ACCIDENTS AND NEAR-MISSES ANALYSIS BY USING VIDEO DRIVE-RECORDERS IN A FLEET TEST

Yuji Arai
Tetsuya Nishimoto
Japan Automobile Research Institute
Japan
Yukihiro Ezaka
Ministry of Land, Infrastructure and Transport
Japan
Kenichi Yoshimoto
University of Tokyo
Japan
Paper Number 01-S4-O-225

ABSTRACT

The drive-recorder records automobile accidents and/or near-misses data. To realize the practical use of drive-recorders in automobiles, a fleet test was conducted on 202 cars and trucks that were in regular use on roads. Some of the tested drive-recorders were video drive-recorders (VDR) equipped with a video recording unit to obtain visual data on accidents and near-misses from the driver's viewpoint. This was the first time for VDRs to be included in a fleet test on drive-recorders. During the fleet test period a total of 30 actual accidents occurred and were recorded, enabling the significance of adding a video recording unit to drive-recorders for obtaining useful data for accident analysis to be examined. It was found that the data collected by VDR enabled traffic accidents to be analyzed chronologically and quantitatively. It was therefore concluded that VDRs are an effective means of analyzing accidents in greater detail.

INTRODUCTION

Many countries are actively developing Intelligent Transport System (ITS) technologies to solve today's various road traffic problems. As part of its ITS program, Japan is developing an Advanced Safety Vehicle (ASV) which will incorporate smart features to prevent accidents and enhance passive safety with the help of advanced electric technologies. To put ASV into practical use, greater knowledge of actual accidents and their causes is needed. However, because accident analysis has depended heavily on such basic data as vehicle body deformations and tire slip marks, little is known about the driving speed and impact speed in accidents.

This study set out to collect more precise accident data by using drive-recorders, some of which were video drive-recorders (VDR) each equipped with a video recording unit. Two types of drive-recorders were developed: one group to record accident data only, and the other group to record both accident data and near-miss data [1]. In this paper, "near-misses" are defined as sudden braking and rapid steering operations by the driver without resulting in an accident. We report here on the data collection performances of drive-recorders including VDR.

FLEET TEST ON DRIVE-RECORDERS

The drive-recorders and their host vehicles employed in the fleet test are outlined in Table 1. Four types of drive-recorders, Recorders-A, -B, -C and UDS, were installed on a total of 202 buses, light trucks and passenger cars. The 13 VDRs used in the test were included among the Recorders-B.

Table 1.
Number of installed recorders

	Type	Number
Recorder-A	Passenger car	40
	Light truck	45
Recorder-B	Passenger car	63
	Light truck	12
	Bus	20
Recorder-C	Passenger car	12
UDS	Passenger car	10
Total		202

As mentioned in our previous report [1], the Recorders-A and Recorders-B that we had developed were both equipped with a pair of accelerometers (one having the maximum measurement capacity of

±20 m/s^2 and the other ±500 m/s^2) and with a gyroscope or a magnetic compass. These recorders were capable of recording driving speed, acceleration, yaw velocity, and other driving operations.

A crash data recording trigger was set at ±18 m/s^2 for Recorders-A and ±10 m/s^2 for Recorders-B. Both started recording the data leading up to the crash by the frequency sampling method. Specifically, the sampling frequency was set at 600 Hz in Recorders-A, and their recording period was set to from 55 seconds before to 5 seconds after impact. In Recorders-B, the data of the ±20 m/s^2 capacity accelerometer were recorded by 30 Hz sampling from 15 seconds before to 15 seconds after the impact, and the data of the ±500 m/s^2 capacity accelerometer were recorded by 600 Hz sampling from 400 msec before to 400 msec after impact. While Recorders-A recorded accident data, Recorders-B recorded both accident and near-miss data. However, both Recorders-A and Recorders-B were capable of operating with a video recording unit.

Each of Recorders-C consisted of a commercially available digital tachograph, to which an accelerometer was added for the present fleet test. These recorders measured longitudinal and lateral accelerations of up to ±20 m/s^2, brake on/off operations (10 Hz rate), driving speed, and driving distance (2 Hz rate). Their recording duration was 20 seconds. For the UDS, the UDS-2156 accident recorder developed by Mannesmann VDO Kienzle Company was used, which was capable of measuring longitudinal and lateral accelerations of up to ±500 m/s^2, driving speed, yaw angle, and brake on/off operations [2]-[6]. The recording duration of the UDS was 45 seconds.

