Journal of the Society of Automotive Engineers Malaysia
Volume 7, Issue 3, pp 183-195, September 2023
e-ISSN 2550-2239

A Review on Event Data Recorder and Its Implementation in Malaysia: Existing Standards and Challenges

N. Hamzah[1], **F. H. Kamaru Zaman[1]***, S. A. Che Abdullah[1], L. Mazalan[1], H. Zainol Abidin[1] and Y. Ahmad[2]

[1] Veh. Intel. & Telematics Lab, College of Eng., Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia
[2] Malaysian Institute of Road Safety Research (MIROS), 43000 Kajang, Selangor, Malaysia

*Corresponding author: fadhlan@uitm.edu.my

REVIEW ***Open Access***

Article History:

Received
1 Jul 2023

Accepted
22 Aug 2023

Available online
1 Sep 2023

ABSTRACT – *An Event Data Recorder (EDR), commonly referred to as a "black box" in the context of automobiles, is a device installed in vehicles to record various data related to the vehicle's operation and the surrounding environment in the event of a crash or other significant event. EDRs have become a standard feature in modern vehicles and play a crucial role in understanding the dynamics of accidents, assisting in vehicle safety research, and providing valuable information for post-accident analysis. Despite the global advancements in EDR technologies, Malaysia is still left behind in integrating EDR systems into the automotive sector. Thus, in this review, we investigate the current landscape of EDR implementation in Malaysia. This paper also presents the current policy and standards of EDR while also exploring the relevant factors contributing to the delay of EDR adoption in Malaysia, including regulatory gaps and public awareness. Several issues regarding data privacy and the legality of EDR are also highlighted here. By investigating the challenges and recommending solutions, this paper aims to provide valuable insights into the status of EDR implementation in Malaysia.*

KEYWORDS: Event Data Recorder (EDR), black box, vehicle safety, standards

Journal homepage: www.jsaem.my

1. INTRODUCTION

An Event Data Recorder (EDR) also commonly known as a "black box" is a device installed in many modern vehicles. The main objective of EDR is to record data related to vehicle operations and performance before, during, and after an event for example a collision (Jawi et al., 2022; Liu et al., 2022). Figure 1 depicts the EDR system on how to collect the data from the EDR. This recorded data serves as a fundamental tool in understanding the collision event and enhancing overall vehicle safety. EDR has the same concept as flight data recorders used in airplanes, but they serve different purposes and record different types of data. EDR is a passive device that does not monitor a vehicle's location, nor does it record video or audio. Instead, EDR will continuously record and monitor the events that happen this may include vehicle speed, engine RPM, brake status, airbag deployment, seatbelt usage, and many more depending on the EDR specifications (Guo et al., 2019). EDR specifications can vary depending on the vehicle model, however, there are some common features and specifications that are typically related to EDR for example the data parameters, triggering events, data recording duration, data storage capacity, data retrieval access, privacy measures, compliance with regulations and integration with the vehicle system. EDR specifications are subject to change as technology evolves and the regulation may be updated. In compliance with regional laws, manufacturers will determine the specific details of the EDR implementation in their vehicles.

FIGURE 1: EDR system and the setup to retrieve data from a crashed car (Ahmad et al., 2022)

The EDR holds an important position in various aspects of vehicle safety, the improvement of technologies, and accident analysis. The main role of EDR is the ability to capture and store critical data related to the vehicle's performance and the actions taken by the driver, mainly in the moments leading up to, during, and after specific events for example collisions (Fay et al., 2002). This data is valuable for accident reconstruction where it can provide the investigators, law enforcement, and experts with insight into the sequence of events that led to the accident (German et al., 2001; Guzek & Lozia, 2002). One of the key contributions of EDRs is in enhancing vehicle safety whereby by analyzing real-world data, automotive manufacturers can gain valuable information on vehicle performance and the safety system. This process enables continuous improvement in safety features and vehicle design (German et al., 2001). Another EDRs significant aspect of his understanding of driver behaviour where all the recorded data from EDRs contribute to efforts to comprehend how drivers respond in the critical moments (Min & Ando, 2020; Shiva Kumar & Murugaanandam, 2023). From this information, it can inform strategies for improving driver education and overall road safety. In terms of insurance investigations, EDR data can aid in determining liability and facilitate a fair resolution and efficiency of legal and insurance claims (Mateen et al., 2023).

Meanwhile, the overall condition of car safety in Malaysia has significantly improved recently, indicating an increasing focus on improving road safety, lessening the severity of accidents, and safeguarding occupants. As a nation with a rapidly expanding automotive industry and a road user, Malaysia has taken steps to address the challenges related to vehicular safety (Jawi et al., 2016). Malaysia has established regulations and standards for vehicle safety, including the implementation of safety features and adherence to crashworthiness standards. The Malaysia Institute of Road Safety Research (MIROS) plays an important role in developing and promoting safety regulations. Since 2006, Malaysia has been improving the car safety level through regulations and a consumer-based approach (Kassim et al., 2016). The Malaysian government has launched various road safety campaigns to raise awareness among road users such as drivers, passengers, and pedestrians. Malaysian authorities also have set guidelines to implement safety features in vehicles including the requirements for airbags, Antilock Braking System (ABS), Electronic Stability Control (ESC), and other safety technologies. However, the implementation of EDR in Malaysia is still pending and has not yet been mandated by the Malaysian government. Malaysian citizens are still lacking awareness and understanding of EDR (Zaman et al., 2023), and emphasized concerns over privacy of the user and the data, stressing the need for campaigns for educational initiatives to highlight the importance of EDR technology in enhancing vehicle safety.

