate is directly related to the sophistication of the reconstruction process. Minimum sampling rate should be 10 times that of the Channel Frequency Class (CFC) or Frequency in Hertz. For simple reconstruction, CFC of 60 is a minimum requirement, so the corresponding sampling rate would be 600 samples per second. A sampling rate of 1800 samples per second should be the target.” [↑](#footnote-ref-44)
44. The T&B WG recommendations originally only included driver seat belt status. [↑](#footnote-ref-45)
45. For light duty vehicles, delta-V is the primary measurement of crash severity. [↑](#footnote-ref-46)
46. We note that transmission gear and individual wheel speeds are not currently data element sets within Part 563 for light vehicles. Steering input is an optional data element within Part 563. [↑](#footnote-ref-47)
47. The NHTSA T&B WG chose to elevate tire pressure and temperature monitoring to the Tier 2 level based on other active programs within NHTSA. [↑](#footnote-ref-48)
48. At the time of the study, we were unaware of any heavy vehicles that have multi-stage air bags. However, we believe that there may be some medium duty trucks that are built on chassis derived from lighter duty vehicles that do have multi-stage air bags. Also, we do not yet know what advances larger trucks will make towards multi-stage air bags as more manufacturers introduce air bag options for their vehicles. [↑](#footnote-ref-49)
49. The engine retarder is a braking method utilized by some diesel engines by which one or more engine cylinders are utilized for compressing air for use in the service air brakes, or for slowing the engine to slow the vehicle. This data element would be used to identify if the system was active during the crash. [↑](#footnote-ref-50)
50. In October 2010, Volvo announced that it would be installing air bag systems as standard equipment on its fleet of heavy trucks and buses. In 2017 Volvo North America announced that it would be offering optional seat mounted rollover air bag (fleetequipmentmag.com/volvo-trucks-new-vnl-series). [↑](#footnote-ref-51)
51. The T&B WG and FMCSA reports refer to this as “Digital Video Imaging.” We have opted to term this “Digital Video Capture” here to avoid confusion with procedures for “imaging” data from HVEDRs for inclusion in agency databases. [↑](#footnote-ref-52)
52. The definition of Event Data Recorder, as used in 49 CFR Part 563 that focuses on light vehicles, explicitly excludes audio or video data. While this may be the case for light vehicle EDRs, industry and the agency could consider the inclusion of video in the definition of heavy vehicle EDRs. [↑](#footnote-ref-53)
53. <https://www.mordorintelligence.com/industry-reports/north-america-dashboard-camera-market> [↑](#footnote-ref-54)
54. Not all events that trigger data collection are crashes. In section 6 of this document we discuss event triggers in more detail. For the purposes of discussion, we will describe the attributes of data collection prior to the crash (pre-crash data or pre-crash interval) and during and just after the crash (crash data or crash interval). The reader should be mindful that the attributes of this data collection are usually applicable to triggering events that are not crashes and as such may be thought of as pre-event trigger data or interval and the post-event trigger data or interval. [↑](#footnote-ref-55)
55. Capture means the process of saving recorded data. [↑](#footnote-ref-56)
56. Recording is the process of storing data into non-volatile memory for later use. [↑](#footnote-ref-57)
57. See FMCSA Report No. FMCSA-PSV-06-001, *Vehicle Data Recorders*, December 2005. [↑](#footnote-ref-58)
58. SAE has defined three data protocol classifications for vehicle applications: Class A, Class B, and Class C. Class A networks support the lowest data rates (typically for convenience operations systems such as on/off switches) up to 10 Kb/s. Class B networks support higher data rates (typically for intermodule communications and non-real-time controls) up to 100 Kb/s. Class C networks support data rates up to 1 Mb/s (typically for vehicle critical, real-time controls). [↑](#footnote-ref-59)