FLEET TEST RESULTS

A total of 30 accidents actually occurred in central Tokyo and were recorded during the fleet test period. Of these, one accident was recorded by a VDR. In all of the accidents, the vehicle body deformation, accident site and injury rating were investigated, and data was collected from the drive-recorders. Figure 1 shows the configurations of the 30 accidents. Vehicle-to-vehicle collisions accounted for 87% of the 30 accidents, with 50% of the vehicle-to-vehicle collisions being rear-end collisions. Regarding injury, no injury and moderate injury of no more than MAIS2 accounted for most of the recorded accidents. The most severe injury, rated MAIS3, was sustained by a pedestrian in a vehicle-pedestrian accident.

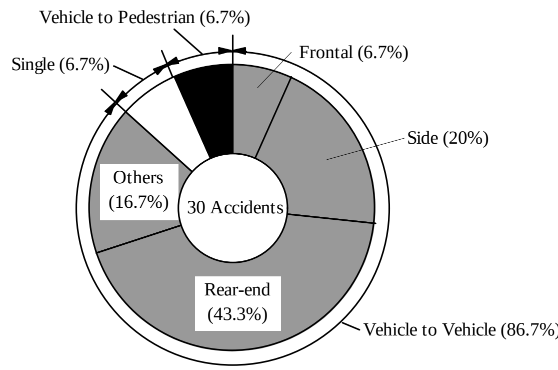

Figure 1. Configurations of the accidents in a fleet test.

ANALYSIS OF ACCIDENTS BY ELECTRIC MEASUREMENT DATA

One of the 30 accidents recorded in the fleet test is reported here as an example. In this accident, a passenger car equipped with a Recorder-A ("Car A") collided into the rear end of another car ("Car B"). The acceleration, driving speed, and accelerator pedal and brake pedal operations of Car A are shown in Figure 2 as recorded by the Recorder-A. Assuming the time at which the recording trigger was activated by collision to be zero second, the running behavior of Car A can be analyzed from the recorded data as follows:

Step 1: Following the operation of the left-indicator lamp, for 8 seconds from -55 to -47 seconds the body of Car A turned left according to yaw velocity data. The driving speed during this interval remained between 30 and 40 km/h.

Step 2: During the 7 seconds from -47 to -40 seconds, Car A was driven straight, while its speed was slowed from 38 km/h to 5 km/h by brake pedal operation.

Step 3: During the subsequent 12 seconds from -40 to -28 seconds, the driving speed was increased to about 20 km/h and the vehicle body was turned right accompanied by operation of the right-indicator lamp.

Step 4: In the 17-second interval from -28 to -11 seconds, the driving speed was reduced by brake pedal operation and then raised to 55 km/h in about 10 seconds.

Step 5: During the following 8.7 seconds from -11 to -2.3 seconds, the driving speed of Car A was gradually decreased to 52 km/h by accelerator pedal on/off operations.

Step 6: From -2.3 seconds the vehicle was slowed to 22 km/h by brake pedal operation, upon which Car A received an impact from the front as shown by longitudinal acceleration data. Car A collided with Car B with an impact speed of 22 km/h.

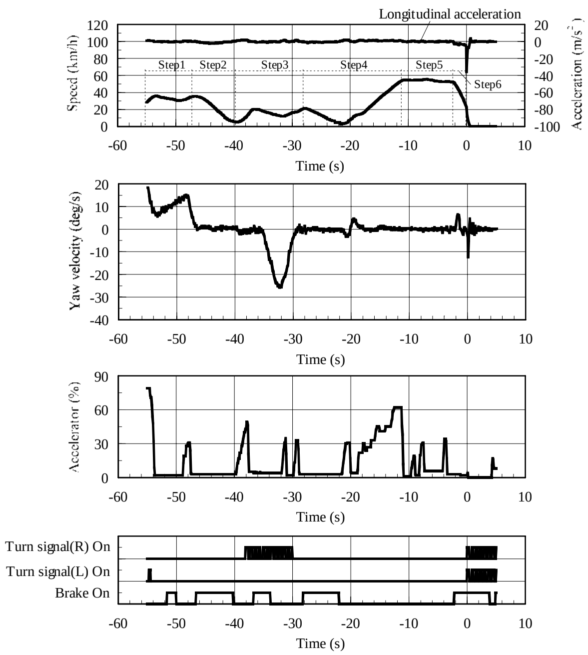

Figure 2. Accident data collected by Recorder-A.

