

# Characteristics of Crash Data from Event Data Recorders in Collisions with Narrow Objects

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**Abstract** - Event data recorders (EDRs) are a valuable tool for in-depth investigation of traffic accidents. EDRs are installed on the airbag control module (ACM) to record vehicle and occupant information before, during, and after a crash event. This study evaluates EDR characteristics and aims to better understand EDR performance for the improvement of accident reconstruction with more reliable and accurate information regarding accidents. The analysis in this report is based on six crash tests with corresponding EDR datasets.

## INTRODUCTION

Event data recorders (EDRs) are a valuable tool for in-depth investigation of traffic accidents. EDRs are installed on the airbag control modules (ACM) to record vehicle and occupant information in the brief time before, during, and after a crash event.

In January 2008, the US National Highway Traffic Safety Administration published their revised final rules regarding EDRs [1]. In March 2008, the Japanese Ministry of Land, Infrastructure, Transport and Tourism finalised the technical requirements for EDR use in light vehicles, defined as vehicles with a gross vehicle weight rating of 3500 kg or less [2]. This rule is comparable to a similar US regulation (49 CFR Part 563) [3]. EDRs are now being installed in ACMs by several automakers in Japan.

EDRs generally record indicated vehicle speed, engine speed, engine throttle or accelerator pedal state, and the state of service brakes before the crash event. Furthermore, delta-V is recorded during crash events. EDRs are thus promising for traffic accident investigations.

However, it is necessary to examine the reliability and accuracy of EDR data. The aim of this study is to evaluate EDR characteristics and to understand EDR performance for the improvement of traffic accident investigations. This study focuses on EDR crash data on collision with narrow objects, real car crash tests were performed to evaluate the resulting data.

## EXPERIMENTAL PROCEDURE

### General Description of Analysis Method

Crash test data are used for EDR data comparison. As shown in Figure 1, accelerometers with a 10 kHz sampling rate were attached to the cars. The acceleration data obtained from the sensors are integrated to obtain delta-V, the velocity change during the collision. Vehicle crash behaviours were captured by high-speed video cameras. An external optical speed sensor is used to obtain vehicle impact velocities.

