Assessing the potential benefits of Autonomous Emergency Braking system based on Indian road accidents.

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Paper Number 17-0399

ABSTRACT

The proportion of highway roads in India is 5% of total road network, which accounts for 63% of the road fatalities (MORTH, 2015). According to a RASSI study, in 50% of the accidents, there were no accident avoidance manoeuvres from the drivers. Only in 30% of the accidents, drivers performed a brake or swerve manoeuvre or a combination of both. This research aims to evaluate the potential benefits of the Autonomous Emergency Braking (AEB), in such collision scenarios, based on the real world data collected from four sampling locations on Indian roads.

Road Accident Sampling System – India (RASSI) database is used for this research. A total of 1779 real world accidents from three different sampling locations are examined by means of in-depth accident reports consisting of about 700 variables per accident case. Accident characteristics prior to the collision are derived using technical reconstruction.

This study focusses on passenger vehicle only and accordingly, data screening is conducted using key parameters to obtain relevant data where effectiveness of AEB can be demonstrated. Vehicle movement prior to critical event (i.e., only vehicle going in a straight line path) and pre-impact stability (i.e., vehicle skidding longitudinally but yaw angle less than 30 deg.) are the two conditions for selecting the cases. A total of 23 cases sufficed to the above criteria and these are reconstructed using PC-Crash.

For each case, a 0.8*g* deceleration pulse of AEB is implemented in the vehicle trajectory. Each case is reconstructed again and the benefit is registered in the following three categories: total collision avoidance, impact speed reduction and no benefit.

The AEB system is currently evaluated for front-rear configuration where driver intervened with emergency manoeuvres. However, the applicability of the system for other accident configurations has to be evaluated as well. Moreover, the current dataset involves data only from National Highways, where generally, the travelling speed is on the higher side. However, the applicability is restricted only to front-rear collision scenarios and the system benefit has to be established further for a wider range of accident scenarios as well.

INTRODUCTION

The United Nations announced a “Decade of Action” 2011 to 2020 for Road Safety to reduce the number of 1.3 million people killed in road crashes every year. 90% of them happen in developing countries [1]. These findings are validated for India by the annual reporting of Ministry of Road Transport & Highways in India, which states that 5% of total road network accounts for 63% of the road fatalities [2]. Therefore, to provide a better ecosystem for safety, the Bharat NCAP was envisioned and which is expected to be enforced by 2018.

A variety of data collected by different agencies across India have highlighted that :

- Contributing factors involved a combination of human, vehicle & infractructure for 60% of the fatalities
- 28% of fatalities occurred due to vehicle factors [3].
- Rear-end collisions (including collisions with parked vehicles) are also envisaged as one of the major collision scenarios [4].
- Only in 30% of the accidents, drivers performed a brake or swerve maneuver or a combination of both.

Considering the aforementioned factors, present aim of the study is to understand whether use of integrated safety would enable the reduction of accidents in specifically rear-end collsions. Therefore, three aspects are discussed during the course of the study to chieve the aim :

- Analysis of accidents available in RASSI database for rear-end collision
- Reconstruction of accidents with and without Autonomous Emergency Braking (AEB)
- Proposing system requirements for AEB’s for Indian conditions

The Autonomous Emergency Braking systems considered in the study are derived from Driving Assistance Package (DAP), i.e. is the sales name of an optional bundle of FCA components in which FCW, BAS PLUS and PRE-SAFE Brake® as well as AB are included as a part of DISTONIC PLUS. It is available since 2005. All DPA functionalities cannot be switched off directly by the driver [1]. Based on this, two additional systems were envisaged and are explained in the subsequent sections.

METHODOLOGY

Data Source

Real world passenger car accident data are essential to understanding characteristics of the accidents and to identify countermeasures to reduce the frequency and the severity of accidents. The analysis of pre-crash dynamics of a passenger car prior to the impact is a way to thoroughly investigate accident causation.