59. Much of the ECU data is standardized under the environmental regulations in 40 CFR Part 86. Part 86 standardizes the collection of and format by which engine emissions data is reported by the ECU. SAE J1587, *Electronic Data Interchange Between Microcomputer Systems in Heavy-Duty Vehicle Applications (Low-Speed Network)*, and SAE J1939, *Recommended Practice for Control and Communications Network for On-Highway Equipment (High-Speed Network)* are two voluntary standards the industry commonly uses to establish requirements for the on-board vehicle networks. [↑](#footnote-ref-60)
60. Alternative strategies may exist wherein the HVEDR does not include any internal sensors (e.g. accelerometers) and merely collects and records the data. In such cases, the location of the recording function may vary widely, and may even occur external to the vehicle itself via telematic systems. [↑](#footnote-ref-61)
61. We note that in Part 563 light vehicle EDR impact resistance is demonstrated through the FMVSS Nos. 208 and 214 crash tests. [↑](#footnote-ref-62)
62. FMVSS No. 208 requires vehicles with a GVWR of 3,855 kg (8,500 lb) or less be subjected to a full frontal rigid barrier impact at 56 km/h (35 mph). [↑](#footnote-ref-63)
63. FMVSS No. 214 requires vehicles with a GVWR of 2,722 kg (6,000 lb) or less be subjected to a movable deformable barrier impact at 53 km/h (33.5 mph). We note that the FHWA report has a calculation error. This error results in a delta-V approximately half that of the crash pulse attained when testing per FMVSS No. 208. [↑](#footnote-ref-64)
64. An analysis of vehicle crashes between 2005 and 2008 in NASS-CDS, and FARS cases indicated that only about 1% of real-world crashes involved a vehicle fire. Results of this analysis were obtained through a research program on EDRs by Virginia Tech. [↑](#footnote-ref-65)
65. Per Automotive Electronics Council Standard AEC-Q200, “Stress Test Qualification for Passive Components.” The 125 degree Celsius upper limit reflects the maximum temperature at which silicon transistors operate properly. [↑](#footnote-ref-66)
66. Santrock, Jeffrey, "Evaluation of Motor Vehicle Fire Initiation and Propagation Part 13: Propagation of an Engine Compartment Fire in a 1998 Front-Wheel Drive Passenger Vehicle," November 2003, Docket # NHTSA-1998-3588-203, General Motors Corporation. (1998 Accord, Frontal impact, engine compartment fire) [↑](#footnote-ref-67)
67. SAE International Recommended Practice, “Heavy Vehicle Event Data Recorder Standard – Tier 1,” SAE Standard J2728, June 2010. [↑](#footnote-ref-68)
68. DOT HS 812 929 [↑](#footnote-ref-69)
69. DOT HS 812 929 [↑](#footnote-ref-70)
70. The FHWA compared the 100 lb, 3 ft. NHTSA drop test to the 200 lb, 5 ft. FHWA drop test by estimating the potential energy of the drop divided by the projected area of contact. By this method it estimated that the FHWA recommendation was 3.3 times more severe. In an effort to compare the actual contact pressure for each proposal, we took a different approach. First, we assumed that the EDR enclosure can be represented by an ideal spring. So, the energy of the fully compressed spring is represented by 1/2kx, where k = spring constant and x = spring deflection. The ratio of the potential energy of each test is known, so the square root of that ratio represents the ratio of the spring displacements. Knowing this, the equation for the spring forces (F = kx) can be used to calculate the ratio of the spring forces. This in turn can be used to calculate the pressure over the two-dimensional projection of the contact area for each test. [↑](#footnote-ref-71)
71. DOT HS 812 929 [↑](#footnote-ref-72)
72. In a 2010 training program offered by the Institute of Police Technology and Management on heavy vehicle data imaging, instructors noted how vehicle operators might ‘tamper’ with crash evidence by cycling the engine, by operating the vehicle and creating new last stop triggers, or by altering ECU settings for final drive ratios. The operator could then effectively erase or alter the engine control data related to a specific crash. [↑](#footnote-ref-73)
