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**Reconstruction and Analysis of Pedal-Misapplication Accidents Using Data From Event  
Data Recorders (EDR) and Dashcams**

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## 1. Introduction

In recent years, the seriousness and frequency of pedal-misapplication accidents have been widely reported in the media, increasing public interest in such accidents. To investigate the causes of these accidents and to develop countermeasures, studies have been conducted using methods such as accident-statistics analysis<sup>(1)</sup>. However, few actual individual accidents have been examined through detailed accident analysis based on specific accident events. Figure 1 shows an example sequence of a pedal-misapplication accident. Of the events in this sequence, previous studies<sup>(2)</sup> related to the factors that lead to pedal misapplication (1) was conducted in which actual individual accidents were aggregated and examined based on the overview of each accident. However, because it is impossible to ascertain detailed accident circumstances, especially those immediately preceding pedal misapplication, the conditions prior to an accident that lead to factors of pedal misapplication have not been examined. Also, with respect to (2), the use of acceleration control devices for pedal misapplication have become widespread in order to suppress unintentional sudden acceleration due to pedal misapplication. These devices suppress sudden acceleration due to pedal misapplication, mainly when accelerating from a standstill or when driving at low speeds. However, even though vehicle user manuals from each manufacturer list the activation requirements for these devices, little analysis has been performed on the activation conditions of these devices in actual accidents.

To address this issue, analyzing specific accident events is considered essential for investigating accident causes in greater detail and for formulating countermeasures that reflect actual accident circumstances.

During traffic accident investigations conducted by the Institute for Traffic Accident Research and Data Analysis (ITARDA), information is obtained on the accident site (including the road and surrounding environment), the parties involved, and the vehicles involved, after which detailed accident reconstruction and analysis are performed. Especially in recent years, event data recorders (EDR) and dashcams have become increasingly widespread, and data are collected from them whenever possible. Because these devices record accident-related information as objective data, they enable more detailed accident reconstruction and analysis.

Therefore, to further clarify the causes of pedal-misapplication accidents and apply those findings to countermeasures, this study aims to identify what conditions in individual accidents lead to factors of pedal misapplication, as well as the activation conditions of acceleration-suppression devices for pedal misapplication. Accordingly, the following two study topics were established, and analysis methods for each topic were examined. These methods were then applied to actual accident cases, and analyses conducted.

○Topic 1: What conditions prior to an accident lead to factors of pedal misapplication?

○Topic 2: What are the activation conditions of acceleration-suppression devices for pedal misapplication?

## 2. Method

### 2-1. Overview

In this study, two pedal-misapplication accident cases derived from traffic accident investigations were used. For each accident case, EDR data, dashcam video, and driver interviews were obtained. Furthermore, accident conditions from just before the collision were reconstructed for the two accident cases. For the reconstruction

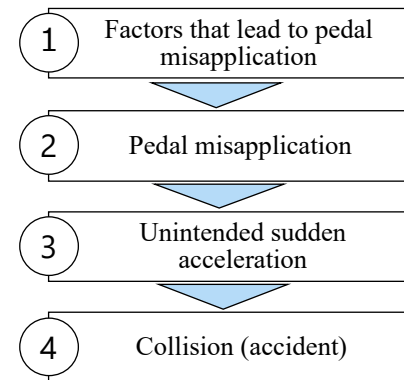


Figure 1. Example sequence of a pedal-misapplication accident

method, we adopted the approach previously proposed by the authors<sup>(3)</sup>, in which EDR data and dashcam video are combined and projected onto a road map to reconstruct pre-collision conditions in a unified, time-series format. Because this method uses objective, quantitative, and diverse data, it results in a ‘reconstruction diagram’ that captures vehicle behavior immediately before the collision as accurately and in as much detail as possible. This includes the vehicle speed and driving trajectory, surrounding road-traffic environment, driver operating status, and in particular the accelerator-pedal depression amount and brake pedal operation (ON/OFF). In this study, reconstruction diagrams were created for each accident case, and the reconstruction results were used to examine the analysis methods for each study topic.