The selection of an appropriate accident database that includes in-depth information on the pre-crash phase of the accidents, in addition to the crash phase and the consequences, or post-crash phase, of the accidents, is crucial. Road Accident Sampling System – India (RASSI) database is used for this research. A total of 1779 real world accidents from three different sampling locations are examined by means of in-depth accident reports consisting of about 700 variables per accident case. Accident characteristics prior to the collision are derived using technical reconstruction.

Data Querying

Data querying was performed using python scripts. The rationale behind querying the RASSI database was to obtain data relevant data about the pre-crash, crash and post-crash phase. The three phases of the crash were captured in 15 separate tables. The RASSI SQL database contains several relational tables which contain several keys that could be used for linking the variables.

Table 1. Description of the data tables: Below tables used from RASSI database to merge & query

Data Tables	Description
Accident	General info about the scene and environmental conditions
Accident event sequence (AccEventSeq)	Specific info for each event (impact) in the crash sequence
Vehicle general documents (VGD)	Vehicle information that is gathered from police documents and from OEM specific documents
Vehicle reconstruction (VehicleRecon)	Info on the reconstruction of the first and the most harmful crash events per vehicle

Query1: The database consisted of 1779 accident for the period 2011-2016. Following merging of the data tables ‘Accident’, ‘VehicleRecon’ and ‘VGD’, initial query on the vehicle type (i.e., body type relevant for

passenger cars) was conducted. Following this merging, 856 cases were extracted where at least one passenger car was involved in these accidents. The description of the tables is shown in Table 1.

For the present study, the front-rear accident configuration was considered. The actor and ego vehicle would be traveling in the same direction and ego vehicle would strike the actor vehicle from rear.

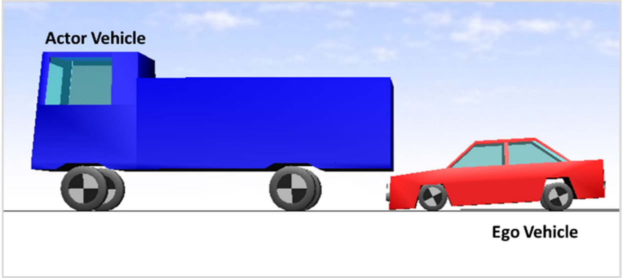


Figure 1. Typical accident configuration considered for the present study: Front-Rear Accidents

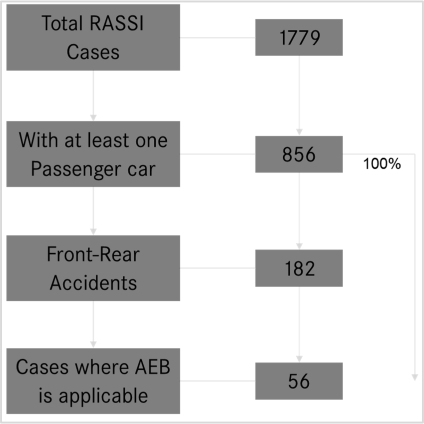


Figure 2. Step-by-step query flow and the final cases count considered for the study.

The present study considered only front-rear collision type where there was good overlap of the ego and actor vehicle prior to the collision. In these kind of circumstances, the radar based autonomous emergency braking system on-board ego vehicle would detect the actor vehicle traveling ahead. The system ideally would need at least 2s of following distance in order to mitigate the collision or to avoid it completely [1]. Hence, the cases where actor vehicle was performing lane change entering the path of ego vehicle and pedestrian cases were not considered in this study. Also, in RASSI database, the lane change and pedestrian accidents do not provide any conclusive evidence about the pre-crash phase which was critical in determining whether the system could detect the obstacles in these kind of circumstances.

