A Comparative Study of Event Data Recorder (EDR) Parameter Systems in American and Japanese Passenger Vehicles: Using Actual CDR Data from Toyota (2010 Model) and Jeep (2014 Model) as Examples

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Abstract

With the global proliferation and standardisation of Event Data Recorders (EDRs) in motor vehicles, data fusion across different vehicle brands during accident reconstruction faces technical challenges stemming from incompatible parameter systems. This study examines two representative vehicles - a Toyota (2010 model year, Association for Computing Machinery (ACM) supplied by DENSO) and a Jeep (2014 model, ACM supplied by TRW) as representative subjects. Utilising Bosch Call Detail Record (CDR) tools to extract real collision data, this study systematically compared differences between Japanese and American EDR parameter systems across six dimensions: event recording architecture, collision pulse (ΔV) sampling strategy, pre-collision data acquisition, restraint system trigger logic, data integrity markers, and parameter notation conventions. Findings reveal: Toyota EDR possesses comprehensive multi-event temporal correlation fields yet employs a compliance-oriented minimalist strategy characterised by low sampling frequency and limited parameter types. Jeep EDR demonstrates high sampling precision and rich parameter coverage, enabling detailed recording of driver evasive manoeuvres, but exhibits weaker event management logic through a product competitiveness-driven expansive strategy. Significant discrepancies exist between the two systems in event numbering logic, sampling standards, ΔV symbol definitions, and incomplete event representation methods, directly creating technical barriers to cross-brand accident reconstruction. This study constructs a four-dimensional comparative framework, extracts quantifiable difference metrics, and analyses typical cases to reveal the root causes of these discrepancies. It proposes standardisation recommendations including unified event benchmarks, standardised sampling frequencies and parameter sets, unified coordinate system definitions, and the promotion of common data formats. This provides theoretical foundations and technical support for the integrated application of multi-brand EDR data and the scientific advancement of traffic accident investigation.

Keywords

Event data recorder, Call Detail Record report, Parameter system comparison, Accident reconstruction, Data fusion

Introduction

The Event Data Recorder (EDR) captures and stores comprehensive vehicle status data both before and after an incident. This data originates from the vehicle's internal sensors and is characterised by its high reliability, precision, and substantial storage capacity. It plays a crucial role in reconstructing the sequence of events, analysing the causes of accidents, and determining liability [1].

At the international regulatory level, the United States National Highway Traffic Safety Administration (NHTSA) issued Regulation 49 CFR Part 563 in 2006 [2]. Technical standards for EDR data elements and capture formats have been established, requiring all light-duty vehicles equipped with EDR systems sold in the United States after September 2012 to comply with these standards [3]. In December 2024, the NHTSA further amended the regulation, extending the pre-collision data recording duration from 5 seconds to 20 seconds and increasing the sampling frequency from 2 Hz to 10 Hz. The new provisions shall take effect in September 2027.

At the domestic regulatory level, China has established an EDR standards framework through GB 39732-2020 “Automotive Event Data Recording Systems” and GB/T 38892-2020 “Vehicle-Mounted Video Driving Recording Systems” [4]. Pursuant to Amendment No. 2 to GB 7258-2017, all newly manufactured passenger vehicles must be equipped with an EDR or an in-vehicle video recording system compliant with the standards from 1st January 2022 [5]. In July 2022, the National Certification and Accreditation Administration incorporated these two standards into the mandatory certification framework for automotive products, marking the entry of EDR application into a legally regulated phase in China.

In judicial practice, EDR data has demonstrated significant advantages in aspects such as vehicle speed assessment and accident pattern analysis. Research indicates that following the implementation of EDR technology, the average time required to determine accident liability has been reduced by 35%, with evidence acceptance rates in court exceeding 90% [6]. In April 2023, the Traffic Management Bureau of the Ministry of Public Security convened a national conference on big data modelling applications for traffic police systems in Ningbo, Zhejiang Province. The event emphasised advancing the aggregation, integration, and operational deployment of traffic management data, thereby providing policy guidance for the in-depth application of EDR data in traffic accident investigations.

Currently, the EDR installation rate in developed countries and regions such as Europe, the United States, and Japan has exceeded 90% [7]. The United States achieved full coverage of EDRs in newly sold passenger vehicles from September 2014 onwards. The European Union requires all new vehicles to be equipped with EDRs from 2022 under the General Safety Regulation. Japan has established the J-EDR industry standard, which references the US CFR 563.

Although China’s EDR industry commenced later, it has developed rapidly. Following the implementation of the new national standard on 1st January 2022, all newly manufactured passenger vehicles are now fully equipped with EDR systems. However, differences exist between China’s GB 39732-2020 and the US 49 CFR Part 563 in technical parameters and data formats. Furthermore, varying data bus protocols employed by different vehicle brands present compatibility challenges for cross-brand data integration [8].

In the practice of in-depth traffic accident investigations and forensic assessments, complex multi-vehicle collisions are increasingly common, often necessitating the integration of EDR data from different vehicle brands for comprehensive reconstruction. However, the incompatibility of parameter systems has become a key bottleneck hindering the efficient application of EDR data.