Next, the running behavior of Car A was analyzed by using the electric measurement data shown in Figure 2. Figure 3 shows the driving path of Car A as calculated from driving speed data and rotation angle data. The analysis suggests that, during the 55 seconds preceding the collision, Car A made a right turn, a left turn and then ran straight for a distance of about 250 m. Figure 4 shows the behavior of Car A near the collision point at 500 ms intervals. Car A ran straight from -4.5 to -2.3 seconds at which point pressure was applied to the brake pedal. After the start of brake pedal operation Car A progressed 24.6 m while maintaining its stability, before colliding into Car B.

As reported above, drive-recorders record quantitatively the vehicle behavior and driving operation in time sequence before and after an accident. By combining data collected by the drive-recorder with information on the traffic and road conditions surrounding an accident, it is possible to analyze the accident in greater detail in terms of the people, vehicles and surrounding factors involved.

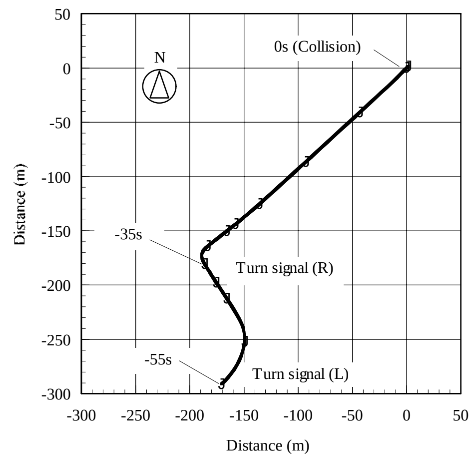

Figure 3. Driving path of Car A.

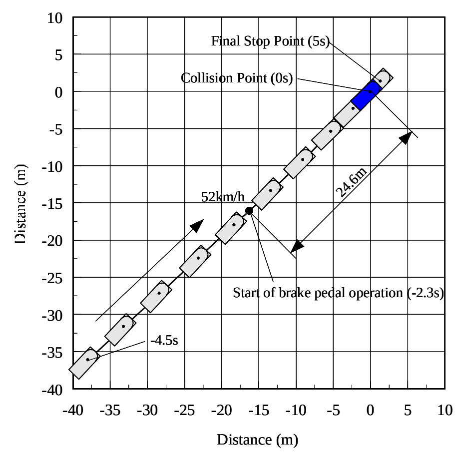

Figure 4. Behavior of Car A near the collision point.

ANALYSIS OF ACCIDENTS BY VIDEO RECORDED DATA

One of the vehicles equipped with a VDR was involved in an accident that was recorded, and the case is examined here as an example of analysis using video recorded data. Table 2 summarizes the visual data recording conditions set for the fleet test. As the video recording unit of Recorder-B was set up to record not only accidents but also near-misses, its trigger threshold was set at a longitudinal acceleration of ±8 m/s^2 or a yaw velocity of ±35 deg/s. The data recording time was set from 10 seconds before to 5 seconds after the crash or the near miss. To record visual data from the driver's perspective, the CCD camera of the video recording unit was attached to the stem of the interior mirror as shown in Figure 5.

Table 2.
Specifications of a video recording unit

Trigger level		±8 m/s^2 (Longitudinal acceleration) , ±35 deg/s (Yaw velocity)
Frame rate		8 fps
Recording time	Before the event	10 s
	After the event	5 s
Camera		Color CCD camera

Figure 5. CCD camera fixed to a passenger car.

Table 3 shows the sequence of the accident from 10 seconds before to 5 seconds after the impact as reconstructed from the visual data and electric measurement data obtained by the VDR of Car A.