## 2-2. Accident reconstruction method

Figure 2 shows an overview of the accident reconstruction method. In Step 1 of this method, the vehicle speed and yaw rate are integrated to calculate the travel trajectory. The final point of the travel trajectory is the moment of collision. In Step 2, the moment of collision is estimated from dashcam videos taken immediately before and after deformation of the hood at the front of the vehicle, with the data at that time being synchronized with the data at the final point of the trajectory. In Step 3, the final point of the trajectory is aligned with the collision point with the obstacle, and the vehicle location is confirmed using the dashcam images, from which a reconstruction diagram showing the trajectory projected onto the road map is obtained.

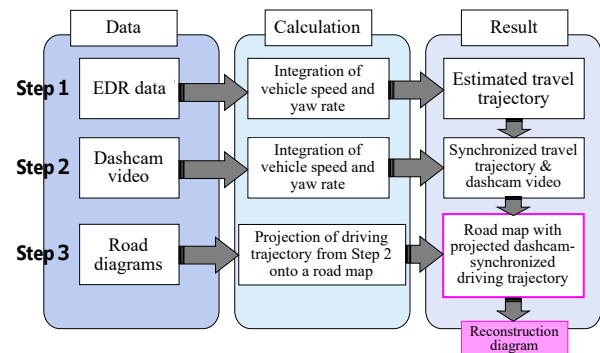


Figure 2. Overview of the accident reconstruction method

## 2-3. EDR data

EDRs record various types of pre-collision data at 2 Hz. Figures 4 and 7 below show vehicle speed, accelerator pedal opening [%], engine throttle opening [%], brake pedal operation [ON/OFF], and steering angle [deg]. The reconstruction diagram shows the data time (t), vehicle speed (V), accelerator pedal opening (Accelerator pedal), engine throttle opening (Engine throttle), brake pedal operation (Brake) [ON/OFF], distance to collision obstacle [m] (described later), and dashcam images in chronological order.

## 2-4. Analysis method for Topic 1

For Topic 1, accident reconstruction results were used to identify what accident conditions lead to factors of pedal misapplication. The previously mentioned existing research<sup>(2)</sup> has shown that there are six main factors of pedal misapplication, as outlined in Table 1. In this study, the items listed in

Table 1. Factors of pedal misapplication

Six factors that lead to pedal misapplication					
1	Needing to distribute attention across many subjects	4	'Surprise', 'panic', or 'haste' due to unexpected vehicle movement		
2	Repeated acceleration and deceleration while driving	5	'Surprise', 'panic', or 'haste' due to the unexpected appearance of another vehicle or a pedestrian		
3	Distracted state (looking away or lost in thought)	6	Foot slipping off the brake pedal and accidentally pressing the accelerator pedal		

Table 1 are treated as factors of pedal misapplication, and conditions leading to these factors are analyzed and identified, particularly the driver operation status immediately before any sharp increase in accelerator pedal opening, vehicle behavior, and the surrounding road-traffic environment. In doing so, information from interviews and audio from dashcam videos are also analyzed. Furthermore, the identified factors of pedal misapplication and the conditions that lead to those factors are used to establish the sequence by which pedal misapplication occurs.

### 2-5. Analysis method for Topic 2

For Topic 2, accident reconstruction results were used to analyze the activation conditions of acceleration-suppression devices for pedal misapplication to determine their status at the time of accident. Operating requirements for these devices are provided in the user manuals<sup>(4)(5)(6)(7)</sup> of the vehicles in which they are installed, with selected examples shown in Table 2. Activation requirements include items such as activation target, activation distance and activation speed. Device activation conditions — including whether the device activated and the causes of any non-activation — were analyzed by comparing the activation requirements shown in the vehicle user manuals with conditions obtained from the reconstruction diagram, such as the vehicle speed following a sharp increase in accelerator pedal opening and the surrounding road-traffic environment.