Although the application value of EDR technology in traffic accident forensic analysis has gained widespread recognition, existing research predominantly focuses on verifying the accuracy of EDR data from single vehicle models. Represented by Toyota (Japanese, Denso supply chain) and Jeep (American, TRW supply chain), these two major technical camps exhibit significant differences in collision trigger threshold settings, acceleration range selection, timestamp alignment mechanisms. And data storage formats: Toyota employs a CAN FD bus architecture with a protocol derived from the J-EDR standard, whereas Jeep adheres to the SAE J1698 standard and the NHTSA 49 CFR Part 563 regulatory framework. This divergence in underlying technical approaches directly results in time zero-point deviations of up to ± 50ms in EDR recordings during collisions between the two vehicles, alongside heightened complexity in acceleration data coordinate system conversion. Notably, the National Traffic Po and system Big Data Modelling Application Experience Exchange Conference convened by the Traffic Management Bureau of the Ministry of Public Security in Ningbo, Zhejiang Province, in April 2023 explicitly stated the need to “advance data convergence and integration” and “focus on building a new ecosystem for traffic management big data applications”. However, whilst the implementation of GB 39732-2020 and GB/T 38892-2020 has standardised domestic EDR installation requirements, it has failed to resolve compatibility issues with data standards for overseas vehicle models from Europe, America, and Japan [9]. Therefore, there is an urgent need for systematic comparative research on CDR test data from Toyota (2010 model) and Jeep (2014 model) vehicles to reveal structural differences in the parameter systems of American and Japanese EDRs. This will establish standardised cross-brand data conversion methods, providing theoretical support for the integrated application of multi-source EDR data in complex traffic accidents.

This study aims to resolve the challenge of multi-vehicle accident data fusion arising from differences in the EDR parameter systems of American and Japanese passenger vehicles [10]. Specific objectives include: Establishing a four-dimensional comparative framework covering event management, sampling strategies, parameter content, and integrity markers. Systematically analysing technical distinctions between Toyota (2010 model) and Jeep (2014 model) in collision trigger thresholds, sampling frequencies, data element definitions, and validation mechanisms. Extracting quantifiable disparity metrics from real-vehicle CDR reports, utilising Bosch CDR tools to read actual collision data from both vehicles, quantifying timestamp deviations, acceleration coordinate system offsets, and delta-V calculation discrepancies, and establishing a parameter mapping matrix to convert unstructured CDR reports into standardised datasets. This study quantifies the specific impact of data discrepancies on accident reconstruction, focusing on how timestamp deviations and coordinate system conversion errors affect collision velocity synthesis and collision pattern reconstruction. It proposes standardization recommendations and outlines a technical pathway for the standardized conversion of cross-brand EDR data. The findings aim to assist traffic management authorities in enhancing the scientific rigour and precision of multi-vehicle accident investigations.

Data sources and methodologies

The two test vehicles selected for this study were a 2010 Toyota (Japanese make, ACM supplier DENSO) and a 2014 Jeep (American make, ACM supplier TRW). Both were accident-damaged vehicles that had triggered collision events and recorded complete EDR data: Toyota recorded three events, while the Jeep recorded two events. The basic parameters, EDR system models, and data extraction methods are detailed in Table 1.

Table 1. Comparison of basic information of the test vehicle with the EDR system.

Project	Toyota vehicles	Jeep vehicles
VIN	JTECH3FJ405005434	1C4HJWE58EL131321
Model year	2010 model	2014 model
ACM Supplier	DENSO	TRW
ACM part number	89170-60491	68185860AA
EDR specification mark	06EDR (NHTSA 49 CFR Part 563 compliant)	Not explicitly stated, but meets the 563 thresholds
Data extraction date	November 28, 2017	November 28, 2017
Extraction mode	DLC (via on-board diagnostic interface)	D2M (Module Direct Connection)
CDR report page number	19 pages	40 pages
The number of events recorded	TRG3、TRG4、TRG5	Most Recent、1st Prior

Data extraction equipment and operation process

(1) Hardware and software environment

Data extraction is carried out using the Bosch CDR Toolbox (version 14.2), which supports a wide range of vehicle protocols and is equipped with dedicated connection cables such as DLC interface cables and D2M direct connection modules. Data reading and parsing is carried out on a laptop with Windows operating system and Bosch CDR software V14.2. To ensure the stable power supply of the module in D2M mode, it is equipped with a 12V DC stable power supply.

(2) Data extraction operation process

For the different levels of electrical system integrity of the two vehicles, DLC mode (Toyota) and D2M mode (Jeep) are used respectively (as shown in Figure 1 and Figure 2).

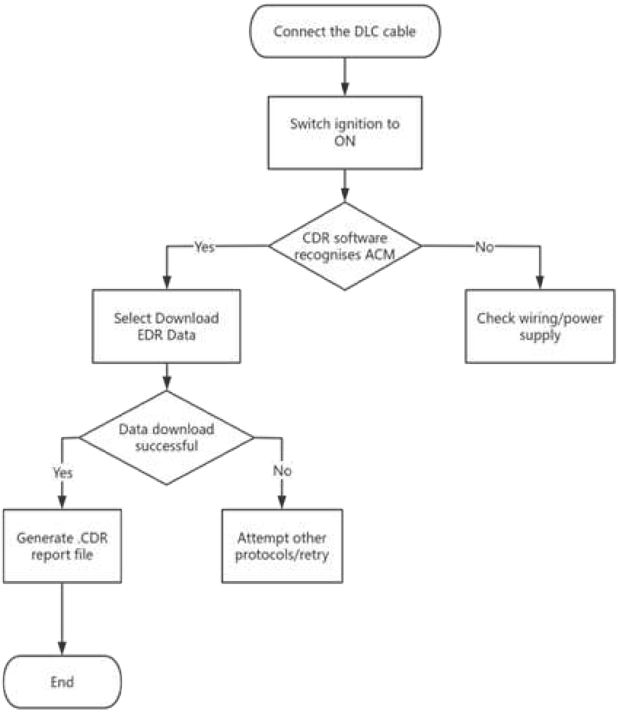


Figure 1. Toyota vehicle DLC mode data reading process.