As shown in Figure 6, the accident involving Car A equipped with a VDR occurred at night. While entering an intersection, Car A collided into the left side of Car B. Both vehicles received only minor damage, and neither driver was injured.

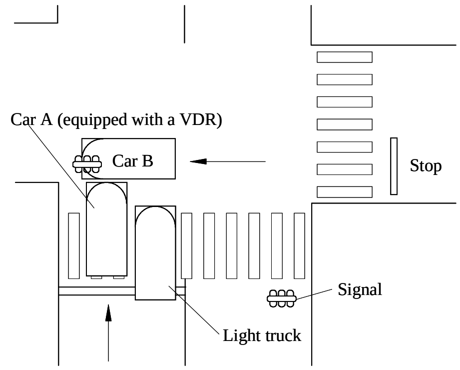

Figure 6. Accident involving car equipped with a VDR.

According to these data of Table 3, Car A started to move at the intersection 6 seconds before collision when the signal turned green. After accelerating for about 2 seconds, Car A decelerated briefly and then accelerated again. Car A collided with Car B in the second acceleration period. Figure 7 shows the conditions about 4 seconds before collision or immediately before Car A entered the intersection area. At that moment, there was a stationary light truck on the front right of Car A as its speed reached 5 km/h.

Table 3.
Results of visual data and electric measurement data

Time (s)		Car A (equipped with a VDR)		Car B	Others (The matter in parentheses is presumptions.)
		Visual data	Electric measurement data	Visual data from Car A	Visual data from Car A
Before the accident	-10				The light truck which had stopped at the right of Car A began to go slowly.
	-9				
	-8				
	-7				
	-6	start (green light)	start (-6.5s)		The light truck stopped.
	-5				
	-4	stopped acceleration once	increased to 5km/h (-4.2s)		
	-3	increased the speed again	·decreased to 2km/h (-3.3s) ·increased the speed again		(The track had stopped at the right of Car A, therefore the direction right side front of Car A became a blind spot.)
	-2				
	-1				CarB began to reflect.
Accident (impact)	0		·impact speed 19 km/h (0s) ·operation of brake pedal (0s) ·stop (0.8s)		Car A collided with the left side of Car B. The occupant of Car A was only a driver.
After the accident	1	stop		·light of the brake lamp ·turned to the right	
	2				
	3		turned to the left (3.8s)		
	4	turned to the left			
	5				

Figure 8 shows a video picture of Car A colliding into the left side of Car B. According to electric measurement data, the impact speed of Car A was 19 km/h and the operation of the brake pedal was initiated immediately after the impact. Although no VDR can record in which direction the driver was looking before a collision, Figure 8 suggests the front-right visibility of the driver of Car A was significantly reduced by the presence of the stationary light truck, causing the driver to overlook Car B. Thus, it is possible to estimate the driver's behavior, the surrounding traffic and road conditions from the visual data recorded by a VDR. Further, visual data can be utilized to verify the findings based on electric measurement data.

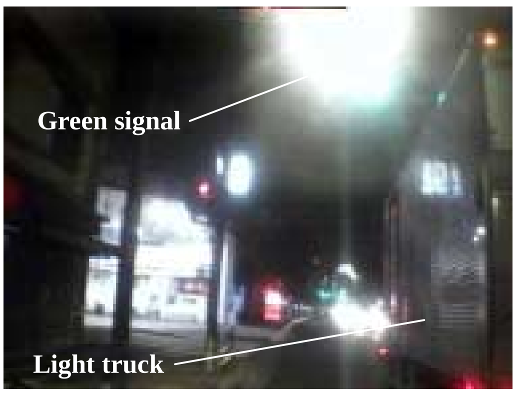

Figure 7. Immediately before Car A entered the intersection area (about 4 seconds before the impact).