Table 2. Activation requirements for acceleration-suppression devices for pedal misapplication (example)

Manufacturer	Main activation target	Activation speed	Activation distance
Company A	Stationary objects ahead and behind	Approx. 15 km/h or less	Approx. 4 m or less
	Vehicle/bicycle rider/pedestrian		Not specified
Company B	Vehicle	Approx. 25 km/h or less	When a target is detected
	Pedestrian/Wall	Approx. 15 km/h or less	
Company C	Obstacles such as walls	Approx. 10 km/h or less	Approx. 5 m or less
Company D	Vehicle/Obstacle	Approx. 15 km/h or less	Approx. 3 m or less

Activation requirements include items such as activation target, activation distance and activation speed. Device activation conditions — including whether the device activated and the causes of any non-activation — were analyzed by comparing the activation requirements shown in the vehicle user manuals with conditions obtained from the reconstruction diagram, such as the vehicle speed following a sharp increase in accelerator pedal opening and the surrounding road-traffic environment.

### 3. Accident Reconstruction Results

#### 3-1. Accident Case 1

Figure 3 shows a schematic diagram of Accident Case 1. Vehicle A was traveling on a two-lane bidirectional road when it rear-ended Vehicle B, which was stopped ahead waiting to turn right. The drivers of both Vehicles A and B were women in their 60s who suffered minor injuries. The weather at the time of the accident was clear and the asphalt roads were dry.

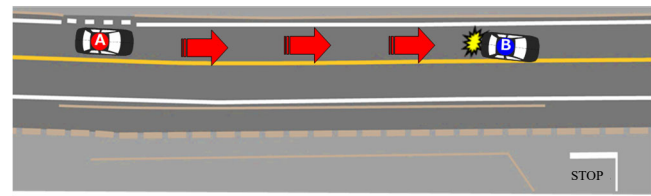


Figure 3. Schematic diagram of Accident Case 1

Figure 4 shows EDR data from Vehicle A. The accelerator pedal opening increased to 100% between -2.0 s and -1.5 s and remained there until the collision. Furthermore, the brake pedal was applied (ON) only at -1.5 s, the same moment at which the accelerator pedal opening began to increase. The engine throttle opening increased sharply between -2.0 s and -1.0 s, decreased sharply at -0.5 s, and increased sharply again until 0.0 s. The vehicle speed was approximately 45 km/h and was approximately 44 km/h at the moment of collision. Also, when interviewed, the driver stated they did not realize they had misapplied the pedal and reported that they had been “driving while thinking about work, etc.” and that they “noticed the vehicle ahead and applied the brake, but it was too late and a collision occurred”.

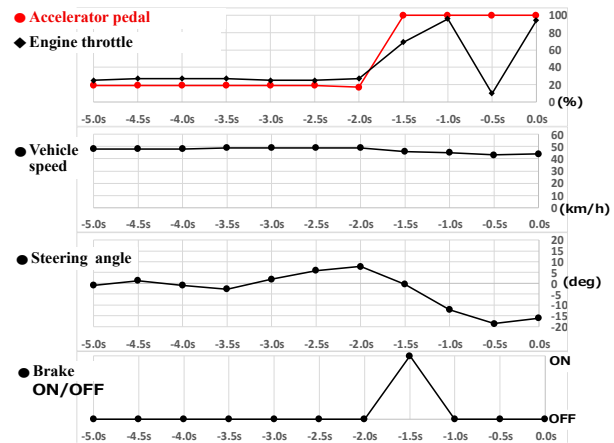


Figure 4. EDR data from Vehicle A (Accident Case 1)

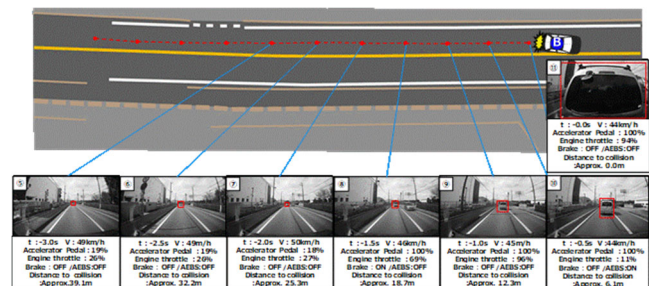


Figure 5. Reconstruction diagram for Accident Case 1

Figure 5 shows the reconstruction diagram. The distance from the point where the accelerator pedal opening started increasing to the moment of collision was approximately 25.3 m.