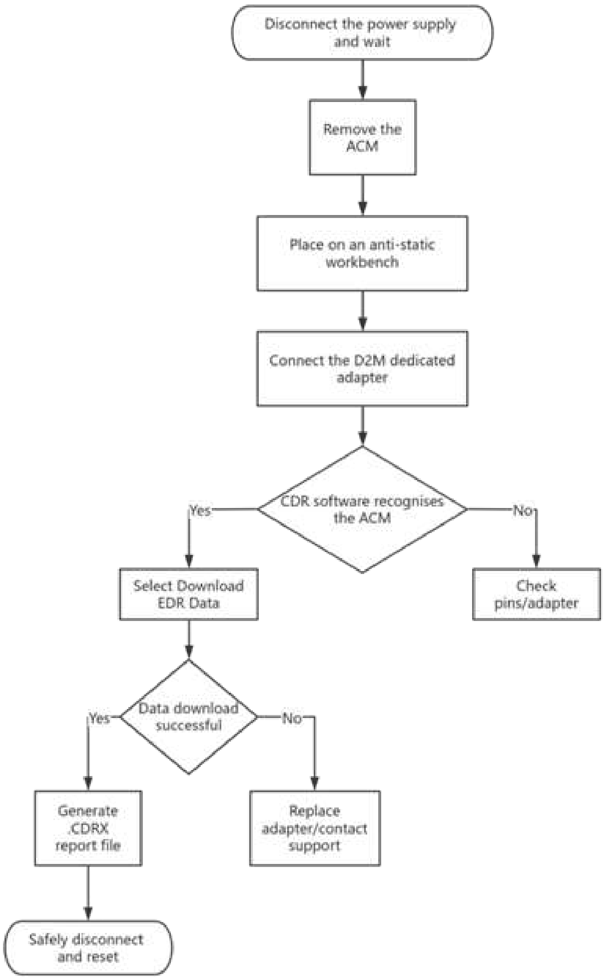


Figure 2. Jeep vehicle D2M mode data reading process Comparison dimension construction method.

To systematically compare the parameter system differences between American (Jeep) and Japanese (Toyota) EDRs, this study constructs a comparative framework from six core dimensions based on the minimum data element set stipulated in 49 CFR Part 563 “Event Data Logger” and the actual presentation structure of the two CDR reports.

Data limitations

EDR data faces multiple precision challenges in accident reconstruction applications. In terms of sampling rate and timing synchronization, different signals are not uniformly collected - the vehicle speed is usually updated in a 100 ms cycle, while the brake signal is mostly recorded by event triggers, which makes the timestamp between signals uncertain in the order of ± 50 ms. There is a model dependence on the ΔV calculation, which is obtained by the airbag control module through the acceleration integration algorithm, but there are differences in the integration window selection and filtering processing of various manufacturers, resulting in systematic deviations from the measurement results of external high-precision IMUs. Data integrity risks cannot be ignored, such as the Jeep’s “recent incident” failing to fully write to non-volatile memory due to power supply interruption in the collision, resulting in missing pre-collision data fields and ΔV anomalies. CDR software relies on the database version when converting the original hexadecimal data into physical quantities, and outdated protocol libraries may lead to interpretation bias.

Comparative analysis of EDR parameter system between Toyota and Jeep

Event recording architecture and multi-event management mechanism

(1) Event identification and numbering logic

Toyota (DENSO 06EDR) uses TRG Count (trigger counter) to identify the timing of events, and its numerical magnitude is inversely related to the time of occurrence - the smaller the count, the earlier the event is triggered. The report shows a strict decreasing sequence: TRG 3 corresponds to the 2nd pre-sequence event, TRG 4 corresponds to the 1st pre-sequence event, and TRG 5 is the Most Recent Event. In addition, the system explicitly records the Previous Crash Type field, for example, in the TRG 5 event, this field is displayed as "Side", which can directly trace the type of attribute of the previous crash.

Jeep (TRW) uses Event Number to identify events, but its numbering mechanism does not guarantee a strict correspondence to the chronological order. The report shows that there is a number jump: Event 1 is marked as 1st Before, Event 3 is marked as Most Recent, and Event 2 is missing or unrecorded, which adds complexity to the timing interpretation. The system does not set the "Pre-order Event Type" field and cannot directly obtain the attribute information of the previous collision and only provides the relative time interval parameter "Time from Event 1 to 2", and the causal association between events needs to rely on manual inference.