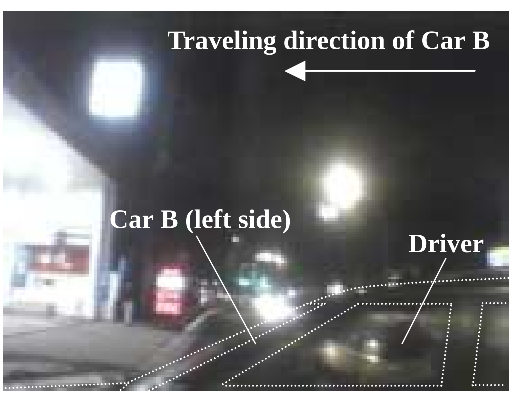

Figure 8. During the impact.

COLLECTION OF NEAR-MISS DATA

By lowering the recording trigger threshold, the drive-recorder can obtain data on near-misses, which are defined as sudden braking and rapid steering operations by the driver without resulting in an accident. Near-miss data were collected by Recorders-B and Recorders-C, and were compiled according to different database items such as sudden braking and rapid steering operations. Using the near-miss data, we are currently investigating the mechanism of occurrence of near-misses and the behavior of individual drivers.

As an index for evaluating drivers' behavior, the frequency of sudden braking and rapid steering per 500 km drive was determined from the data obtained by Recorders-C. "Sudden braking" was defined as an instance of longitudinal deceleration of 6.0 m/s^2 or more, and "rapid steering" as an instance of lateral acceleration of ±6.0 m/s^2 or more. Figure 9 shows the near-miss data of five drivers all driving within the central Tokyo area. All the five drivers performed more sudden braking actions than rapid steering operations. Driver-A recorded few sudden braking and steering actions, while driver-E registered the greatest number of near-miss actions. Near-miss data therefore can be useful for diagnosing driving behavior and developing driving safety programs and driver assistance devices.

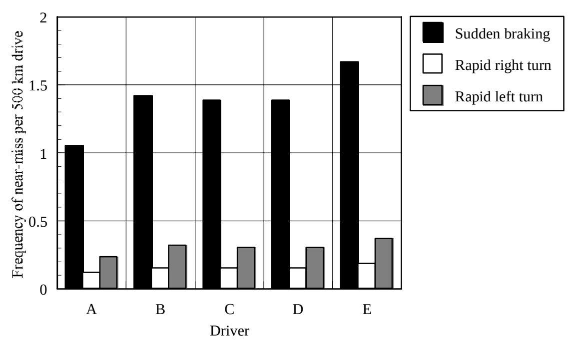

Figure 9. Results of driving characteristic data.

CONCLUSIONS

In this paper we reported data obtained from a fleet test on actual accidents and near-misses. The analysis of the collected data indicates that drive-recorders have the following advantages:

1. Drive-recorders are capable of recording accidents chronologically and quantitatively. Driving speed and acceleration/deceleration data are particularly useful for reducing injuries to occupants.
2. The recorded data on the driver's sudden braking and other accident avoidance maneuvers can be used to reproduce accidents in greater detail.

3. Visual data on vehicle behavior and surrounding conditions supplement the data of 1 and 2 above and are useful for analyzing accidents in greater detail in terms of the people, vehicles and surrounding factors involved.

REFERENCES

1. Nishimoto, T., Yoshimoto, K., Nishida, H., Arai, Y. and Ohmae, H., “Development and Validation of a Drive-Recorder for Automobile Accidents,” JSAE Paper 20005174, 2000

2. Fincham, W. F., Kast, A. and Lambourn, R. F., “The Use of a High Resolution Accident Data Recorder in the Field,” SAE Paper 950351, 1995

3. Salomonsson, O. and Koch, M., “Crash Recorder for Safety System Studies and as a Consumer's Product,” SAE Paper 910656, 1991

4. Barth, J., Gutsch, W., Wiesbaum, S., Kast, A., Berg, F. A. and Grandel, J., “The Kienzle UDS Analyses of Reference Accidents for the Qualification of the System,” Verkehrsunfall und Fahrzeugtechnik, pp. 1-9, 1994

5. Lehmann, G. and Cheale, A., “The Contribution of Onboard Recording Systems to Road Safety and Accident Analysis,” 16th ESV Conference, Paper Number 98-S2-O-34, 1998

6. Ueyama, M., Koura, M., Kast, A. and Chikasue, H., “Study on Traffic Accidents Mechanism with UDS and TAAMS,” JSAE Paper 9539941, 1995