Query2: In order to obtain accidents where ego vehicle passenger car had first contact with actor vehicle, further merging of the tables was necessary. To the above merged tables in Query1, 'AccEventSeq' and the other vehicle's 'VGD' were merged. The rationale behind this merging was to extract the cases where AEB was capable of detecting obstacle and possibly intervene if required. Only front-rear accident scenarios resulted in extraction of 182 cases. The criteria to obtain AEB applicable cases was used with two parameters: 'PRESTAB' and 'GADEV'. The variable 'PRESTAB' was used to select cases where ego vehicle was either traveling in a straight line path or longitudinally skidding with yaw angle not more than 30 degree. While the variable 'GADEV' was used to select cases where there was direct damage in the front of the ego vehicle, ensuring that ego vehicle was the striking vehicle. The Figure 2, shows the step-by-step querying procedure that resulted in a total of 56 cases where AEB system was capable of detecting the actor vehicle.

System Definition

The system considered for the present study was a hypothetical autonomous emergency braking system. The system could detect an obstacle using radar sensors located in the front of the ego vehicle passenger car. The system would provide headway warning to the driver and alert about the possible collision situation. In spite of the warning, if there was no reaction from the driver, the system would intervene by partially braking at 0.4*g* deceleration. Still if there was no reaction from the driver, the system would intervene before collision and provide full braking at 0.8*g* thereby reducing the impact speed. The maximum deceleration provided by the system was limited to 0.8*g* considering the maximum frictional coefficient value in the range of 0.8 to 0.9.

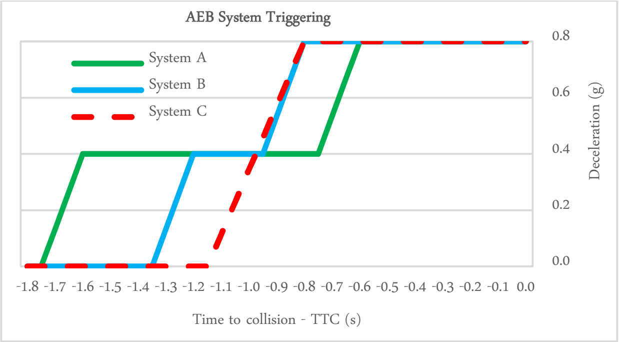


Figure 3. Triggering mechanism of three systems considered in the present study.

As the present study was based on the Indian accidents, the objective was to identify the best fit autonomous emergency braking systems suitable for the conditions. Varying certain critical parameters like partial braking and full braking trigger time, the three systems (System A, System B and System C) were derived. The Figure 3 shows the different triggering mechanism of three systems prior to the collision. In the next section, each of the systems are explained in detail. The triggering mechanisms of all the three systems were kept in-line with the driving assistance package (DAP) system [1, 10].

Table 2. Characteristics of System A

System Parameter	Value
Detection range	200 m
Detection angle	100°
Time delay for activation of Partial Braking	0.15*s*
AEB Partial Braking deceleration value	0.4*g*
Time delay for activation of Full Braking	0.15*s*
AEB Full Braking deceleration value	0.8*g*
Partial Braking activation before collision	TTC – 1.6s
Full Braking activation before collision	TTC – 0.6s

Table 3. Characteristics of System B

System Parameter	Value
Detection range	80 m
Detection angle	100°
Time delay for activation of Partial Braking	0.15*s*
AEB Partial Braking deceleration value	0.4*g*
Time delay for activation of Full Braking	0.15*s*
AEB Full Braking deceleration value	0.8*g*
Partial Braking activation before collision	TTC – 1.2s
Full Braking activation before collision	TTC – 0.8s

System A: System A with two radar sensors i.e., long and short range radar would support the driver in case of emergency situation. With the support of these radars, System A would give a headway warning 2.6s prior to the collision. Upon no reaction from the driver, the System A would provide partial braking at 0.4*g* after 1s of headway warning. System A would start braking autonomously from 1.75s before collision with time delay of 0.15s. Still if there was no response from the driver, the System A would ramp up the braking and autonomously provide full braking at 0.8*g* from 0.75s before collision with time delay of 0.15s. The characteristics of System A are shown in the below Table 2.