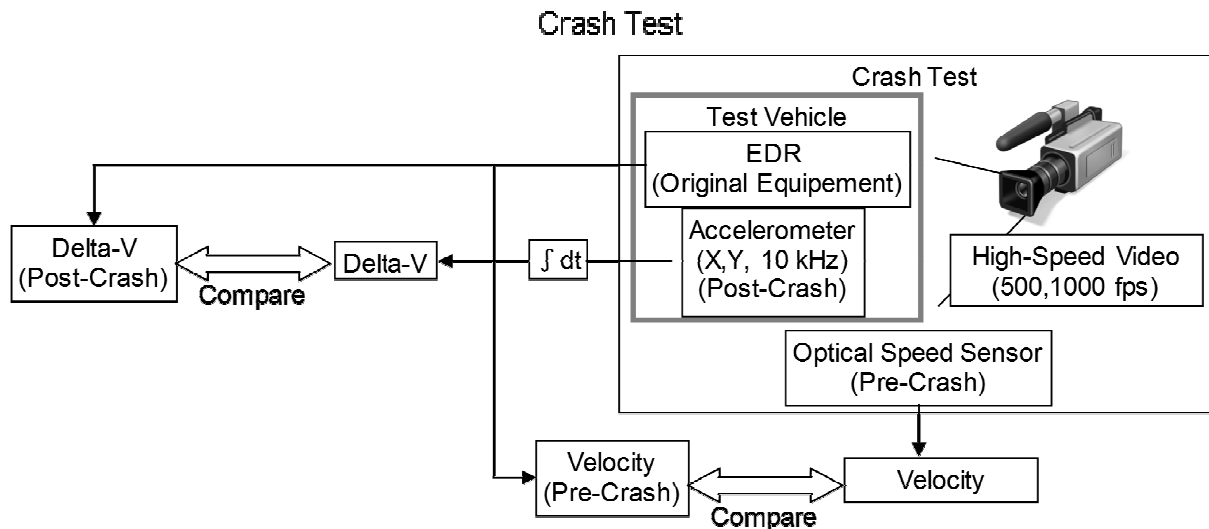


Figure 1 Analysis method in crash tests

Pre-crash velocity recorded by each EDR ( $V_{EDR}$ ) was compared with data from an optical speed sensor ( $V_{op}$ ). Post-crash maximum delta-V and delta-V versus time history EDR data were compared with the data calculated using ACM accelerometers (A-EDR) and data from high-speed video cameras (Video). Where A-EDRs were not available, data from accelerators on the centre of the car floor were used.

### Crash Tests Conditions

Typical real-world accidents such as a single-car collision against a road-side object were simulated in crash tests. As Figure 2 shows, six crash tests were performed to evaluate the EDR data. Toyota Corollas were used as test vehicles. The test vehicles were equipped with ACMs at the centre floor in front of the shift lever box under the centre console. After crash tests, the ACMs were removed for downloading the EDR data. Details of each test condition are below.