2. EXISTING STANDARDS AND REGULATIONS ON EDR

The current EDR standards and regulations provide a complete framework for the functionality, data parameters, and performance of EDR in vehicles. These standards serve as a crucial reference point for manufacturers, regulators, and stakeholders in the automotive industry, offering a structured set of guidelines to ensure uniformity and consistency in the implementation and operation of EDR. These standards are not static rather they are dynamic entities that may evolve at the rapid pace of technological advancements. As emerging technologies continue to shape the automotive landscape,

standards for EDR must adapt to encompass novel functionalities and data requirements, keeping pace with the ever-changing dynamics of the industry. On a global scale, the establishment of standards for EDR has been led by influential bodies such as the United Nations Economic Commission for Europe (UNECE) and the International Organization for Standardization (ISO). These organizations, recognized for their authority and expertise, have played an important role in developing the standards that transcend geographical boundaries, fostering a harmonized approach to ERD implementation and regulation. As the automotive industry continues to innovate, these standards will remain instrumental in providing a robust framework that aligns with evolving technological landscapes, fostering a safer and more standardized future for vehicle data recording.

Several regulations have been established by the global committees, including (i) UNECE Regulations, NHTSA Standards, (ii) Chinese GB Standards, and (iii) EU Regulations. These complete standards and regulations are designed to standardize the application of EDR within each respective country or region. Each set of guidelines serves the purpose of ensuring uniformity, compliance, and safety in the implementation and functionality of EDR, aligning with the specific needs and regulations of the corresponding authority.

2.1 UNECE Regulation No. 160

UNECE regulation No. 160 also known as R160E established uniform provisions concerning the approval of motor vehicles concerning the Event Data Recorder (EDR) for M_1 and N_1 motor vehicles categories (UN, 2022). The regulations pertain to the basic requirements for the collection, storage, and crash survivability of event data resulting from motor vehicle crashes. It does not include the guidelines for tools and methods used in data retrieval because those aspects are contingent upon national or regional-level requirements. These provisions aim to guarantee that EDR captures relevant data in a readily accessible format, essential for thorough crash investigations and the analysis of safety equipment effectiveness, such as advanced restraint systems. The recorded data intends to enhance comprehension of the conditions leading to crashes and injuries, thereby supporting the evolution of safer vehicle designs. The requirements for vehicles that have EDR include data elements, data format, data capture, crash test performance, and finally survivability.

Every vehicle equipped with an EDR must capture the data elements and data format outlined as mandatory and those deemed necessary under specified minimum conditions. The procedure of data capture for EDR is that the recorded data remains in the vehicle until retrieval, complying with national or regional legislation, or until overwritten as per specified conditions. The EDR non-volatile memory buffer is designed to accommodate data related to at least two different events. Data elements for each event are captured based on specific conditions, including changes in vehicle velocity, activation of occupant restraint systems, and vulnerable road user safety systems. The locking of data occurs in certain circumstances to prevent overwriting, for example when a non-reversible restraint system is deployed or during a frontal impact exceeding a specified velocity change. The establishment of time zero is defined by various criteria, including the activation of restraint control algorithms and the deployment of safety protection systems. There are 65 Data elements specified in this standard, where 58 elements are mandatory as shown in Table 1.

TABLE 1: Mandatory data elements specified by UNECE Regulation No.160

Delta-V, longitudinal Maximum delta-V, longitudinal Time, maximum delta-V, longitudinal Speed, vehicle indicated. Engine throttle, % full (or accelerator pedal, % full) Service brake, on/off Ignition cycle, crash Ignition cycle, download Safety belt status, driver Airbag warning lamp Frontal air bag deployment, driver. Frontal air bag deployment, front passenger. Time from event 1 to 2 Complete file recorded (yes, no)	Pretensioner deployment, time to fire, front passenger. Seat track position switch, foremost, status, driver. Seat track position switch, foremost, status, front passenger. Safety belt status, rear passengers Tire Pressure Monitoring System (TPMS) Warning Lamp Status Longitudinal acceleration (pre-crash) Lateral acceleration (pre-crash) Yaw Rate Traction Control Status AEBS status Cruise Control System

Delta-V, lateral Maximum delta-V, lateral Time maximum delta-V, lateral Time for maximum delta-V, resultant. Engine rpm Vehicle roll rate. ABS activity Stability control Steering input Safety belt status, front passenger Passenger airbag suppression status, front Frontal air bag deployment, time to nth stage, driver Frontal air bag deployment, time to nth stage, front passenger Side airbag deployment, time to deploy, driver. Side airbag deployment, time to deploy, front passenger. Side curtain/tube air bag deployment, time to deploy, driver side. Side curtain/tube air bag deployment, time to deploy, passenger side. Pretensioner deployment, time to fire, driver.	Adaptive Cruise Control Status (driving automation system level 1) VRU secondary safety system deployment, time to deploy. VRU secondary safety system warning indicator status Safety belt status mid-position front Far-side impact center airbag Lane departure warning system status Corrective steering function (CSF) status Emergency steering function (ESF) status Automatically commanded steering function (ACSF) category A status Automatically commanded steering function (ACSF) category B1 status Automatically commanded steering function (ACSF) category B2 status Automatically commanded steering function (ACSF) category C status Automatically commanded steering function (ACSF) category D status Automatically commanded steering function (ACSF) category E status Accident emergency call system status