System B: System B approach to autonomous emergency braking was similar to System A. The characteristics of System B are shown in Table 3. However, the main difference was the radar. The radar used was a short range radar only and hence the detection of obstacle would be delayed. This resulted in reduced time to collision. However, the System B would provide headway warning to the driver 2s prior to the collision. The average driver reaction time to an emergency situation is about 0.8s [9]. If the average driver doesn't react to headway warning, the System B would intervene autonomously and partially brake at 0.4*g*. But the duration of partial braking would be 0.4s as shown in Figure 3. The System B would ramp up the deceleration 0.8s prior to collision by providing full braking at 0.8*g*.

Table 4. Characteristics of System C

System Parameter	Value
Detection range	80 m
Detection angle	100°
Time delay for activation of Full Braking	0.3*s*
AEB Full Braking deceleration value	0.8*g*
Full Braking activation before collision	TTC – 0.8s

System C: System C functionality when compared to both System A and B was defined differently. The System C doesn't provide any partial deceleration as shown in Figure 3 and the characteristics of the System C are shown in Table 4. These kind of systems would be used in city driving conditions where speeds are relatively low when compared to highway speeds. The System C would provide headway warning to the driver 1.6s before collision. Following the warning for 0.8s, if the driver doesn't intervene, the system would brake autonomously at 0.8*g* full braking.

System Application

For each accident in the database, there would be reconstruction file (.pro file reconstructed in PC-Crash) associated with the case. This section illustrates the method adopted to reconstruct the exemplary accident case by integrating the three AEB systems. Apart from the original reconstruction file, there would be three more reconstruction files showing the impact of these AEB systems in the accident scenario.

In the exemplary case, the ego vehicle passenger car and the actor vehicle truck were travelling in the same direction. Actor vehicle was traveling ahead of ego vehicle. Ego vehicle driver fell asleep and hit actor vehicle in the front-rear accident configuration. As shown in Figure 4, ego vehicle impact speed (v_e) was 110 km/h and actor vehicle (v_a) was 43 km/h. As driver of ego vehicle was asleep, there was no collision avoidance manoeuver from the driver. This collision resulted in fatal injury to the ego vehicle driver, while the passenger of the ego vehicle sustained serious injuries. No injuries were observed for actor vehicle driver.

In the original crash reconstruction, t=0 would be the point of impact. In the pre-crash phase, there was no collision avoidance manoeuvers performed by the ego vehicle driver. Hence, the assumption made was that ego vehicle and actor vehicle drivers were traveling at the constant speed. So the initial speed at t=-1.6s would be 110 km/h for the ego vehicle and actor vehicle would be 43 km/h. Backward simulation was performed from t=0 to t=-1.75s. The position at t=-1.75s are noted and this position of ego and actor vehicle would be the new t=0 position for the subsequent simulations integrated with the three AEB systems.

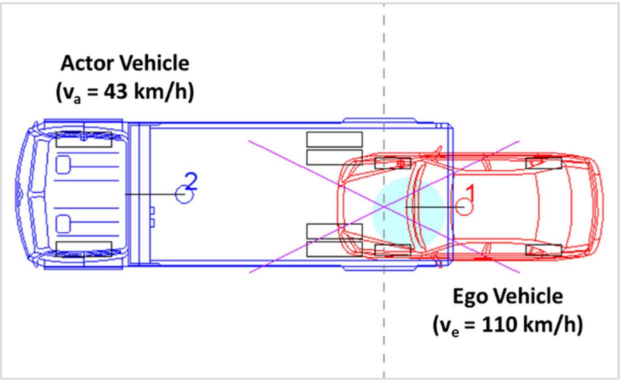
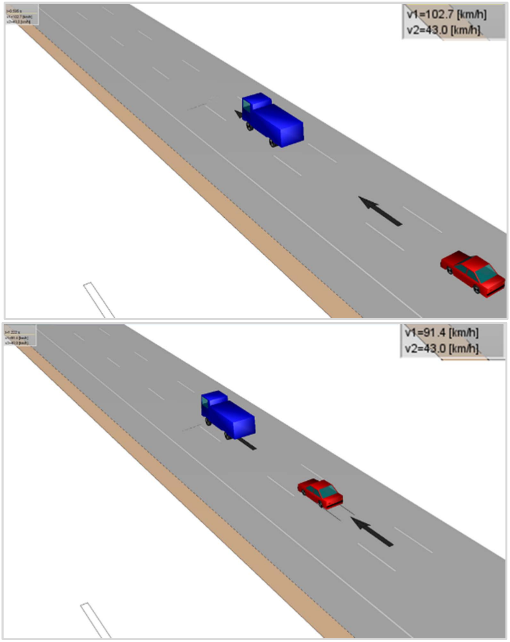