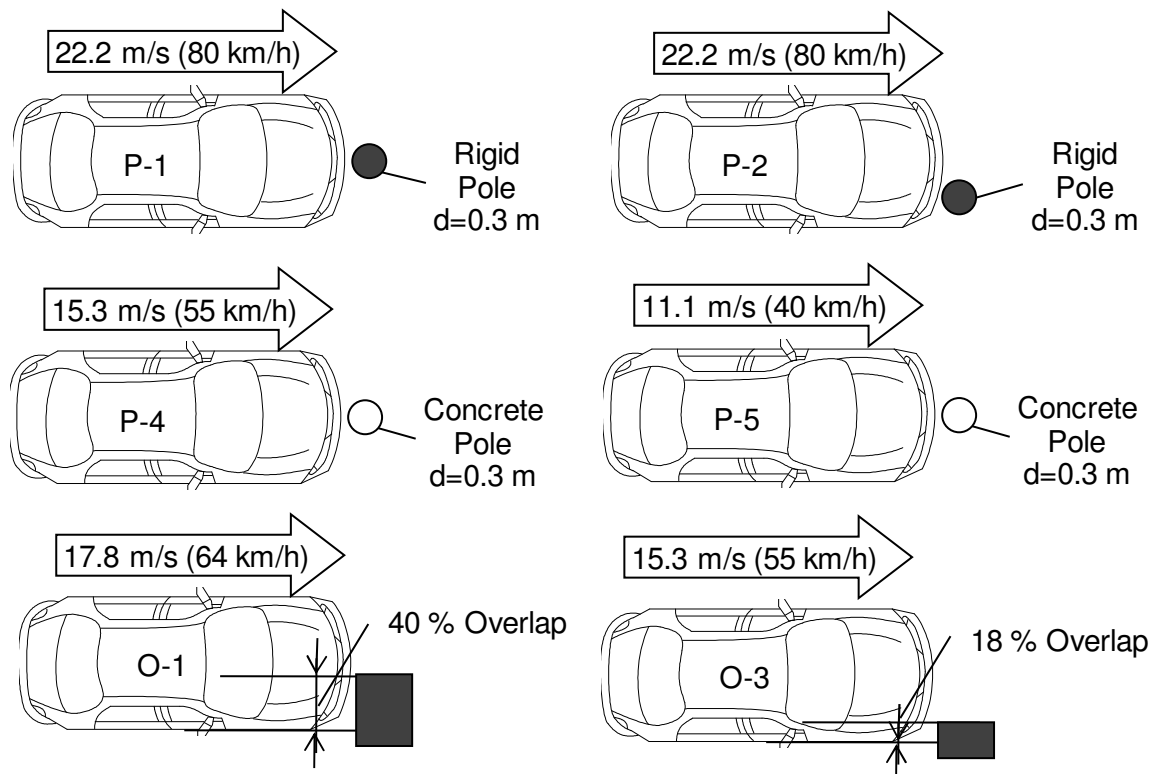


Figure 2 Conditions for the six crash tests

#### *Car to rigid pole frontal centre collision (P-1)*

Test vehicle P-1 was a Toyota Corolla with front, side, and curtain airbags. The impact speed was 22.2 m/s (80 km/h). The pole was a steel pipe filled with concrete. The pole diameter was 0.3 m, which is a common size for electric utility poles in Japan. The front centre of the test vehicle collided against the pole.

#### *Car to rigid pole frontal offset collision (P-2)*

Test vehicle P-2 was a Toyota Corolla with front, side, and curtain airbags. The impact speed was 22.2 m/s (80 km/h). The pole was a steel pipe filled with concrete. The pole diameter was 0.3 m. The test vehicle's right front side member collided against the pole (offset 460 mm).

#### *Car to concrete pole collision at high speed (P-4)*

Test vehicle P-4 was a Toyota Corolla with front, side, and curtain airbags. The impact speed was 15.3 m/s (55 km/h). A concrete pole was used to model the type of electric utility pole common in Japan. The pole diameter was 0.3 m. The front centre of the test vehicle collided against the pole.

#### *Car to concrete pole collision at low impact speed (P-5)*

Test vehicle P-5 was a Toyota Corolla with front, side, and curtain airbags. The impact speed was 11.1 m/s (40 km/h). A concrete pole was used to model the type of electric utility pole common in Japan. The pole diameter was 0.3 m. The front centre of the test vehicle collided against the pole.

### *Car to rigid barrier offset collision (O-1)*

Test vehicle O-1 was a Toyota Corolla with front, side, and curtain airbags. The impact speed was 17.8 m/s (64 km/h). The test condition was a 40% overlap on the right side against a rigid barrier.

### *Car to rigid barrier sideswipe (O-3)*

Test vehicle O-3 was a Toyota Corolla with front, side, and curtain airbags. The impact speed was 15.3 m/s (55 km/h). The test condition was an 18% overlap on the right side (beyond the front side member) against a rigid barrier.

## **RESULTS**

### **Test Vehicle Conditions**

Figure 3 shows high-speed video images and photographs of the test vehicles. The left column in the figure shows high-speed video images of the test at the maximum deformation with a time counter at the top right of the images. The centre column in the figure shows positions of the test vehicle after collision. The right column in the figure shows deformation of the test vehicles. Time zero is defined at contact of the front bumper against a pole or a barrier. Test observations are described in detail below.