(2) Multi-event time correlation information

The Toyota EDR system records the time interval between the current event and the previous sequence event triggered by the "Time from Previous Pre-Crash TRG" field, which is capped at 16381 ms, where TRG 4 is displayed as "-4 ms" and TRG 3 is displayed as "-16,381 or greater", and the negative value indicates the time backward direction. Another key field, "Time from Pre-Crash TRG", is used to calibrate the latest event, and TRG 5 is recorded as "4 ms". In addition, the system establishes the associated index between the pre-crash data page and the collision pulse page through the "Linked Pre-Crash Page" mechanism to ensure that the two types of data are strictly matched during the parsing process and avoid cross-event data crosstalk.

The Jeep EDR system records the time interval between two events through the "Time from Event 1 to 2" field, but this parameter only provides the relative duration without distinguishing the sequence of events, which increases the ambiguity of the interpretation of the collision sequence. The report shows contradictory values for the same parameter across different event records: "1.5 sec" in the Most Recent Event and "0.0 sec" in the 1st Prior Event, suggesting that the system may have lost time baselines or confusion in event numbering logic due to power outages. The system does not configure associated fields such as "Previous Crash Type" or "Linked Page", which can neither trace the type attributes of the previous crash nor the index matching mechanism between the pre-collision data and the collision pulse data, and the data integrity and correlation are weaker than the Toyota scheme.

Comparison of collision pulse (ΔV) sampling strategies

(1) Sampling interval and number of data points

Toyota ΔV was recorded from 10 ms and increased negatively, peaking at -10.3 mph at 180 ms and then maintaining the platform to 200 ms. The curve has no obvious pulse spikes and is characterized by slow rise and fall (as shown in Table 2).

Table 2. Comparison of EDR pre-collision data recording characteristics of Toyota and Jeep.

Comparison item	Toyota (TRG 5)	Jeep (1st prior event)
Sampling interval	10 ms	2 ms
Record duration	0~200 ms	0~300 ms
Data points	21	150
Longitudinal ΔV peak	-10.3 mph @ 180 ms	-28.0 mph @ 102 ms
Lateral ΔV peak	24.5 mph @ 11 ms (B-pillar)	9.3 mph @ 84 ms

(2) ΔV curve morphology and key characteristics

The Jeep ΔV starts at 0 ms, at 2 ms intervals, and peaks at -28.0 mph at 102 ms, with a significant decline (gradually falling back after 130 ms). The curve presents a typical collision pulse waveform, which can be used for dynamic inversion such as acceleration and collision force (as shown in Figure 3 and Figure 4).

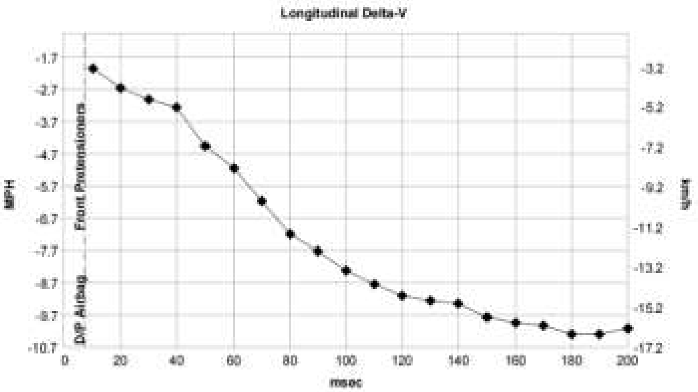
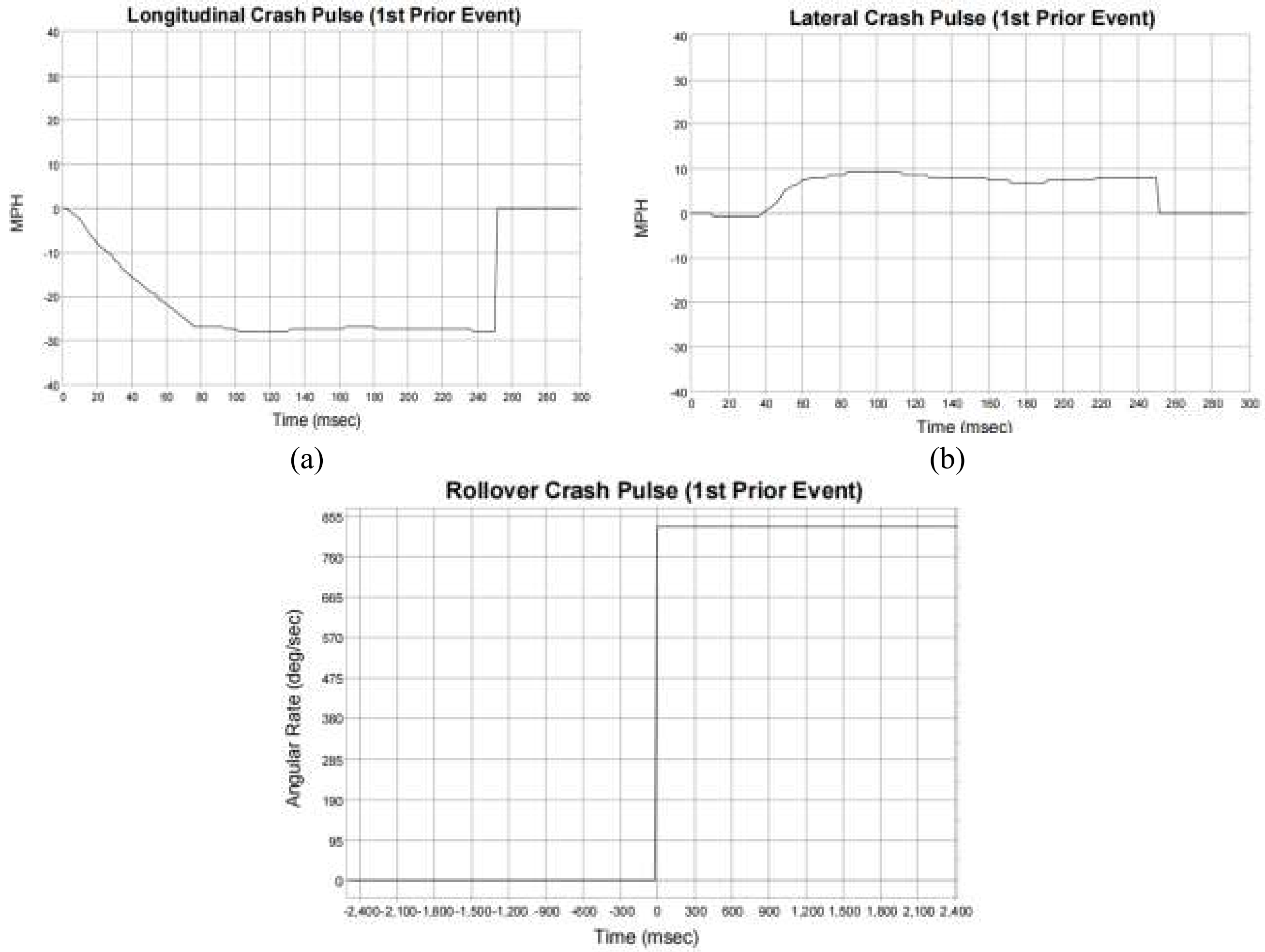