Figure 4. Schematic representation of actor and ego vehicle engagement at impact in PC-Crash.

As mentioned in the previous section, the three systems with trigger time at 1.6s, 1.2s and 0.8s were incorporated in to the reconstruction for checking the benefit of System A, System B and System C respectively. The assumption made in the present study was that systems would detect the actor vehicles for these front-rear configurations. The reconstruction of all three systems was performed by adding new sequence step in the PC-Crash file. The schematic of the accident reconstruction is shown in Figure 5.



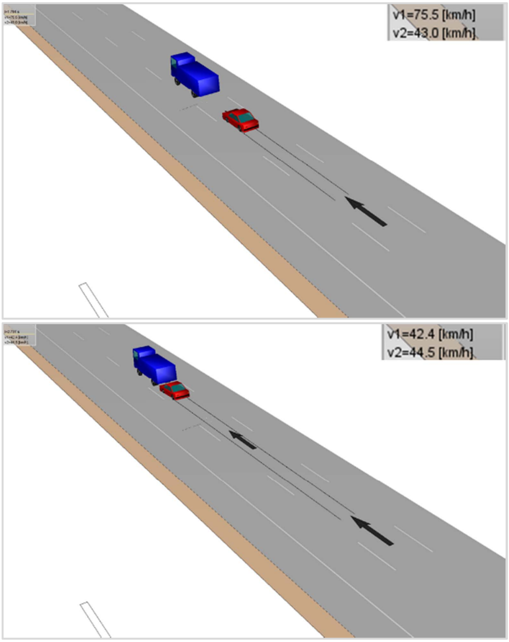


Figure 5. Reconstructed accidents sequence with respect to time and distance.

As indicated in the Figure 3, the partial braking for System A would trigger at 1.75s before collision with a system time delay of 0.15s. While full braking would trigger at 0.75s before collision with another system delay of 0.15s.

For System B, t=0 would be the same start position as in System A simulation. But the ego and actor vehicles would be traveling for 0.25s with constant speed. The partial braking would trigger at 1.35s before collision with a system time delay of 0.15s and full braking at 0.95s before collision with another 0.15s of system time delay. The partial and full braking deceleration values are the same for both the systems (System A and System B) i.e., partial braking at 0.4*g* and full braking at 0.8*g*.

For the System C reconstruction, t=0 would be the same as for the previous two reconstructions, but the ego and actor vehicles would be traveling for 0.5s with constant speed. As there is no partial braking in the System C, full braking would trigger 1.1s before collision with a system time delay of 0.3s. The Table 5 shows the comparison of ego vehicle impact speeds (v_e) observed from all three reconstructions integrating the systems.