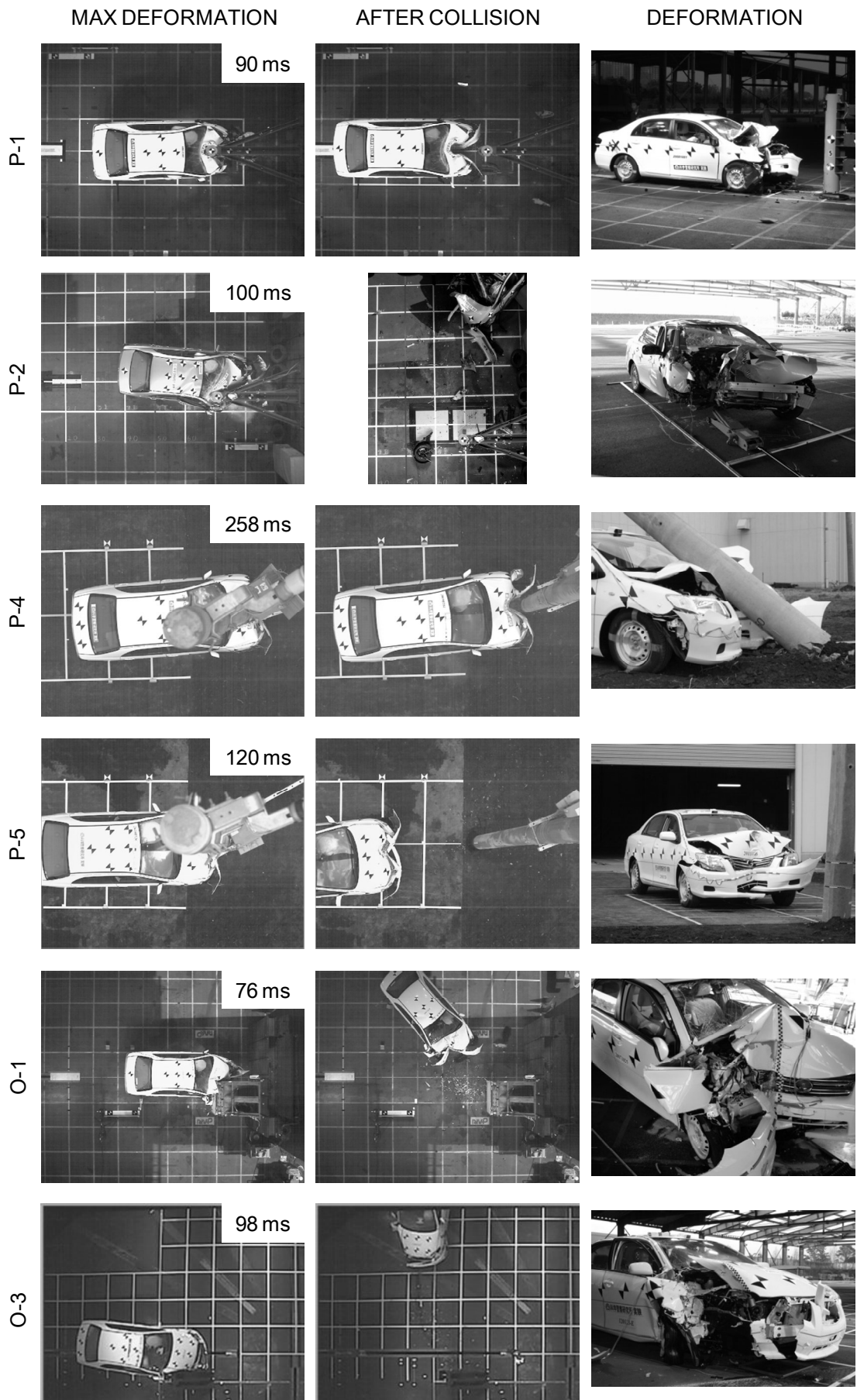


Figure 3 High-speed camera and photographic images

#### *Car to rigid pole frontal centre collision (P-1)*

After the collision, P-1 rebounded approximately 1.5 m from the pole. The front airbags deployed at the instant of the collision. The lateral accelerometers did not detect the impact, so the side and curtain airbags did not deploy. The pole dented the centre of the engine room. The maximum deformation was approximately 1.1 m. The side members were bent on the inside.

#### *Car to rigid pole frontal offset collision (P-2)*

After the collision, P-2 rotated approximately 135° clockwise, and moved left approximately 5.5 m. The front airbags deployed at the instant of the collision. The lateral accelerometers did not detect the impact, so the side and curtain airbags did not deploy. The right side member was crumpled. The right wheel drive axel was broken. The maximum deformation was approximately 1.2 m. The left side member was bent on the inside.

#### *Car to concrete pole collision at high speed (P-4)*

After the collision, P-4 ran approximately 1.0 m over the base of the pole. The front airbags deployed at the instant of the collision. The lateral accelerometers did not detect the impact, so the side and curtain airbags did not deploy. The pole dented the centre of the engine room approximately 0.57 m. The pole broke at ground level, and slowly leaned onto P-4 after the collision.