2.2 National Highway Traffic Safety Administration (NHTSA) Standards (USA)

National Highway Traffic Safety Administration (NHTSA) mandates that individuals who voluntarily install EDR in their vehicles must adhere to the guidelines provided by the NHTSA – 49 CFR PART 563 (NHTSA, 2006). The gross vehicle weight rating (GVWR) must be within 3,855 kilograms or less. The EDR must record 15 essential data elements and 30 additional data elements if the vehicle is equipped to record all those elements. These 15 essential elements are shown in Figure 2. The data format must be standardized with a specification for range, accuracy, resolution, recording duration, sampling rate and filter class. The EDR also enables us to record two events in a multi-event crash. Furthermore, the regulation mandates vehicle manufacturers to make a retrieval tool for EDR information commercially accessible (Tsoi et al., 2013). Additionally, it requires that vehicle manufacturers incorporate a standardized statement in the owner's manual disclosing the presence of an EDR in the vehicle and explaining its intended purposes. The ultimate regulation aims to standardize and augment the quantity of recorded crash information accessible via EDR. Safety researchers can leverage this standardized data to gain deeper insights into crash dynamics, enabling the identification of more effective countermeasures for crashworthiness and crash avoidance. This, in turn, contributes to the advancement of motor vehicle safety. EDR meeting the rule's specification may also furnish a more comprehensive and valuable dataset for the Automatic Collision Notification (ACN) system, aiding in the assessment of the necessity and extent of emergency responses to traffic crashes.

2.3 Chinese GB Standards

This information came from the manual issued by the State Administration for Market Regulation and Standardization Administration of the People's Republic of China (SAC, 2020). The Chinese GB standards focus on the implementation of EDR in the M_1 vehicle category. There are 60 data elements specified in this standard. The data is stored in a specific Electronic Control Unit (ECU) in the form of a time series. To initiate the recording and storage of an EDR the conditions must be met. If an event recorded by the EDR meets specified locking conditions, the data will be locked to prevent it from being overwritten by subsequent events and vice versa. There are three types of acceleration being will trigger the recording lateral, longitudinal, and normal acceleration. Lateral acceleration refers to the Y-component of the vector acceleration experienced by a point in the vehicle. It is considered positive from the driver's left to right, as perceived while seated in the vehicle and facing the direction of forward travel (refer to Figure 1). Longitudinal Acceleration is the X-component of the vector acceleration at a point in the vehicle. It is positive in the direction of forward vehicle travel, as depicted in Figure 3. Normal Acceleration is the Z-component of the vector acceleration at a specific point in the vehicle. It is positive in a downward direction, as illustrated in Figure 1. The event shall be recorded when the vehicle meets the trigger threshold conditions where for the vehicles recording "delta-V, longitudinal" exclusively, the

trigger threshold is defined as a change in vehicle velocity in the X-axis direction equal to or exceeding 8km/h within a 150ms interval. For vehicle recording “delta-V, lateral” as we, the trigger threshold is a change in vehicle velocity in either the X-axis or Y-axis direction equal to or exceeding 8 km/h within a 150ms interval. In both cases mentioned above, if the event duration is less than 150ms, and there is a change in vehicle velocity equal to or exceeding 8km/h, the trigger threshold is considered reached.

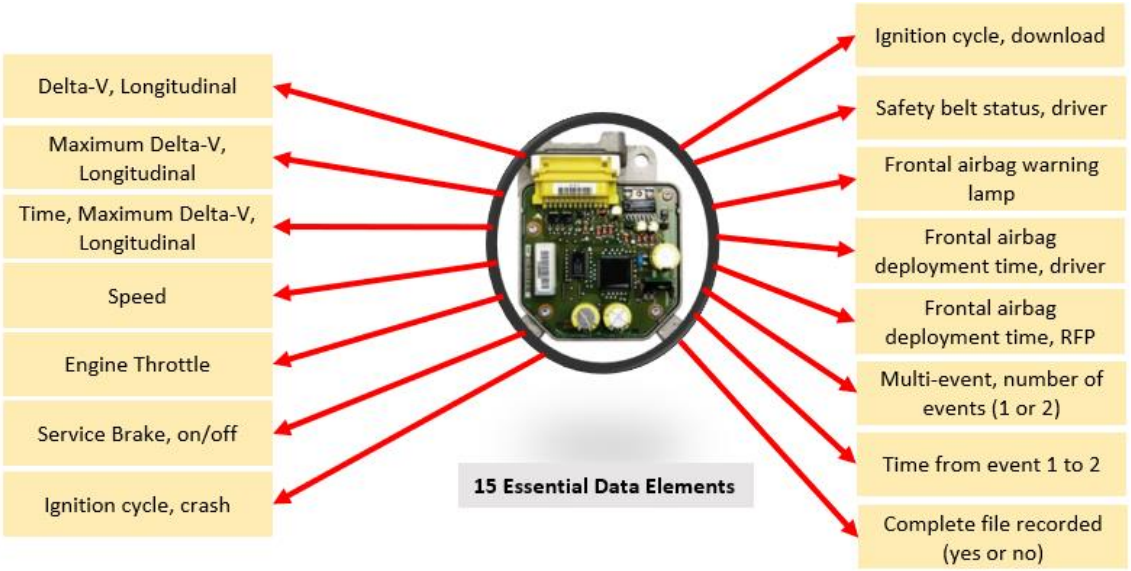

FIGURE 2: 15 essential data elements specified in NHTSA – 49 CFR PART 563

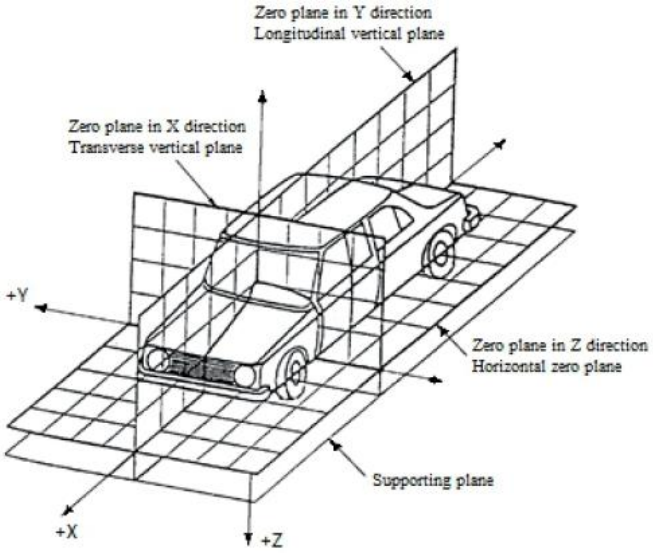

FIGURE 3: Coordinate System of the Vehicle (SAC, 2020)