Table 5. Impact Speed Comparison for all systems

Reconstructions	**v_e (km/h)**
Original Case	110
System A	53.3
System B	67.8
System C	82.9

Table 6. Ego vehicle impact speed (in km/h) comparison for all systems for different scenarios

$[u_e, u_a]$ km/h	**v_e with System A**	**v_e with System B**	**v_e with System C**
[121, 43]	73.6	81.8	94.4
[110, 43]	53.3	67.8	82.9
[99, 43]	NC*	NC*	70.9
[121, 47.3]	71.4	81	94.2
[110, 47.3]	NC*	65.6	82.5
[99, 47.3]	NC*	NC*	70.2
[121, 38.7]	75.2	82.7	94.6
[110, 38.7]	58.7	69.2	83.2
[99, 38.7]	NC*	52.6	71.3

** NC – No Collision*

To see the effectiveness of the three systems, the traveling speed was also varied for the both actor and ego vehicles. The speed variance of 10% was considered for both the vehicles. The considered traveling speed for ego vehicle (u_e) were 99 km/h, 110 km/h and 121 km/h; while for the actor vehicle traveling speed (u_a) were 38.7 km/h, 43 km/h and 47.3 km/h. For every accident case, a total number of 27 simulation were carried (3 traveling speed for actor vehicle times 3 traveling speeds for ego vehicle times 3 systems for each ego and actor vehicle traveling speed). The Table 6 shows the impact speeds obtained for all the 27 simulations.

RESULTS

Findings

After accident cases extraction, investigation of the data was performed for the 56 cases. The ego vehicle collision partner was categorized into four main groups: collision with passenger car, bus, trucks and other (mostly VRUs like two wheelers excluding pedestrians). The Figure 6 shows the distribution of accidents by actor vehicle 'BODYTYPE'. In 50% of the accidents, passenger car collision partner was truck and in 30% of the cases, it was a passenger car itself.

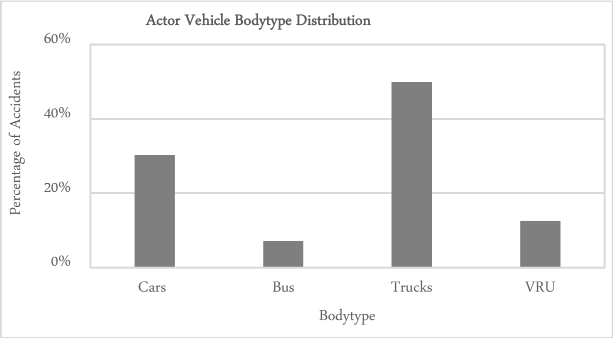


Figure 6. Accident distribution by collision partner (N = 56 Cases)

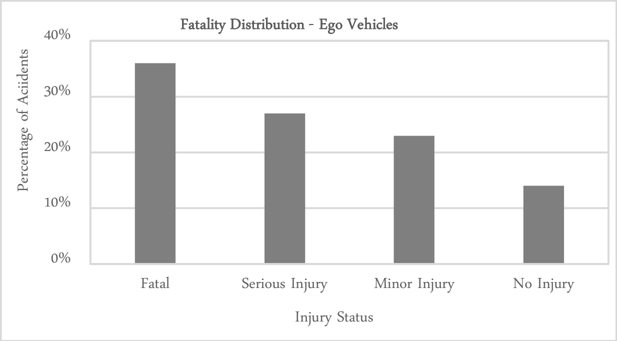


Figure 7. Accident distribution by injury severity (N = 56 cases)

Overall, about 35% of the accidents involved AIS6 injuries (i.e., fatal) and over 25% of the accidents involved serious injuries (AIS3+). As shown in Figure 7, minor and no injuries were observed in 22% and 13% of the accidents respectively. Among the 28 passenger car vs. truck accidents, 13 cases include fatal (AIS6) accidents. In the 16 passenger car vs. passenger car accidents, 50% of the cases include either fatal or serious injuries (AIS3+) while fatal injuries was observed in two cases.