#### *Car to concrete pole collision at low impact speed (P-5)*

After the collision, P-5 rebounded approximately 2.4 m. The front airbags deployed at the instant of the collision. The lateral accelerometers detected the impact, but the side and curtain airbags did not deploy. The pole dented the centre of the engine room approximately 0.42 m. The pole base receded approximately 0.17 m. The pole did not break, but its surface cracked.

#### *Car to rigid barrier offset collision (O-1)*

After the collision, O-1 rotated approximately 45° clockwise, and rebounded approximately 2.0 m from the barrier. The front airbags deployed at the instant of the collision. The lateral accelerometers did not detect the impact, so the side and curtain airbags did not deploy. The vehicle deformation was approximately 0.8 m. The bumper reinforcement and the right-front side member crumpled.

#### *Car to rigid barrier sideswipe (O-3)*

After the collision, O-3 rotated approximately 90° clockwise, and moved approximately 4.5 m from the barrier. The front airbags deployed at the instant of the collision. The lateral accelerometers detected the impact, but the side and curtain airbags did not deploy. The vehicle deformation was approximately 1.12 m. There was no damage to the front side member. The front right tire and the suspension were broken.

## Pre-Crash Data from EDRs

EDRs recorded the vehicle impact speed, and the recorded speed was compared with data from the optical speed meter in Table 1. In all tests, airbag accelerometers sensed an impact shock. In particular, O-3 sensed the impact shock despite there being no deformation of the G sensor-equipped side member. The absolute differences between the EDR impact velocities ( $V_{EDR}$ ) and those obtained from the optical speed sensors ( $V_{OP}$ ) were less than 1 m/s.

Table 1 Comparison results of pre-crash impact velocities in the tests

Vehicle	Target	Impact Point	$V_{OP}$	$V_{EDR}$	Difference	
			m/s	m/s	m/s	%
P-1	Rigid Pole	Centre	22.4	22.8	0.4	1.8
P-2	Rigid Pole	Right	22.2	22.2	0	0
P-4	Concrete Pole	Centre	15.3	15.6	0.3	2.0
P-5	Concrete Pole	Centre	11.2	11.1	-0.1	-0.9
O-1	Rigid Barrier	40% Overlap	17.9	17.8	-0.1	-0.6
O-3	Rigid Barrier	18% Overlap	15.4	15.6	0.2	1.3

## Post-Crash Data from EDRs

EDRs record the max delta-V and time history curve of the delta-V by 200 ms. The maximum delta-V are compared with the data calculated with A-EDR in Table 2. Time history curves for the longitudinal direction are shown in Figure 4 with values calculated using A-EDR and high-speed videos.

Table 2 Comparison results of post-crash maximum delta-V in the tests

Vehicle	Target	Impact Point	Max delta-V <sub>A-EDR</sub>	Max delta-V <sub>EDR</sub>	Difference	
			m/s	m/s	m/s	%
P-1	Rigid Pole	Centre	25.0*	17.5	-7.5	-30.0
P-2	Rigid Pole	Right	22.5	20.9	-1.6	-7.1
P-4	Concrete Pole	Centre	12.6	11.7	-0.9	-7.1
P-5	Concrete Pole	Centre	12.2	14.5	2.3	18.9
O-1	Rigid Barrier	40% Overlap	17.4	20.2	2.8	16.1
O-3	Rigid Barrier	18% Overlap	16.5	15.1	-1.4	-8.5

\*Data calculated using an accelerometer at the centre of the rear seat.