Figure 3. Longitudinai Delta-V.



(c)

Figure 4. Jeep 1st prior event (a) the longitudinal velocity response over time, (b) the lateral velocity response over time, and (c) the angular rate response indicative of rollover behavior.

Pre-collision data collection content and resolution

(1) Sampling frequency and sample capacity

The Toyota (TRG 5) and the Jeep (1st Prior Event). For the Toyota (TRG 5), the sampling interval is approximately 1 second, resulting in a total of 6 samples. In contrast, the Jeep (1st Prior Event) employs a much finer sampling interval of 0.1 seconds, which yields a significantly larger number of samples, totaling 51. This difference in sampling parameters reflects a higher temporal resolution for the data collected during the Jeep's first prior event.

Table 1. Comparison of Toyota and Jeep EDR speed signal sampling characteristics.

Comparison item	Toyota (TRG 5)	Jeep (1st Prior Event)
Sampling interval	About 1 second	0.1 seconds
Number of samples	6	51

(2) Parameter types and physical formats

The pre-collision parameters of Toyota EDR are limited to five basic data: vehicle speed, brake switch, accelerator pedal voltage, engine speed and gear, of which the accelerator pedal is output with a voltage value of 0~5V, which needs to be converted into an opening percentage in combination with the maintenance manual, which is a non-standardized physical quantity, and there are obstacles to direct interpretation. Jeep EDR records the opening of the accelerator pedal in the form of a percentage, which has a clear physical meaning, and additionally covers complete chassis and active safety parameters such as steering input, yaw angular speed, ESC status, four-wheel speed, tire pressure, cruise control and manifold pressure - the steering angle is positive for left turn (-28°~+6°), the yaw angular speed is counterclockwise (-4.06~+0.53 deg/sec), and the ESC status includes fault light identification , the wheel speed records the four-wheel data independently at rpm.

Constrain the system to trigger the recording logic

Toyota EDR records the trigger of the restraint system at a single point in time, "Time to Deployment Command" is defined as the time interval between the trigger and the issuance of the airbag ignition command, the driver and passenger airbags and pretensioners are 7 ms in the TRG 5 event, and the untriggered device is marked as "Not Commanded", and the "Event Severity Status" of 1~3 levels is used to characterize the collision intensity (this time it is level 3). Jeep EDR adopts a two-stage ignition timing, in the 1st Prior event, the driver's airbag is 10 ms in the first stage, 40 ms in the second stage, and the passenger airbag is 10 ms in the first stage and 25 ms in the second stage. In addition, the Jeep report includes the "Occupant Size Classification" field for occupant size classification, which does not record specific values, but reflects the design orientation of American EDR in the direction of occupant protection refinement.

Data integrity identification and incomplete event characterization

Toyota EDR uses the Recording Status field for event-level integrity identification, which is divided into two levels: "Complete" and "Incomplete", and the three events extracted this time all show "Complete", and the collision pulse and pre-collision data are fully presented. Jeep EDR uses Complete File Recorded (Yes/No) as the integrity identifier, its Most Recent Event shows "No", the collision pulse part prompts "Contains No Recorded Data", all fields of the pre-collision data are marked as Signal Not Available (SNA) from -2.0 s, and the maximum ΔV appears -15,907.1 mph - This anomaly stems from an ACM power supply interruption during a collision that causes data to not be fully written to non-volatile memory. There are significant differences between the two mechanisms: Toyota only provides event-level integrity judgment, while Jeep's SNA mechanism implements field-level missing annotation, which can still retain valid information when the data part is available, with a higher degree of refinement. At the same time, the extreme outliers in the Jeep incomplete event also warn users that the EDR data must be evaluated for integrity and outlier cleansing before it can be used for quantitative analysis.