Table 7. Accident distribution by collision avoidance manoeuvers (N = 56 cases)

Manoeuvres	Cases	Percentage
None	35	62.5%
Braking	7	12.5%
Steer	8	14.3%
Brake & Steer	5	8.9%
Unknown	1	1.8%

In 63% of the accidents, driver did not perform any collision avoidance manoeuver as shown in Table 7. Passenger car driver performed collision avoidance manoeuvers in about 35% of the cases (i.e., 12.5% for braking, 14.3% for steering and 8.9% for a combination of brake and steer). Only in one case, there was no information about the driver collision avoidance manoeuver. There could be many causal factors like very late or no reaction of the driver due to inattentiveness or distraction or sleep or fatigue; driver misinterpretation of the distance to the actor vehicle resulting in insufficient brake application and driver non-comprehension of the emergency situation.

In the 35 cases where there were no collision avoidance manoeuvers, the average impact speed is about 45 km/h. The 50th and the 75th percentile value for the impact speed were 49.5 km/h and 80 km/h. This indicates that impact speed is above 50 km/h in over 17 cases out of 35 cases.

Systems Comparison

This section focusses on establishing which of the systems would best fit to the requirements of the collision dataset. Among the 56 cases extracted from RASSI database, only in 23 cases, accident reconstruction (.pro file) was available. For each of these 23 cases, 27 simulations were carried out which resulted in a total of 621 simulations. There was no reconstruction in the remaining 33 because of insufficient data.

Figure 8 below shows comparison of the three systems based on 621 reconstructed simulations and Table 8 illustrates the collision avoidance capacity of the systems. It is observed that System C provides the least benefit out of all the systems with the collision avoidance capacity of 19% with an impact speed reduction restricted to 37%. However, the simulation results shows that through maximum benefit in terms of impact speed (80%) and kinetic energy (57%) reduction was achieved with System A and was able to avoid collisions in 48% of simulations. However, System B also shows a comparable benefit to System A with an impact speed (70%) and kinetic energy (46%) reduction with a collision avoidance capacity of 41%.

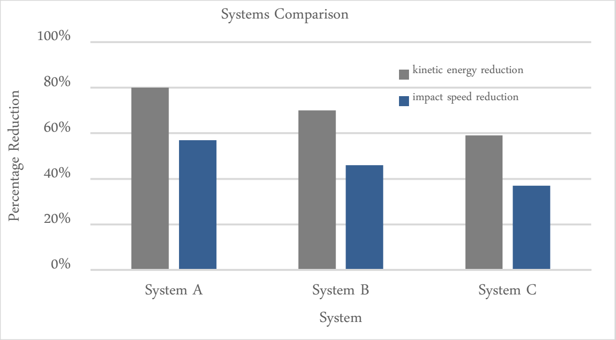


Figure 8. Kinetic energy and impact speed reduction by all the systems

Table 8. Collision Avoidance by all the systems

System	Simulations	Collision Avoidance
System A	207	48%
System B	207	41%
System C	207	19%

Injury Risk Curves for System Comparison

Figure 9 below illustrates the risk of AIS3+ & AIS 6 injuries with respect to impact speed for the real world data.

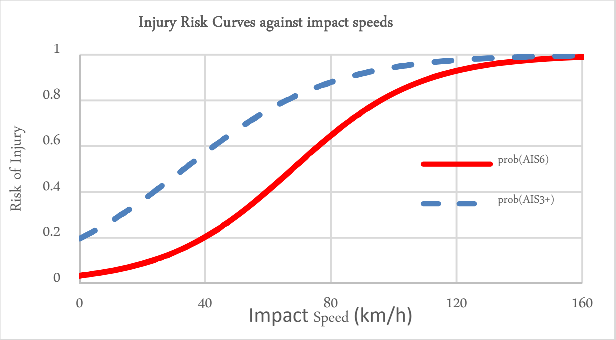


Figure9. Curves showing the risk of AIS3+ and AIS6 injury against impact speed of ego vehicle.

