Effectiveness of Automatic Emergency Braking in Simulated Traffic Accident Scenarios.

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I. INTRODUCTION

Recently, more vehicle models are equipped with automatic emergency braking (AEB). The effectiveness of AEB in collision damage mitigation is usually assessed in a proving ground following a prescribed test protocol. In reality, there may be various situations in which AEB is activated. It is expected that AEB could mitigate the impact severity even if the collision is not avoided. This paper proposes a multiscale simulation methodology to help to estimate the effectiveness of AEB in simulated traffic accident scenarios.

II. METHODS

The proposed methodology is to conduct a series of simulations of traffic flow, near miss cases and vehicle collisions. It enables to simulate various collision scenarios and to estimate injury severity of vehicle occupants. First, a traffic accident simulation is performed to detect near miss cases between vehicles that incidentally occur due to driver errors. Next, precrash simulations are conducted to compare vehicle maneuvers with and without AEB. Lastly, crash simulations are conducted to analyze vehicle deformation and occupant kinematics in order to estimate the effectiveness of AEB in injury mitigation.

Traffic Accident Simulation

The microscopic traffic simulator VISSIM was used to simulate the traffic flow at the center area of Toyota City in the weekend afternoon. The simulation model included vehicles, pedestrians and road infrastructure, such as roadways, sidewalks, crosswalks and traffic lights. The traffic volume was measured at the actual location and defined in the simulation model. Default parameters were used to simulate driving maneuvers such as following the proceeding vehicle with acceleration and deceleration. Originally, VISSIM does not simulate traffic accidents as it automatically adjusts the inter-vehicle distance. Error models were newly developed to imitate the top five driver errors [1] such as lack of attention, distraction, over speed, misestimation, and insufficient safety check. The simulation detected a near miss case when the distance between two vehicles became shorter than a predetermined value (Fig. 1).

Fig.1. Traffic Accident Simulation.

Precrash Simulation

The vehicle dynamics simulator CarMaker was used to simulate vehicle motions in the near miss case. The target vehicle was represented by a midsize sedan model. Precrash simulations were performed in two cases with and without AEB (prototype). For the case with AEB, it was assumed that the sensing ranges were 45 degrees in viewing angle and 100 meters in detection distance. The AEB was activated when the sensor detected other vehicles and determined the possibility of collision.

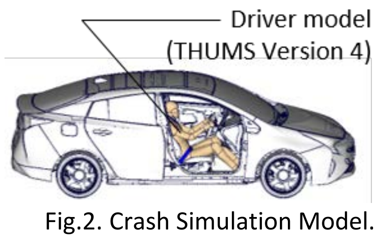

Fig.2. Crash Simulation Model.
(Right front door undisplayed)

Crash Simulation

Crash simulations were performed using the finite element (FE) analysis program LS-DYNA. The vehicle motions obtained from the precrash simulations were used in the crash simulation as the initial condition. Figure 2 shows the FE model of the midsize sedan with a driver model represented by THUMS Version 4 AM50.

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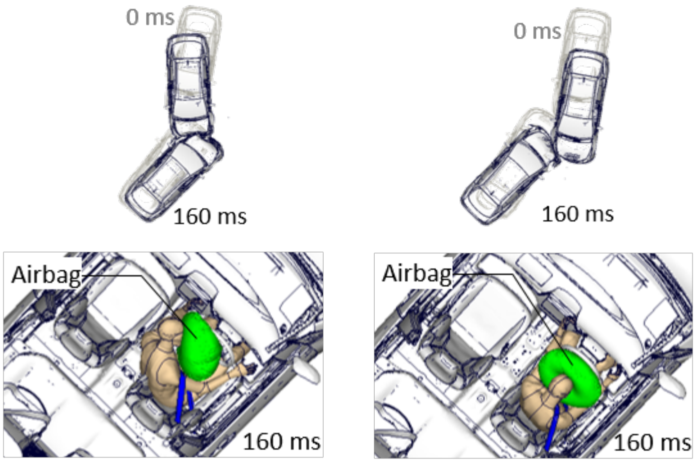
The driver was restrained by a 3-point seatbelt, a driver airbag and a curtain airbag. The injury assessment values (IAVs) of the head, thorax, abdomen and legs were calculated and the ratios with respect to the injury assessment reference values (IARVs) [2] were compared with and without AEB.

III. INITIAL FINDINGS

A near miss case was detected at an intersection in the traffic accident simulation. A vehicle in the intersection started a right turn misestimating the speed of an oncoming vehicle. In this case, the simulation resulted in a collision. Precrash simulations were performed to compare the vehicle motions with and without AEB. In Case A, the speed of the right-turning vehicle was 20 km/h while that of the oncoming vehicle was 50 km/h. Both vehicles did not brake. In Case B, the right-turning vehicle was stopped by AEB while the speed of the oncoming vehicle was 50 km/h. The oncoming vehicle collided with the left frontend of the right-turning vehicle in Case A, while right frontend in Case B. Crash simulations were conducted by using the speed and position of the two vehicles with and without AEB. Figure 3 compares the deformation of the two vehicles and the occupant motion in the right-turning vehicle between the two cases. The right-turning vehicle was moved laterally by the oncoming vehicle in Case A while it was pushed back in Case B. In Case A, the occupant moved left forward in the cabin and contacted the left end of the airbag. In case B, the occupant moved almost straight foward and contacted the center of the airbag. The occupant of the oncoming vehicle contacted the center of airbag in both cases. Figure 4 shows the IAV/IARV ratios for the two occupants in the two cases. All ratios were below 1.0. For the right-turning vehicle occupant, abdomen deflection and BrIC in Case B were lower than those in Case A. For the oncoming vehicle occupant, the ratios were lower in Case B except abdomen deflection.



Case A (Without AEB) Case B (With AEB)
Fig.3. Vehicle Deformations and Occupant Motions.

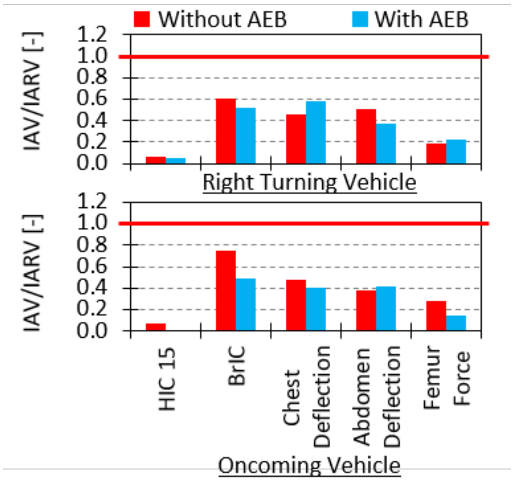


Fig. 4. Injury Value Ratios (IAV/IARV).

IV. DISCUSSION

In Case A, the occupant head in the right-turning vehicle rotated when contacting the left end of the airbag and generated a relatively high BrIC value. It indicates that the vehicle lateral motion rotated the occupant head. In Case B, the injury values of the oncoming vehicle occupant were generally lower than those in Case A. It is considered that the reduction of impact severity (owing to the AEB of the right-turning vehicle) resulted in the low injury values. The present study mainly focuses on the methodology of continuous simulation from traffic flow to collision rather than the accuracy of predictions. However, it is expected that the methodology will help to assess the injury mitigation effect of AEB and other safety functions in actual road traffic.

V. REFERENCES

[1] Web site of National Police Agency of Japan.

[2] NHTSA's new car assessment program - Request for comments. Federal Register: 78522 - 78591, NHTSA, Washington, D.C., USA, 2015.