Differences between parameter symbol conventions and physical meanings

There are brand differences in the positive definition of the horizontal ΔV: Toyota uses "outside the car → inside the car" as a reference, and Jeep uses "left → right" as a reference. This difference in symbol convention is a direct technical obstacle to cross-brand EDR data fusion, and if directly combined and used, it may lead to direction interpretation errors, and multi-vehicle collision reconstruction can be carried out after manually converting the coordinate system (as shown in Table 4).

Table 2. Parameter definition comparison.

Parameters	Toyota is defined in the positive direction	Jeep forward definition
Longitudinal ΔV	Forward	Forward
Lateral ΔV	Outside to Inside	Left to Right (left to right, driver's perspective).
Yaw angular velocity	Not recorded	Counter clockwise
Turn to input	Not recorded	Steering wheel turned counter clockwise

NHTSA 563 standard compliance assessment

Although the Toyota 06EDR does not explicitly comply with the NHTSA 49CFR Part 563 regulation in the report, the data elements fully cover the requirements of the regulation, and Toyota clearly states that the 12EDR and subsequent versions are designed to comply with the 563 rules. The Jeep EDR report does not declare 563 compliances, but its core parameters such as recording thresholds, ΔV sampling, and pre-collision speed all meet the minimum requirements of the regulation, substantially reaching the compliance level.

In terms of event management, Toyota has completed multi-event time series correlation fields (TRG Count, Time from Previous Pre-Crash TRG), and Jeep can only record event intervals and cannot reconstruct the time series. In terms of collision pulse recording, the Jeep 2 ms sampling rate is 5 times that of Toyota (10 ms), which can restore the real collision waveform, and Toyota only meets the minimum regulatory requirements. In the pre-collision data, the parameter richness of Jeep's 10 Hz sampling frequency and 30+ fields are much higher than that of Toyota (1 Hz, 5 fields), which can directly support driver behavior analysis. The recording logic of the restraint system is very different: Jeep uses a two-order ignition timing, and Toyota records a single-order time and event severity level. In terms of data integrity identification, both systems can identify incomplete events, but Jeep's SNA mechanism implements field-level missing annotation, which is more granular. The horizontal ΔV is inconsistent in the forward direction definition (Toyota's "outside→in-car", Jeep's "left→right"), and cross-brand data fusion requires coordinate system conversion. In terms of regulatory compliance, Toyota is expressly compliant with NHTSA 563 rules, which Jeep does not express but actually meets. In terms of overall strategy, Toyota adopts the minimum set configuration, and Jeep adopts the extended set configuration.

Comparative verification of typical cases

Toyota multi-event timing correlation case (TRG 4→TRG 5)

In three incidents recorded by Toyota vehicles, TRG 4 (side impact) and TRG 5 (frontal collision) constituted a continuous collision. The "Time from Pre-Crash TRG" of the TRG 5 is only 4 ms, and the "Previous Crash Type" is clearly marked as "Side", which directly indicates that the frontal collision conditions have been met within a very short time after the side collision is triggered. The two incidents share the same set of pre-collision data, with the speed gradually dropping from 39.8 mph to 31.1 mph in the first 5 seconds of the collision, the brake switch being triggered at -3.6 s and -2.6 s but off now of collision, and the driver's and passenger's seat belts are in a buckled state (as shown in Figure 5).

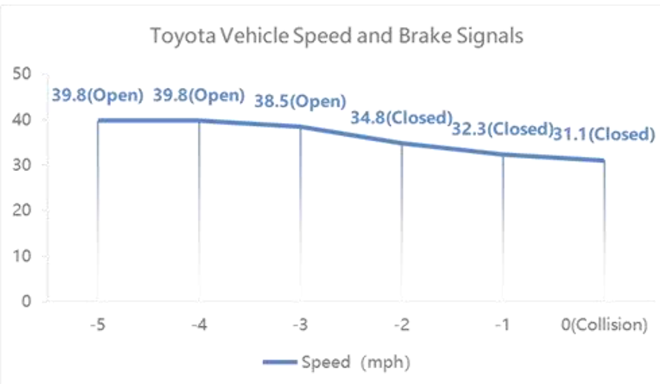


Figure 1. Toyota vehicle speed and brake signal status.

Figure 5 shows the evolution of vehicle speed and brake signal state in the first 5 seconds of a Toyota vehicle's collision. As can be seen from the figure, the driver briefly applied the brakes about 3.6 seconds before the collision, but then released it, and the brake switch was OFF when the collision occurred. The vehicle speed continued to drop from 39.8 mph in -4.6 s to 31.1 mph in 0 s, indicating that the vehicle was in the deceleration and coasting stage before the collision.