73. In an April 5, 2010 final rule (75 FR 55488), the FMCSA amended the Federal Motor Carrier Safety Regulations (FMCSRs) to incorporate new performance standards for EOBRs installed in commercial motor vehicles (CMVs) manufactured on or after June 4, 2012. On-board hours-of-service (HOS) recording devices meeting FMCSA's current requirements and installed in CMVs manufactured before June 4, 2012 may continue to be used for the remainder of the service life of those CMVs. This rule was subsequently vacated after a court decision striking down the rule. In 2015, FMCSA published a final rule amending the Federal Motor Carrier Safety Regulations (FMCSRs) to establish: minimum performance and design standards for hours-of-service (HOS) electronic logging devices (ELDs); requirements for the mandatory use of these devices by drivers currently required to prepare HOS records of duty status (RODS); requirements concerning HOS supporting documents; and measures to address concerns about harassment resulting from the mandatory use of ELDs. A copy of the ELD final rule can be found in docket number FMCSA–2010–0167 at [www.regulations.gov](http://www.regulations.gov). [↑](#footnote-ref-74)
74. Docket No. NHTSA–2004–18029–2. See pages 32943 to 32944. [↑](#footnote-ref-75)
75. These same features are now available on many consumer grade Dash Cam devices. [↑](#footnote-ref-76)
76. See *Development of Requirements and Functional Specifications for Event Data Recorders*, FHWA IVI Program 134 Final Report Federal Highway Administration (FHWA), December 2004. [↑](#footnote-ref-77)
77. As an example, in its investigation of a motorcoach crash on August 8, 2008 in Sherman, Texas, the NTSB concluded that the motorcoach travelled for nearly 3 seconds between a steering axle tire failure and impact with a bridge guardrail. See http://www.ntsb.gov/doclib/reports/2009/HAR0902.pdf. [↑](#footnote-ref-78)
78. Recall that this does not imply that the driver push the manual trigger prior to the event. Data recorded prior to manual triggering will be collected due to the data buffer of the systems. [↑](#footnote-ref-79)
79. See Docket No. NHTSA-2004-18029, pages 32939 and 32946. The agency published a notice on December 13, 2012 proposing the installation of EDRs in light duty vehicles. See Docket NHTSA-2012-0177. NHTSA issued a withdrawal of the proposed rule on February 2019 (84 FR 2804). [↑](#footnote-ref-80)
80. See 75 FR 17220. [↑](#footnote-ref-81)
81. A recent Virginia Tech research program (sponsored by NHTSA) indicated that of the 39 data elements recommended by the SAE J2728 standard, only about 25 percent have been completely adopted by the commercial motor vehicle industry. [↑](#footnote-ref-82)
82. See FMCSA Report No. FMCSA-PSV-06-001, *Vehicle Data Recorders – Task Order 7 of the Commercial Motor Vehicle Technology Diagnostics and Performance Enhancement Program*. [↑](#footnote-ref-83)
83. See Table 4.1 above. [↑](#footnote-ref-84)
84. See Tables 4.1, 4.2, and 4.3 above. [↑](#footnote-ref-85)
85. Estimated from FMCSA Report No. FMCSA-PSV-06-001, *Vehicle Data Recorders – Task Order 7 of the Commercial Motor Vehicle Technology Diagnostics and Performance Enhancement Program,* December 2005. [↑](#footnote-ref-86)
86. Estimated from FMCSA Report No. FMCSA-PSV-06-001, *Vehicle Data Recorders – Task Order 7 of the Commercial Motor Vehicle Technology Diagnostics and Performance Enhancement Program,* December 2005. [↑](#footnote-ref-87)
87. *International Consultative Committee for Radio (CCIR).* [↑](#footnote-ref-88)
88. 77 FR 74144 [↑](#footnote-ref-89)
89. 84 FR 2804 [↑](#footnote-ref-90)
90. See DOT HS 812 128: Data Modernization-Report to Congress, March 2015. [↑](#footnote-ref-91)
91. In 2015, FMCSA published a final rule amending the Federal Motor Carrier Safety Regulations (FMCSRs) to establish: Minimum performance and design standards for hours-of-service (HOS) electronic logging devices (ELDs); requirements for the mandatory use of these devices by drivers currently required to prepare HOS records of duty status (RODS); requirements concerning HOS supporting documents; and measures to address concerns about harassment resulting from the mandatory use of ELDs. A copy of the ELD final rule can be found in docket number FMCSA–2010–0167 at [www.regulations.gov](http://www.regulations.gov). [↑](#footnote-ref-92)
92. This technical document refers to a historical version of this standard. [↑](#footnote-ref-93)
93. This technical document refers to a historical version of this standard [↑](#footnote-ref-94)