2.4 Regulation (EU) 2019/2144 of The European Parliament and of The Council

According to the EU General Safety Regulation (GSR) enacted in November 2019, EDR will be obligatory for new light vehicle types starting from July 2022 and for all new light vehicles beginning July 2024 (European Parliament & Council of the European Union, 2019; Nouzovsky et al., 2022). This requirement will be further extended to include heavy vehicles, with the respective deadlines set for January 2026 and January 2029. EDRs are obligated to meet specific regulatory requirements. The recorded and stored data concerning the period surrounding a collision-shortly before, during, and immediately after must encompass the vehicle’s speed, braking, position, tilt on the road, state, and rate of activation of safety systems, 112-based eCall in-vehicle system, brake activation and relevant

input parameters of onboard active safety and accident-avoidance systems. This recording should be carried out with a high level of accuracy to ensure data survivability. Deactivation of these recorders is strictly prohibited. In terms of recording and storing data, the recorders must operate on a closed-loop system, ensuring that data is collected in an anonymized form, and safeguarded against manipulation and misuse. Additionally, they should enable the identification of the precise vehicle type, variant version, and notably, the active safety and accident-avoidance systems equipped in the vehicle. Access to the recorded data by national authorities, based on Union or national law, is restricted to accident research and analysis purposes, including type approval of systems and components. This entire process should align with Regulation (EU) 2016/679 and be facilitated through a standardized interface. Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons regarding the processing of personal data and the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation). The summary of the UN Regulation No.160, NHTSA – 49 CFR PART 563, Chinese GB Standards and Regulation (EU) 2019/2144 is given in Table 2.

TABLE 2: Summary of the global standards regarding EDR

Global Standard	Type of Vehicles	Recorded Parameter
UNECE Regulation No. 160	M_1 and N_1 motor vehicle categories.	58 mandatory parameters to be recorded.
National Highway Traffic Safety Administration (NHTSA) Standards	The gross vehicle weight rating (GVWR) must be within 3,855 kilograms or less.	15 essential data parameters with 30 additional data parameters if the vehicle can record the data.
Chinese GB Standards	M_1 vehicle categories.	17 Level A data elements and 43 Level B data elements need to be recorded. Level A data elements mean data shall be recorded if the vehicle is equipped with an EDR system. Level B data elements mean when the vehicle is equipped with an EDR system and relevant devices.
Regulation (EU) 2019/2144 of The European Parliament and of The Council	Light vehicle types.	Vehicle's speed, braking, position, tilt on the road, state, and rate of activation of safety systems, 112-based eCall in-vehicle system, brake activation, and relevant input parameters of onboard active safety and accident-avoidance systems.

2.5 Vehicle Road Safety Regulation in Malaysia and EDR Implementation

In Malaysia, cars are one of the most common vehicles involved in accidents rather than motorcycles, lorries, and vans (Redhwan & Karim, 2010). According to Malaysian Road Safety Council Statistics, the common three causes of road accidents are speeding, careless driving, and careless overtaking. The statistics showed that driver's behavior is the main cause of road accidents. Moving toward road safety, the Ministry of Transport Malaysia (MOT) has introduced a Road Safety Plan 2022 – 2030 where the Malaysian government has emphasized that by the year 2030, 100% of new and used vehicles will meet the quality safety standards following either UN rules or the nationally recognized equivalent (MOT, 2022).

Malaysia has implemented comprehensive road safety regulations including the speed limit, seatbelt usage, and helmet-wearing regulations and a maximum Blood Alcohol Concentration (BAC) level has been mandated. For example, the speed limit in urban areas has been set from a range of 50km/h to 80km/h, and for rural areas is between 70km/h to 110km/h. For seatbelt usage is compulsory for all private vehicle occupants. Helmet-wearing has been made compulsory since 1973. Currently, the Malaysian government is in the process of amending the Road Transport Act 1987 for the Blood Alcohol Concentration (BAC) level in Malaysia, further demonstrating its commitment to enhancing road safety standards in the country.

The delayed implementation of Event Data Recorders (EDR) in Malaysia can be attributed to various factors. One key factor is the absence or delay in establishing standards, regulatory frameworks, and mandates related to EDR installation in vehicles. The lack of specific regulations or requirements from the government may lead manufacturers to deprioritize the integration of EDR technology into vehicles. Despite Malaysia's current lag in EDR adoption, a positive initiative has been undertaken by MIROS and Cybersecurity Malaysia (CSM). Their signing of a memorandum of cooperation (MOC) highlights the significance of vehicular digital data and evidence (CSM, 2022), indicating a step towards recognizing the importance of EDR technology. Another significant factor contributing to the delay is the lack of awareness and education among citizens, policymakers, and automotive industry stakeholders (Zaman et al., 2023). This lack of understanding poses a substantial barrier to the adoption of EDR technology. Without a comprehensive understanding of the benefits that EDR brings to improving road safety, there may be insufficient pressure for its widespread implementation.