Jeep complete event crash pulse and risk avoidance case (1st prior event)

Jeep 1st Prior Event is a complete record event, and its high sampling rate and multi-parameter characteristics are fully reflected. In terms of collision pulses, the longitudinal ΔV is sampled at 2 ms intervals, reaching a peak of -28.0 mph at 102 ms, and the lateral ΔV reaches a peak of 9.3 mph at 84 ms. The pre-collision data fully reproduces the driver's avoidance behavior: the vehicle speed drops from -5.0 s to 62 mph at -0.1 s to 57 mph at -0.1 s, the brake is continuously triggered from -0.4 s to -0.1 s, the steering input is continuously negative (-28°~-5°) indicating a sharp turn to the right, the accelerator pedal is retracted from 35% to 11%, and the yaw angular speed is negatively peaked at -4.06 deg/s, which is highly synchronized with the steering operation - the above data fully records the "braking + steering" of about 0.5 seconds before the collision Comprehensive hedging operations. The restraint system record shows that the driver's airbag is ignited in two stages (1st stage 10 ms, 2nd stage 40 ms), the passenger airbag is 10 ms in the first stage, 25 ms in the second stage, and the pretensioner command is triggered; In terms of occupant status, the driver's seat belt is buckled, and the front passenger is not wearing a seat belt (as shown in Figure 6).

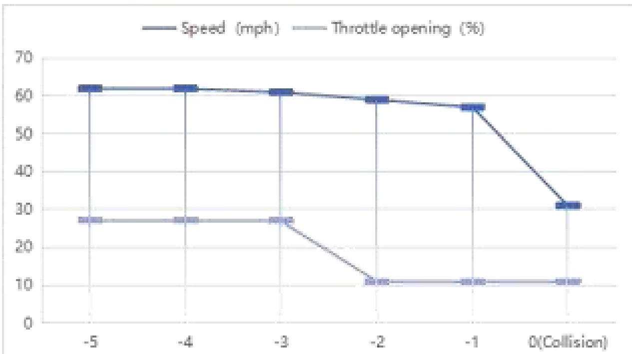


Figure 2. Jeep vehicle speed and throttle opening variation.

Most recent event

Jeep Most Recent Event is a typical case of data write failure due to power supply interruption. The report clearly marks “Complete File Recorded = No”, the collision pulse section shows “Contains No Recorded Data”, all more than 30 fields of the pre-collision data are marked as “SNA” from -2.0 s onwards, and the maximum longitudinal and lateral ΔV is physically impossible of -15907.1 mph - an anomaly caused by uninitialized memory or error flag bits. The Jeep CDR manual states: “If the ACM is powered off during the event, all or part of the event data may be lost”, combined with the fact that the front of the vehicle is severely damaged and the battery is disconnected, it can be confirmed that the power supply interruption at the moment of the collision caused the data to be not fully written to non-volatile memory. This event can only be used as a negative teaching material for integrity assessment, and its ΔV outliers, missing collision pulses and field-level SNA are strictly prohibited from being used for quantitative reconstruction, but the existence of the event and seat belt status and other information are still of reference value. This case demonstrates the advantages of the Jeep SNA mechanism in field-level missing annotation and warns that EDR data must be used as evidence after completeness evaluation and outlier identification.

Discussion

Analysis of the causes of differences

(1) Regulation-oriented differences: minimum set strategy and extended set strategy

The significant difference between Toyota and Jeep’s EDR parameter system stems from the fundamental difference in regulatory compliance strategies. Toyota CDR Report P1 clearly states: “The specifications for 12EDR or later are designed to be compatible with NHTSA’s 49CFR Part 563 rule.” Although the 06EDR involved in this experiment is not marked as “compatible”, its data elements completely cover the 563 mandatory fields and do not record any 563 non-mandatory parameters - this is a typical compliance minimum set strategy: to meet regulations as the upper limit, control costs, and reduce system complexity. The Jeep EDR report does not specify 563 compatibilities, but the actual recorded ΔV threshold, pre-collision speed, seat belt status, etc. all meet the 563 requirements. At the same time, Jeep vehicles capture a substantial set of 563 non-mandatory parameters, including steering input, yaw rate, ESC status, wheel speed, tire pressure, and cruise control data. This constitutes a deliberate expansion strategy, whereby manufacturers augment mandatory datasets with extensive parameters to enhance data utility, thereby facilitating in-depth accident reconstruction and demonstrating product competitiveness. The National Highway Traffic Safety Administration (NHTSA) Regulation 49 CFR Part 563 - EDRs only specify basic data elements and do not unify event logic, time synchronization, and data structure. This provides a direct regulatory footnote to the differences between the two lines.

(2) Differences in supplier technical routes

The technical heritage and product positioning of ACM suppliers are another core cause of the difference. Toyota is equipped with DENSO ACM, as the world’s leading integrated supplier, its EDR function is highly integrated into the airbag control module, and the design priorities are reliability, cost, and compliance, so it adopts simplified solutions such as 10 ms ΔV sampling, 1 Hz pre-collision recording, and voltage-based accelerator pedal signal. Jeep is equipped with TRW (now ZF) ACM, TRW is deeply involved in the occupant safety system, and EDR is regarded as the recorder and prover of the performance of the safety system, so it adopts a refined design such as a high sampling rate of 2 ms, more than 30 pre-collision parameters, and a two-stage ignition timing.