**3-2. Accident Case 2**

Figure 6 shows a schematic diagram of Accident Case 2. Vehicle A proceeded through a T-junction with a stop sign, accelerated near the stop line, and then collided with a utility pole on the right. The driver of Vehicle A was a man in his 80s who suffered minor injuries. The weather at the time of the accident was clear and the asphalt roads were dry.

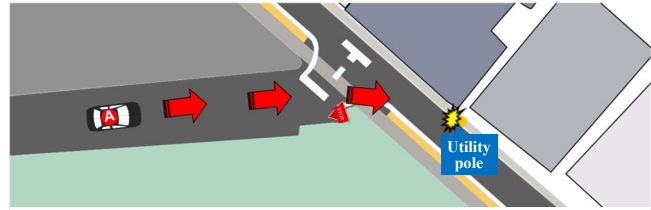


Figure 6. Schematic diagram of Accident Case 2

Figure 7 shows EDR data from Vehicle A. The accelerator pedal opening increased to a maximum of 79% between -4.0 s and -3.0 s, decreased to 0% at -2.5 s, and then remained at 100% from -2.0 s until the collision. The engine throttle opening increased sharply between -2.5 s and -1.5 s, but decreased from -1.0 s until the collision. Also, the brake pedal was not applied (OFF) at any time. When interviewed, the driver said they didn't realize they had misapplied the pedal and stated that they "did not clearly remember" the conditions immediately before the accident. Furthermore, dashcam audio revealed that the driver had been talking with the passenger prior to the accident.

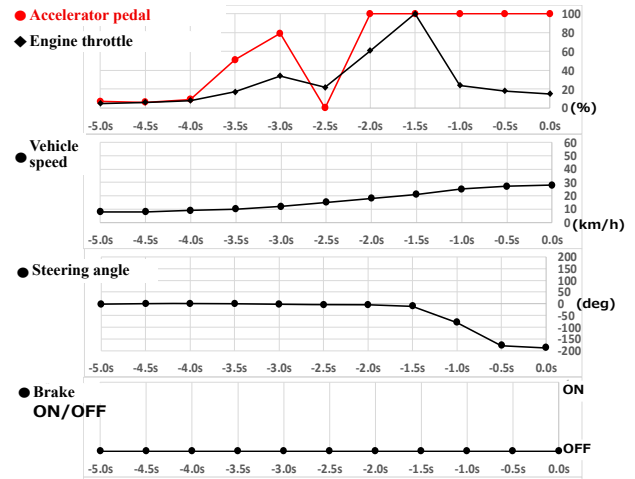


Figure 7. EDR data from Vehicle A (Accident Case 2)

Figure 8 shows the reconstruction diagram. As shown in Figure 8, the distance from -4.0 s, when the accelerator pedal opening started increasing, to the moment of collision was approximately 20.3 m, and from -2.5 s, when it increased again, to the moment of collision was approximately 15.6 m.

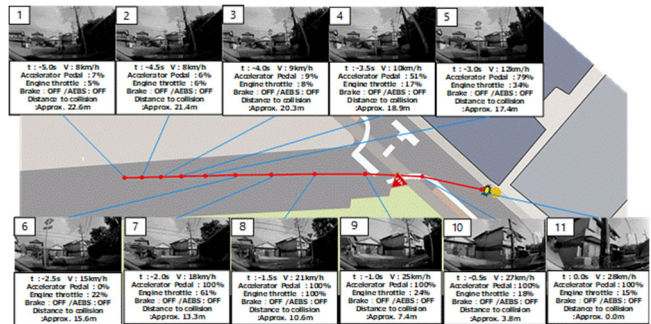


Figure 8. Reconstruction diagram for Accident Case 2

**4. Accident Analysis**

**4-1. Topic 1: Analysis of factors of pedal misapplication**

Conditions that lead to factors of pedal misapplication were identified using the accident reconstruction results (reconstruction diagrams) for Accident Cases 1 and 2, together with the factors of pedal misapplication shown in Table 1.