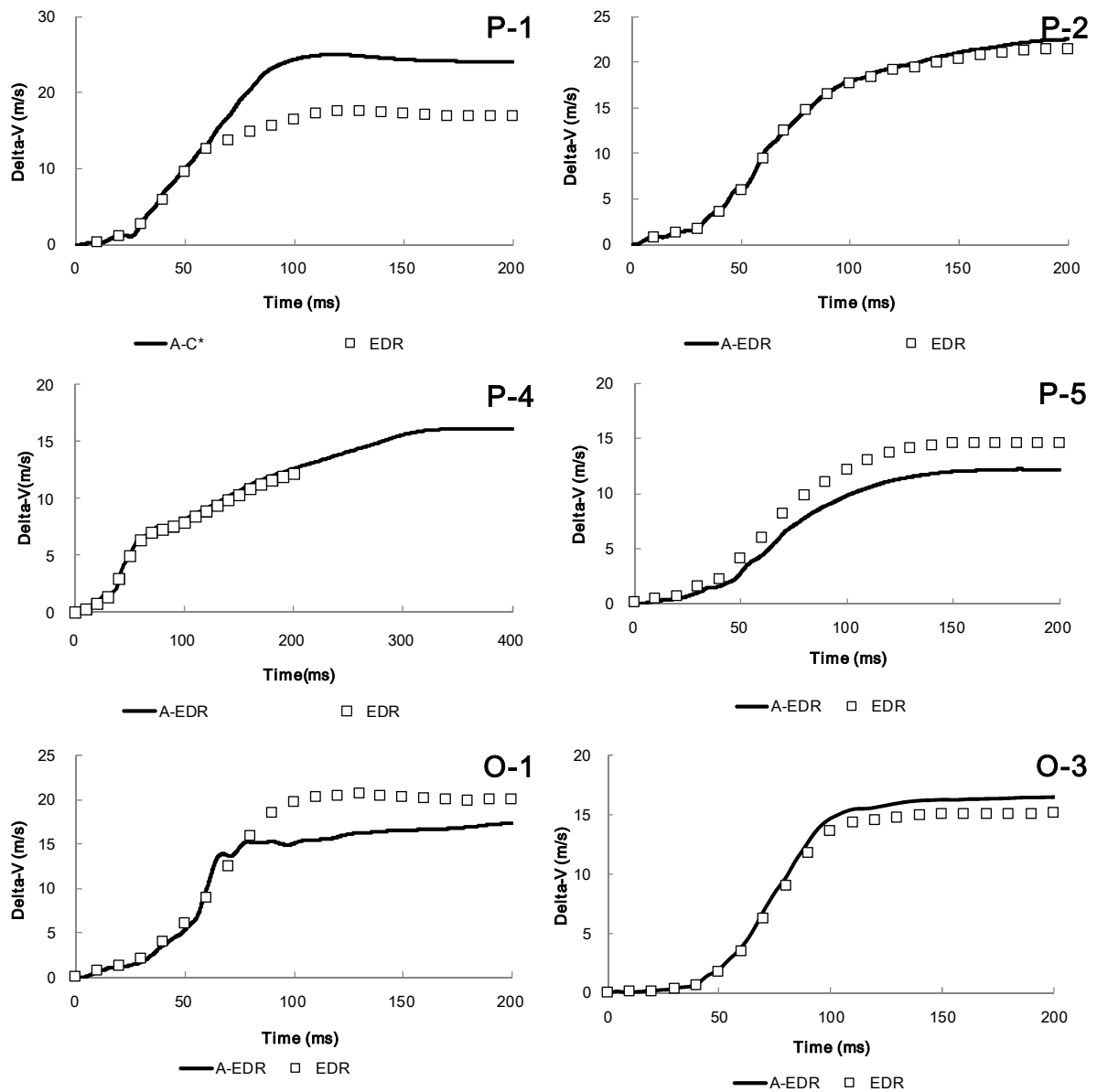


Figure 4 Time history curves of delta-V

\*Data calculated using an accelerometer at the centre of the rear seat.