(3) Model age and industry evolution

This experiment is Toyota in 2010 and Jeep in 2014, and the four-age difference objectively reflects the industry progress of EDR technology. Around 2010, NHTSA 563 was still in the promotion period, and most car companies took “meeting the minimum requirements” as their primary goal; In 2014, EDR has become a mature configuration, and American car companies took the lead in expanding it into an accident reconstruction data platform. However, it should be emphasized that the essential difference in the event management mechanism cannot be explained by age - the Toyota 06EDR (2010) already has strong timing correlation fields such as TRG Count and Time from Previous Pre-Crash TRG, while the 2014 Jeep still lacks such a design, which reflects the fundamental difference between Japanese and American models in EDR functional positioning.

Actual impact on accident reconstruction work

In the practice of accident reconstruction, the integration of EDR data of different brands faces the obstacle of parameter system differentiation of “Japanese emphasis on timing and American emphasis on details”. In terms of event timing alignment, Toyota uses TRG Count to decreasing to characterize the sequence of events, and Jeep uses Event Number, which may be out of order, and the two lack a unified time series reference system. In terms of ΔV waveform comparison, the Toyota 10 ms smooth curve and the Jeep 2 ms fine pulse cannot be directly compared on the same timeline, and additional errors need to be resampled or waveform fitted. In terms of the definition of lateral ΔV direction, Toyota’s “Outside to Inside” and Jeep’s “Left to Right” forward direction convention are incompatible, and direct merging will lead to an incorrect interpretation of the collision direction.

Standardization recommendations for cross-brand EDR data interoperability

Unified event numbering and time benchmark: Under the current standard, Toyota uses TRG Count with decreasing timing, and Jeep uses Event Number without guaranteeing timeline, and the two cannot be directly corresponded. It is recommended to force the recording of the “absolute sequence number of events” accumulated from the ignition cycle, and the “time interval of pre-sequence events” with an accuracy of not less than 1 ms and establish a unified timing reference system with reference to the Toyota mechanism. Specification pre-collision sampling frequency and minimum parameter set: Toyota 1 Hz sampling only 5 parameters and Jeep 10 Hz sampling more than 30 parameters are very different. It is recommended to forcibly increase the pre-collision sampling frequency to not less than 10 Hz, record the recording time not less than 5 seconds before the collision, and include the steering input, braking status, ESC status, and accelerator pedal opening percentage into the mandatory data elements, which have irreplaceable evidentiary value for the identification of drivers’ hazard avoidance behavior and the determination of accident liability. Unified symbol convention and coordinate system definition: Horizontal ΔV positive direction definition conflicts (Toyota “Outside to Inside” vs. Jeep “Left to Right”) lead to cross-brand data fusion barriers. It is recommended to force the unified horizontal ΔV forward direction to be “Left to Right” based on the driver’s perspective and add a coordinate system schematic diagram on the first page of the CDR report to clearly mark the positive direction and symbol rules of each axis. Unified incomplete event identification and outlier handling: Toyota’s event-level “Recording Status” and Jeep’s field-level “SNA” identification are not granular, and outliers are not automatically suppressed. It is recommended to enforce field-level missing identification to distinguish between three situations: “equipment is not equipped”, “signal is not available”, and “data is not recorded”; CDR software should automatically mark “outliers” for physically impossible values (such as ΔV>100 mph) and prohibit unprocessed exports, and assume the responsibility for initial screening of data reasonableness. Promote the international common format of EDR data: Based on the ISO/SAE 21448 framework, formulate a common mode for EDR data exchange (such as XML Schema), and uniformly define the units, symbols, accuracy, and missing identifier meta information of core data blocks such as event sequences, collision pulses, pre-collision timing series, and constraint system states, which is the core policy recommendation to improve data interoperability.

Conclusion

Through the in-depth comparison of the two EDR systems of Toyota (DENSO 06EDR) and Jeep (TRW), the essential differences between Japanese and American parameter systems are revealed: Toyota has a strong multi-event timing association but insufficient sampling accuracy and parameter richness, while Jeep has an advantage in sampling accuracy and parameter richness but is weak in multi-event correlation management. This difference stems from different technical strategies - the Japanese system adopts a regulation-oriented cost-first minimum set strategy, while the American system adopts a product competitiveness-oriented extended set strategy - which has constituted a technical barrier to cross-brand accident reconstruction, which is manifested in the incompatibility of event numbering logic, inconsistent pre-collision sampling standards, inconsistent ΔV symbol conventions, and different incomplete event representation methods. Standardization is the fundamental way to solve the above problems, and it is necessary to upgrade the second-generation EDR standard based on NHTSA 563 to unify event management, sampling frequency, parameter content and data format.

Future research can be expanded in four directions: first, expand the sample size and include more brands such as Honda, Ford, Tesla, and BYD to establish an EDR parameter system classification map; second, carry out real vehicle collision verification, and verify the accuracy of EDR ΔV and the systematic differences between brands through controlled tests; The third is to explore the cloudification of EDR data and build a cloud accident reconstruction platform that uploads in real time and analyzes in a unified format after collision. Fourth, promote the application of forensic appraisal, formulate cross-brand EDR data joint use specifications based on the conclusions of this study, and provide technical support for the determination of responsibility for compound collision accidents.

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Conflicts of Interest

The author declares no conflict of interest.

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