**(Accident Case 1)** Figure 5 shows that in Accident Case 1, the accelerator pedal opening increased sharply between -2.0 s and -1.5 s. Results of analyzing the conditions prior to the sharp increase identified two factors and the conditions leading to them. The first factor was '3. Distracted state (looking away or lost in thought)' (referring to the item with the same number in Table 1; same applies below). The condition identified as leading to that factor was 'driving while thinking about work'. This inference was based on the driver stating in their interview in Section 3-1 that they were "driving while thinking about work, etc." The second factor was '6. Foot slipping off the brake pedal and accidentally pressing the accelerator pedal'. The condition identified as leading to

that factor was ‘simultaneous application of the accelerator and brake pedals’. Because the accelerator and brake pedals were applied simultaneously only at –1.5 s, it was inferred that while attempting to apply the brake pedal, the driver's foot slipped off the pedal and accidentally applied the accelerator pedal instead. Based on these findings, it is possible that in Accident Case 1, driving while lost in thought led to a distracted state in which the driver’s foot slipped off the brake pedal when attempting to apply it, causing them to press the accelerator pedal instead and resulting in pedal misapplication.

**(Accident Case 2)** Figure 8 shows that in Accident Case 2, the accelerator pedal opening increased sharply between –4.0 s and –3.0 s. Results of analyzing the conditions prior to the sharp increase identified two factors and the conditions leading to them. The first factor was ‘3. Distracted state (looking away or lost in thought)’. The condition identified as leading to that factor was ‘driving while talking with the passenger’. This inference was based on audio from the dashcam video in Section 3-2 indicating that the driver had been talking with the passenger while driving. The second factor was ‘4. ‘Surprise’, ‘panic’, or ‘haste’ due to unexpected vehicle movement’. The condition identified as leading to that factor was ‘vehicle acceleration between -4.0 and -3.0’. The accelerator pedal was pressed between –4.0 s and –3.0 s, and the vehicle was accelerating rather than decelerating. Under normal conditions, the driver would decelerate to stop at the stop line ahead, and if the driver of Vehicle A believed they had applied the brake pedal to do so, the vehicle’s accelerating rather than decelerating would have been unexpected movement from the driver’s perspective and likely caused a reaction of surprise, panic, or haste. Based on these findings, it is possible that in Accident Case 2, driving while talking with the passenger led to a distracted state in which the driver misapplied the pedal. The subsequent movement of the vehicle, which did not decelerate, likely resulted in surprise, panic, or haste, causing the driver to momentarily release the accelerator pedal but then apply it again.

Based on the above, by using the accident reconstruction results (reconstruction diagrams) together with the factors of pedal misapplication, conditions that lead to factors of pedal misapplication were identified, and the sequence leading to pedal misapplication could be inferred.

**4-2. Topic 2: Analysis of activation conditions of acceleration-suppression devices for pedal misapplication**

Device activation conditions were analyzed using the accident reconstruction results (reconstruction diagrams) for Accident Cases 1 and 2, together with the activation requirements for acceleration-suppression devices for pedal misapplication as specified in vehicle user manuals.

**(Accident Case 1)** Table 3 shows excerpts from a user manual<sup>(8)</sup> regarding the activation requirements of the acceleration-suppression device for pedal misapplication installed on Vehicle A. The activation requirements (Table 3) indicate that the device activates when the vehicle speed is approximately 10 km/h or less and when a vehicle or obstacle exists within approximately 4 meters ahead of the vehicle. However, as shown in Figure 5, the vehicle speed was above 44 km/h after –0.5 s, when the distance to Vehicle B became 6.1 meters or less. Based on these findings, although the obstacle was within activation distance, the vehicle speed did not satisfy the activation requirements. Therefore, the acceleration-suppression device for pedal misapplication is considered to have not activated. Also, the engine throttle opening changed from 100% to 0% between –1.0 s and –0.5 s even

Table 3. Activation requirements for acceleration-suppression device for pedal misapplication

Activation requirement type	Activation requirement
Activation target	Vehicle/obstacle
Distance to target	Within 4 meters ahead
Vehicle speed	Approx. 10 km/h or less

though the accelerator pedal was fully depressed at 100%. This may be due to the vehicle's AEBS being ON at the same moment, suggesting that activation of the AEBS suppressed any increase in engine throttle opening.