## DISCUSSION

Comparison of EDR-recorded pre-crash velocity with the results from an optical speed sensor indicates that the EDR pre-crash velocities were very accurate. The pre-crash speed data were not affected by collision type. EDRs detected impact with two accelerometers (satellite sensors) installed on side members (Figure 5). After a detected impact, longitudinal delta-V is calculated using data from ACM accelerometers.

It was easy for P-2 and O-2 to detect the impact, because the impact point was near the satellite sensor. For P-1, P-4, and P-5, the side members were bent during the collision. This means that the impacts reached side members along a bumper reinforcement, allowing satellite sensors to accurately detect the impact.



There was accuracy of delta-V in the O-3 sideswipe test, although the contact area is exterior to a side member on which a satellite sensor is fixed.

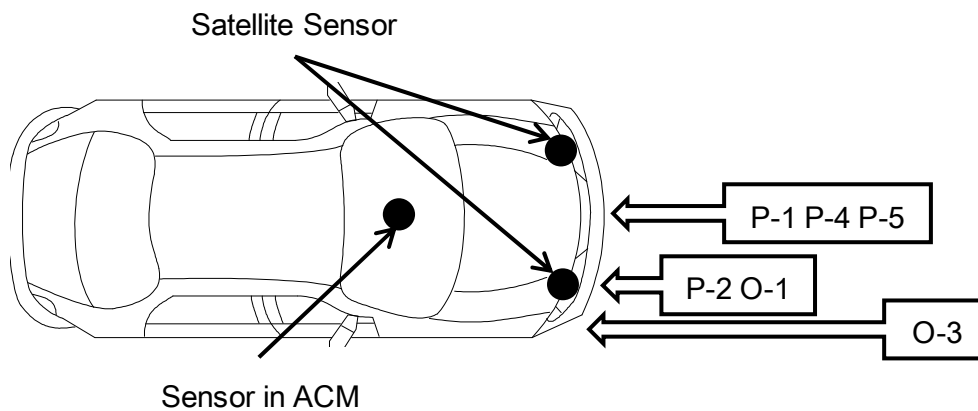


Figure 5 Position of accelerometers and impact points in each crash test

Comparison of the maximum delta-V and the delta-V versus time history data recorded in the EDRs with the results calculated from accelerometers indicates that maximum delta-V in a collision with large deformation at the vehicle centre (P-1 and O-1) results in a non-negligible error. This is attributable to large deformation of the ACM, which is positioned at the bottom of the centre console (Fig. 5). In P-1 in particular, the centre of vehicle was seriously damaged, breaking the bolts retaining the ACM and displacing it from its mounting. There is also significant error in P-5, despite the damage to P-5 being small and there being no damage to the ACM mounting. The cause of this error is unknown, so further research is needed.

The collision period typically ends at about 100 ms, so the time history of delta-V increases up until around 100 ms and is flat thereafter. Note that delta-V in test P-4 continued increasing slightly after 100 ms because the pole fell onto P-4's bonnet after the collision.

## CONCLUSION

This study evaluated the characteristics of EDRs to better understand their performance and improve traffic accident investigations. Six actual car crash tests were performed and analysed, focusing on EDR crash data obtained in collisions with narrow objects. Pre-crash data from EDRs were very accurate and reliable. Satellite sensors detected impacts even when the impact point was far from the sensors, due to bumper reinforcements. Post-crash data from EDRs varied, and large errors in delta-V were seen in some tests. One reason for significant error was major damage to the ACM.

## REFERENCES

- [1] 49 CFR Part 563, Event Data Recorder Final Rule, [Docket No. NHTSA-2006-25666] RIN 2127-AI72, August, 2006.
- [2] 49 CFR Part 563, Event Data Recorder Final Rule, [Docket No. NHTSA-2008-0004] RIN 2127-AK72, January, 2008.
- [3] J-EDR technical requirement, [http://www.mlit.go.jp/kisha/kisha08/09/090328\\_.html](http://www.mlit.go.jp/kisha/kisha08/09/090328_.html), March 28, 2008.