Despite the relatively limited implementation of EDR technology in Malaysia, research indicates that Malaysian citizens are inclined to prioritize the purchase of safer vehicles (Kassim et al., 2016). This trend is particularly encouraging as safer cars often incorporate EDR technology. Such a preference among consumers has the potential to raise awareness regarding the importance of EDR technology in enhancing overall vehicle safety. It is noteworthy that initiatives such as the MOC between MIROS and CSM signify a positive step toward addressing the challenges associated with EDR adoption in Malaysia. However, ongoing efforts are crucial to raising awareness, educating stakeholders, and establishing clear regulatory frameworks to drive the effective implementation of EDR technology across the country.

3. DATA PRIVACY GUIDELINES FOR EDR

Data privacy guidelines for EDR are crucial to ensure that the collection, storage, and use of vehicle-related data comply with privacy laws and protect individual's rights. Lack of privacy is one of the main reasons for the non-acceptability of the EDR (Eyssartier, 2015; Gabler et al., 2005). Ensuring the privacy of drivers and safeguarding the responsible use of EDR data are pivotal considerations in the evolving landscape of vehicular technology. The establishment of a comprehensive set of guidelines emerges as a crucial imperative. This set of guidelines serves as a protective framework, delineating protocols, and principles aimed at upholding the privacy rights of drivers while addressing the utilization of EDR data. These guidelines are designed to navigate the complex intersection of technology and personal information. By laying out clear expectations and ethical standards, the guidelines are to balance between leveraging EDR data for the enhancement of vehicle safety and respecting the privacy concerns of individuals.

3.1 UNECE Regulation No. 160

There are no specifications defined in UNECE Regulation No.160 (Langer et al., 2022).

3.2 National Highway Traffic Safety Administration (NHTSA) Standards (United States)

To address the privacy concerns, NHTSA underscored the importance of obtaining the owner's consent for EDR data collection to protect any information regarding the potential to identify an individual. Concerning EDR, the primary information for potential identification is the vehicle identification number (VIN), which is gathered during the download of EDR data. This discussion delves into the necessity of collecting VIN information, its purpose in processing EDR data, and the precautions taken by the agency to ensure its secure handling. While the final rule does not mandate the recording of VIN information by EDR, the complete VIN of a vehicle becomes an essential input in existing EDR extraction tools to

facilitate the accurate conversion of electronic EDR data into a usable format. The inclusion of the full VIN accounts for any running changes that might occur during a specific model year, making the use of a shortened VIN impractical. We acknowledge that such VIN information is generally available through alternative means during crash reconstruction, such as reading the VIN label on the vehicle itself. Moreover, parties like law enforcement may combine EDR data with personally identifying information routinely acquired during a crash investigation. Regarding the use of EDR data, the agency incorporates the collected information into extensive crash-related databases to enhance its understanding of specific crash events. it is crucial to note that the information within the databases is neither retrieved nor retrievable by name or any other individual identifier.

The rationale behind safeguarding VIN information lies in the identification of the vehicle rather than providing personal details about an individual. EDR data alone cannot ascertain the specific driver of the vehicle at any given time. Despite VIN information not falling under the definitions of a "record" or "system of records" as per the Privacy Act, NHTSA takes precautionary measures to prevent the release of VIN information. This is because VIN information can be employed in commercially available programs to ascertain the current owner of a vehicle. As a practical measure, information within records that has the potential to indirectly identify individuals is not made public unless explicitly required by law. Before releasing information from databases containing EDR data, the agency removes the last six characters of the VIN, preventing the identification of a specific vehicle and potentially, through indirect means, the identity of the vehicle's current owner. Considering the measures, NHTSA is confident that they have undertaken adequate steps to safeguard the EDR user privacy.

3.3 Chinese GB Standards

There are no such specifications on the data privacy defined in Chinese GB Standards (SAC, 2020).

3.4 Regulation (EU) 2019/2144 of The European Parliament and of The Council

The European Parliament and The Council have established guidelines to safeguard the privacy of vehicle owners. The regulations emphasize that EDR must be equipped to record and store data in a way that limits its utilization exclusively for Member States to conduct road safety analysis and assess the effectiveness of specific measures. Importantly, this process should occur without any potential for identifying the owner or holder of a particular vehicle based on the stored data. Any processing of personal data, including information about the driver processed in EDR or details concerning the driver's drowsiness, attention, or distraction, must adhere to Union data protection law, specifically Regulation (EU) 2016/679 of the European Parliament and the Council (6) on the protection of natural persons with regards to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation). EDR should function within a closed-loop system, ensuring that the stored data is overwritten and preventing the identification of the vehicle or holder. Moreover, both the driver's drowsiness and attention warning and the advanced driver distraction warning should refrain from continuously recording or retaining any data beyond what is necessary for the purposes for which they were collected or processed within the closed-loop system. Furthermore, the processing of personal data collected through the 112-based eCall in-vehicle system is subject to specific safeguards outlined in Regulation (EU) 2015/758 of the European Parliament and the Council (7). To further safeguard data privacy, an EDR must not have the capability to record and store the last four digits of the vehicle indicator section of the vehicle identification number or any other information that could potentially identify the individual vehicle, its owner, or holder.