**(Accident Case 2)** Table 4 shows excerpts from the user manual<sup>(9)</sup> for Vehicle A regarding the activation requirements of the acceleration-suppression device for pedal misapplication. Although the activation target was shown to be an obstacle ahead, there was no description of requirements for activation distance and activation speed. Meanwhile, as shown in Figure 8, although the accelerator pedal opening increased from 0% at -2.5 s to 100% and remained there until the moment of collision, the engine throttle opening increased sharply reaching 100% at -1.5 s, but then decreased toward -1.0 s and dropped to 15% at the moment of collision. In other words, any increase in engine throttle opening was suppressed despite the accelerator pedal opening being at 100%. Furthermore, because any increase in vehicle speed was also suppressed, the acceleration-suppression device for pedal misapplication is considered to have activated.

Based on the above, using the accident reconstruction results (reconstruction diagrams) together with the activation requirements for acceleration-suppression devices for pedal misapplication as specified in vehicle user manuals, it was possible to estimate the device activation conditions — specifically, whether the device activated and the causes of any non-activation.

Table 4. Activation requirements for acceleration-suppression device for pedal misapplication in Vehicle A (Accident Case 2)

Activation requirement type	Activation requirement
Activation target	Obstacle ahead
Distance to target	Not specified
Vehicle speed	Not specified

## 5. Summary

By investigating the following topics, this study aimed to identify what conditions in individual accidents lead to factors of pedal misapplication, and the activation conditions of acceleration-suppression devices for pedal misapplication.

○Topic 1: What conditions prior to an accident lead to factors of pedal misapplication?

○Topic 2: What are the activation conditions of acceleration-suppression devices for pedal misapplication?

For Topic 1, a method was presented for identifying conditions that lead to factors of pedal misapplication using the accident reconstruction results (reconstruction diagrams) together with the factors of pedal misapplication shown in existing research<sup>(2)</sup>. Applying this method to the accident cases made it possible to estimate the sequence of events that led to pedal misapplication.

For Topic 2, a method was presented for estimating device activation conditions — specifically, whether the device activated and the causes of any non-activation — using the accident reconstruction results (reconstruction diagrams) together with the activation requirements for acceleration-suppression devices for pedal misapplication as specified in vehicle user manuals. By applying this method to the accident case, it is considered that for Vehicle A in Accident Case 1, the acceleration-suppression device for pedal misapplication did not activate because, although the obstacle was within activation distance, the vehicle speed did not satisfy the activation requirements. Furthermore, because any increase in engine throttle opening was suppressed despite the accelerator pedal opening being at 100%, and because any increase in vehicle speed was also suppressed, the acceleration-suppression device for pedal misapplication is considered to have activated.

Using objective data from EDRs and dashcams makes it possible to understand accident circumstances in greater detail and enables analyses to be conducted that take specific accident events into account. This, in turn,

enables the factors of pedal misapplication and the activation conditions of acceleration-suppression devices for pedal misapplication to be analyzed in more detail. Such analyses may also be utilized in the future to further investigate accident causes and formulate countermeasures that reflect real-world accident conditions. Especially with regard to accident countermeasure studies, this approach can be used to evaluate the effectiveness of acceleration-suppression devices for pedal misapplication based on device activation conditions in real-world accidents, as well as to identify issues for improving device performance.

One challenge for such applications is the need to conduct accident analyses of the type presented in this study on a larger number of accident cases and to accumulate the resulting findings. It is therefore considered essential to obtain individual accident cases by continuing to conduct traffic accident investigations.

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