4. LEGAL AND PRIVACY ISSUES IN EDR USAGE

The usage of EDR in vehicles raises various legal and privacy issues that require careful consideration. Among the legal issues related to the use of EDR are data ownership, compliance with diverse regulations, data acceptability in court, and data tampering and authenticity. Determining the ownership of EDR data poses a legal dilemma. Within the insurance industry, the concept of data ownership lacks well-defined rules (Athavale & Borna, 2008). While a driver's record is considered their personal property (Guilbot et al., 2016), it is notable that insurance inspectors or law enforcement officers may also seek access to such data. It motivates the insurance companies to establish rules and standards that clear ownership boundaries. Addressing this data ownership in the insurance sector gives

transparent guidelines for data ownership and promotes responsible data access practices (Mateen et al., 2023; Thom & Maccarley, 2008).

Compliance with diverse regulations can pose a complex challenge. As discussed in section 2.0, existing global standards and regulations have different requirements. The standardization of global standards and regulations is essential to simplify compliance for manufacturers. Another legal issue is the EDR data acceptability in court. The collected data is difficult to utilize and authenticate, thereby complicating the presentation of such information as evidence in legal proceedings (Daily et al., 2008). Currently, there are no standardized norms or guidelines for the admissibility of EDR data in legal contexts. Addressing this issue is crucial for establishing the credibility and reliability of such data in legal proceedings.

Preventing data tampering to ensure data integrity and authenticity can be challenging and demands comprehensive strategies and technological solutions. This is essential in the context of EDR, where the collected data holds significant importance for various applications, including accident reconstruction and safety analysis. Establishing foolproof mechanisms to authenticate the source and timeline of recorded data becomes crucial. Techniques such as digital signatures, secure time-stamping, and blockchain technologies (Mateen et al., 2023) are gaining attention as potential solutions. Implementing these technologies in EDR systems requires careful consideration of their compatibility, efficiency, and adherence to regulatory requirements. Furthermore, the legal landscape surrounding data tampering issues needs continuous refinement. Clear and comprehensive legislation, along with strict enforcement mechanisms, is vital to prevent malicious activities and hold accountable those who attempt to compromise the integrity of EDR data.

The collected EDR data also raised a personal privacy concern when EDR collects detailed information about driving behavior (Min & Ando, 2020). This will raise a question about individual driving practices it can breach the privacy of the vehicle's owner or the operators. While guidelines exist to address these privacy concerns, the evolving nature of driving behavior data collection demands ongoing discussion and refinements in the regulatory framework.

Thus, addressing legal and privacy issues in EDR usage requires a holistic approach, encompassing technological innovations, regulatory enhancements, and collaborative efforts among manufacturers, regulatory bodies, and cybersecurity experts. Striking the right balance between safety insights and individual privacy rights is an ongoing issue that requires continuous dialogue, refinement of regulations, and the implementation of cutting-edge technologies to ensure the responsible and secure use of EDR systems.

5. CHALLENGES IN EDR IMPLEMENTATIONS

The integration of EDR as a crucial vehicle safety feature and for accident analysis has become indispensable, yet it is not without its challenges. Foremost, among these challenges is the issue of privacy concerns (Eyssartier, 2015; Kowalick, 2002; Losavio et al., 2015). The detailed data collection performed by EDR raises worries about privacy, particularly for the ownership and utilization of personal driving behavior data. Balancing the need for safety insight with individual privacy rights is an ongoing challenge. Despite the existence of established guidelines on how to handle data privacy, the complexity of this issue means that a complete resolution cannot be guaranteed. The evolving landscape of technology, coupled with the expanding scope of data collection, the need for continuous refinement and adaptation of privacy frameworks. The challenges lie in creating a framework that not only addresses current concerns but also anticipates and addresses emerging issues, for a secure and ethical environment. In addition to tightening privacy regulations, there has also been a research initiative undertaken to develop a methodology for transferring data from EDR in a manner that preserves privacy (Chim et al., 2013; Patsakis & Solanas, 2013; Yeung et al., 2014).

A significant challenge within the domain of EDR pertains to data standardization and regulation. The lack of global standardization in EDR specification and regulations introduces difficulties in achieving interoperability and consistency across diverse regions and among various manufacturers. Key standards and regulations, including those established by UNECE, China, the USA, and the EU seek to address this challenge. However, the limited adoption of EDR in certain implementations has contributed to a scarcity of comprehensive standards and regulations. Notably, the UNECE regulation

is embraced by some countries such as Japan, reflecting a regional alignment with global standards (UNECE, 2022). The diversification of regulatory frameworks worldwide underscores the need for greater harmonization to enhance the effectiveness and widespread acceptance of EDR technologies.

Ensuring the reliability and accuracy of EDR data is paramount for its effective utilization in accident reconstruction and safety analysis (Vandiver et al., 2013). The establishment of robust calibration and testing standards is imperative to uphold the credibility of the recorded data. Addressing this issue stands out as a significant challenge in the implementation of EDR technology. The expanding body of literature delves into methodologies and strategies aimed at maintaining the accuracy of EDR data (Carr et al., 2015; Ruth et al., 2012; Ruth & Daily, 2011; Ruth & Tsoi, 2014; Tsoi et al., 2013; Vandiver et al., 2013), reflecting the ongoing efforts to enhance the precision and dependability of this critical information source.

Retrofitting or implementing EDR systems in older vehicles poses a considerable cost challenge. Encouraging widespread adoption becomes particularly challenging in regions where regulations do not mandate EDR installation. A case in point is Malaysia, where, currently, there are no regulations in place for compulsory EDR installations. This absence of regulatory frameworks further complicates the task of promoting the universal integration of EDR technology in vehicles, especially those that predate the advent of built-in EDR systems. The importance of regulatory influence in shaping the adoption landscape is underscored by the fact that regions lacking such mandates face difficulties in compelling vehicle owners, manufacturers, and other stakeholders to invest in EDR technology. The cost considerations, coupled with the lack of legal directives, create an environment where the incorporation of EDR becomes more contingent on voluntary initiatives, potentially impeding the realization of widespread implementation.

6. RECOMMENDATIONS

Several recommendations for enhancing EDR technology and implementation of EDR in Malaysia include regulatory compliance where the need to emphasize the importance of strict adherence to regulatory guidelines governing EDR installation, functionality, and data management as well as advocate for comprehensive and updated regulatory frameworks. To protect the privacy of the owner, there is a very important need to prioritize the implementation of good privacy protection measures within EDR systems. This will address the concerns related to data collection, storage, and sharing by incorporating anonymization techniques and complying with data protection laws. There is also a need to improve data accuracy and reliability by establishing stern calibration and testing standards and continuously updating these standards to align with technological advancement. To increase the success in the implementation of EDR, the authority needs to conduct a public awareness campaign to educate vehicle owners, manufacturers, law enforcement, and other stakeholders. The government needs to take responsibility for conducting a campaign to emphasize the advantages, functionalities, and privacy safeguards associated with EDR technology. Additionally, investment in ongoing research and development efforts can further improve EDR capabilities. This includes research to explore advanced sensors, artificial intelligence (AI), and communication protocols to develop more sophisticated accident analysis and safety improvements.

7. CONCLUSION

As a conclusion, EDR plays an important role in enhancing vehicle safety, accident analysis, and overall road safety measures. The extensive adoption of EDR technology offers many benefits, including improved accident reconstruction, data-driven safety improvement, and more informed policymaking. However, the successful implementation of EDR came with several challenges. Privacy concerns, standardization issues, and varying regulations and standards across regions are several challenges that need careful consideration and resolution. Enhancing privacy safeguards, international collaboration for standardization, and ongoing research and development efforts are key steps in overcoming these challenges. Additionally, educational initiatives and public awareness campaigns are important in filling the knowledge gap among vehicle owners and stakeholders. The implementation of EDR in Malaysia, faces a unique challenge, including regulatory gaps and limited public awareness. Efforts to fill these gaps through comprehensive regulations, financial incentives, and campaigns are essential for the successful integration of EDR technology. As technology evolves, EDR should continue to adapt to new technology such as artificial intelligence and advanced sensors to further improve

accident analysis and safety measures. In conclusion, the effective integration of EDR requires a multilayered approach, involving regulatory bodies, manufacturers, researchers, and the public to ensure a safer and more informed future for road transportation.

ACKNOWLEDGEMENT

The authors express their deepest gratitude to ASEAN NCAP Collaborative Holistic Research (ANCHOR) IV for supporting this research.

REFERENCES

Ahmad, Y., Radzi, M. A. M., Mustaffa, S., Kassim, K. A. A., & Ramli, M. S. (2022). Analyzing driver response in real-world fatal crashes using the Event Data Recorder (EDR). Journal of the Society of Automotive Engineers Malaysia, 6(2), 65-76.

Athavale, M., & Borna, S. (2008). Some issues for insurers on the use of Event Data Recorders. Journal of Insurance Issues, 1-15.

Carr, L., Rucoba, R., Barnes, D., Kent, S., & Osterhout, A. (2015). EDR pulse component vector analysis. SAE Technical Papers, 2015 (April).

Chim, T. W., Yiu, S. M., Yeung, C. Y., Li, V. O. K., & Hui, L. C. K. (2013). Secure, privacy-preserving, distributed motor vehicle event data recorder. 2013 International Conference on Connected Vehicles and Expo, ICCVE 2013 - Proceedings, 337-342.

CSM (2022). Memorandum of Cooperation (MOC) signing between CyberSecurity Malaysia and Malaysian Road Safety Research Institute (MIROS) Ayer Keroh, Melaka. Retrieved from https://www.cybersecurity.my/cybernews/2022/Q2/eng/happening.html

Daily, J. S., Singleton, N., Downing, E., & Manes, G. W. (2008). The forensics aspects of event data recorders. Journal of Digital Forensics, Security and Law, 3(3), 2.

European Parliament, & Council of the European Union. (2019). Regulation (EU) 2019/2144 of The European Parliament of the Council of 27 November 2019 on type-approval requirements for motor vehicles and their trailers, and systems, components and separate technical units intended for such vehicles, as regards their g general safety and the protection of vehicle occupants and vulnerable road users, amending Regulation (EU) 2018. Official Journal of the European Union, L4(726), 43-167.

Eyssartier, C. (2015). Acceptability of driving an equipped vehicle with drive recorder: The impact of the context. IET Intelligent Transport Systems, 9(7), 710-715.

Fay, R., Robinette, R., Deering, D., & Scott, J. (2002). Using Event Data Recorders in collision reconstruction. SAE Technical Papers, 2002(724).

Gabler, H., Gabauer, D. J., Newell, H. L., & O'Neill, M. E. (2005). Use of Event Data Recorder (EDR) technology for highway crash data analysis. In Use of Event Data Recorder (EDR) Technology for Highway Crash Data Analysis.

German, A., Comeau, J. L., Monk, B., McClafferty, K. J., Tiessen, P. F., & Chan, J. (2001). The use of Event Data Recorders in the analysis of real-world crashes. Proc. CMRSC-XII, 10-13.

Guilbot, M., Serre, T., Naude, C., & Ledoux, V. (2016). Legal conditions for implementing EDRs in public fleets of vehicles. In ITS 2016-11th ITS European Congress (p. 10p).

Guo, F., Qian, Y., & Li, W. (2019). Vehicle speed accident reconstruction based on event data recorder. Proceedings - 2nd World Conference on Mechanical Engineering and Intelligent Manufacturing, WCMEIM 2019, 722-727.

Guzek, M., & Lozia, Z. (2002). Possible errors occurring during accident reconstruction based on car “Black Box” records (No. 2002-01-0549). SAE Technical Paper.

Jawi, Z. M., Kassim, K. A. A., Isa, M. H. M., Hamzah, A., & Ghani, Y. (2016). Towards safer cars in Malaysia. Journal of Advanced Vehicle System, 3(1), 1-13.

Jawi, Z. M., Talib, M. Z. A., Aziz, F. A. A., Ariffin, A. H., & Salleh, A. S. (2022). A new era of black box – Refreshed approach via latest technologies and the challenges. Journal of the Society of Automotive Engineers Malaysia, 6(3), 166-177.

Kassim, K. A. A., Arokiasamy, L., Isa, M. H. M., & Osman, I. (2016). Automotive consumerism towards car safety in Malaysia. Procedia - Social and Behavioral Sciences, 219, 424-430.

Kowalick, T. M. (2002). Real-world perceptions of emerging Event Data Recorder (EDR) technologies. Click, 146, 1-8.

Langer, R., Michl, M., Paula, D., & Hof, H. (2022). Security analysis of an Event Data Recorder system according to the HEAVENS model. June 2023.

Liu, W., Shen, W., Harn, L., & Luo, M. (2022). A fast VANET-assisted scheme for Event Data Recorders. Security and Communication Networks, 2022(1), 7816483.

Losavio, M., Pastukov, P., & Polyakova, S. (2015). Cyber black box/Event Data Recorder: Legal and ethical perspectives and challenges with digital forensics. Journal of Digital Forensics, Security and Law, 10(4).

Mateen, A., Khalid, A., Lee, S., & Nam, S. Y. (2023). Challenges, issues, and recommendations for blockchain- and cloud-based automotive insurance systems. Applied Sciences (Switzerland), 13(6).

Min, K., & Ando, A. (2020). Analysis on characteristics of dangerous driving events via recorded data of drive-recorder. Transportation Research Procedia, 48(2019), 1342-1363.

MOT (2022). Malaysia Road Safety Plan 2022-2030. Ministry of Transport Malaysia (MOT), 1-76. Retrieved from https://www.mot.gov.my/en/land/safety/road-safety-plan-2021-2030

NHTSA (2006). Final Regulatory Evaluation - Event Data Recorders (EDRs). National Highway Traffic Safety Administration.

Nouzovsky, L., Kohout, T., Vrtal, P., & Kocian, K. (2022). Validation of EDR data for the purpose of the forensic expertise. 2022 Smart Cities Symposium Prague, SCSP 2022.

Patsakis, C., & Solanas, A. (2013). Privacy-aware Event Data Recorders: Cryptography meets the automotive industry again. IEEE Communications Magazine, 51(12), 122–128.

Redhwan, A. A., & Karim, A. J. (2010). Knowledge, attitude and practice towards road traffic regulations among university students, Malaysia. IIUM Medical Journal Malaysia, 9(2).

Ruth, R. R., & Tsoi, A. (2014). Accuracy of translations obtained by 2013 GIT tool on 2010-2012 Kia and Hyundai EDR speed and delta-v data in NCAP tests. SAE Technical Papers, 1.

Ruth, R., & Daily, J. (2011). Accuracy of Event Data Recorder in 2010 Ford Flex during steady state and braking conditions. SAE International Journal of Passenger Cars - Mechanical Systems, 4(1), 677-699.

Ruth, R., Bartlett, W., & Daily, J. (2012). Accuracy of event data in the 2010 and 2011 Toyota Camry during steady state and braking conditions. SAE International Journal of Passenger Cars - Electronic and Electrical Systems, 5(2), 358-372.

SAC (2020). National Standard of the People's Republic of China - Event Data Recorder System. GB 5749-20(January), 1-22.

Shiva Kumar, P., & Murugaanandam, S. (2023). Event data recorder and transmitter for vehicular mishap analysis based on sensor. 2023 International Conference on Computer Communication and Informatics, ICCCI 2023, 1-6.

Thom, P. R., & Maccarley, C. A. (2008). A spy under the hood: Controlling risk and automotive EDR. Risk Management, 22-26.

Tsoi, A., Hinch, J., Ruth, R., & Gabler, H. (2013). Validation of event data recorders in high severity full-frontal crash tests. SAE International Journal of Transportation Safety, 1(1), 76-99.

UN (2022). Agreement concerning the adoption of harmonized technical United Nations Regulations for wheeled vehicles, equipment and parts which can be fitted and/or be used on wheeled vehicles and the conditions for reciprocal recognition of approvals granted on the. World Forum for Harmonization of Vehicle Regulations (WP.29), 1958(October), 29-54.

UNECE (2022). Review of the existing national / regional activities and a proposed way forward for EDR. (2022). 1(April 2021). Retrieved from https://unece.org/transport/documents/2022/04/informal-documents/edrdssad-review-existing-national-regional

Vandiver, W., Ikram, I., & Randles, B. (2013). Accuracy of pre-crash speed recorded in 2009 Mitsubishi Lancer event data recorders. SAE Technical Papers, 2.

Yeung, C. Y., Law, W. C., Chim, T. W., Yiu, S. M., Li, V. O. K., & Hui, L. C. K. (2014). Distributing blackbox data to multiple vehicles in a secure and privacy-preserving manner. 2014 International Conference on Connected Vehicles and Expo, ICCVE 2014 - Proceedings, 804-809.

Zaman, F., H., K., Rozaimi, I. D., & Che, S. A. (2023). Malaysian public's perception toward Event Data Recorder (EDR) in vehicles. 1-13.

.