The effect of ego vehicle impact speed on risk of injury were investigated by applying logistic regression analysis [8]. The main objective was to derive an improved analytical expression for the AIS6 and AIS3+ injury risk function. The probability of death, *P(v)*, was then assumed to be the following:

$$P\ (v) = \frac{1}{1+\ e^{-(a+bv)}} \qquad \textbf{(Equation1)}$$

where *v* was the impact speed and a, b, two parameters to be estimated by the method of maximum likelihood [6, 7].

The resulting probability function of AIS6 and AIS3+ injury, *P(AIS6) and P(AIS3+)*, is presented in Equation 2 and Equation 3 respectively. Logistics regression resulted in the intercept value and the coefficient value of ego vehicle impact speed, v_e. The intercept value for AIS6 and AIS3+ injury were -3.33 and -1.41 respectively. Also, the coefficient of v_e for AIS6 and AIS3+ injury were 0.04 and 0.05 respectively. The impact speed variable was statistically significant according to the Wald chi-square test, the p-value for AIS6 and AIS3+ injury risk were 0.0003 and 0.001.

$$P\ (AIS6) = \frac{1}{1+\ e^{-(-3.33+0.05v_e)}} \qquad \textbf{(Equation 2)}$$

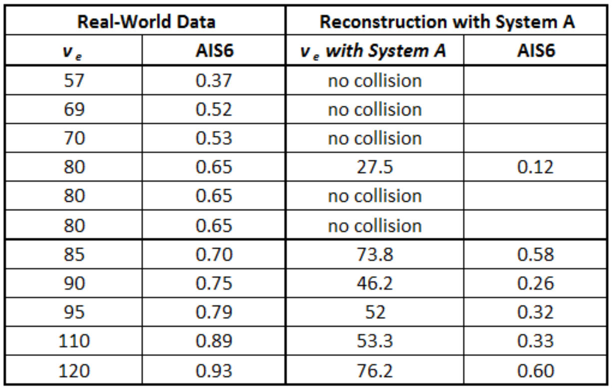
$$P\ (AIS3\ +) = \frac{1}{1+\ e^{-(-1.41+0.04v_e)}} \qquad \textbf{(Equation 3)}$$

It was observed that the injury risk for AIS3+ & AIS 6 begin from 0.19 & 0.034. The reason for risk of injury even at impact speed of 0 km/h was because of collision with VRUs (excluding pedestrians) and in these collisions the injury happened to the VRUs. This could be attributed to the fact that injury risk curves were created based on all the injuries sustained irrespective of the occupant in the passenger car or VRU. It was observed that the impact speed greater than 50 km/h, the potential risk of AIS3+ injury was greater than 67% & of AIS6 injury was greater than 29%. While for impact speed greater than 64 km/h, the potential risk of AIS3+ injury was greater than 79% & of AIS6 injury was greater than 45%.

DISCUSSION

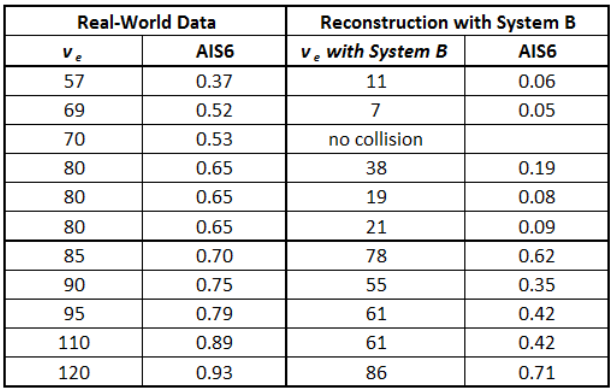
Benefit Assessment

The analysis based in the previous section suggested that System C offered the least benefit and was not considered further. Now to demarcate the benefit of System A & B, the systems were evaluated for their reduction in injury risk (AIS6 & AIS3+) for impact speeds above 50 km/h & 64 km/h. Figure 10 & 11 illustrate the comparison of AIS6 injury risk of System A & System B with real world data.



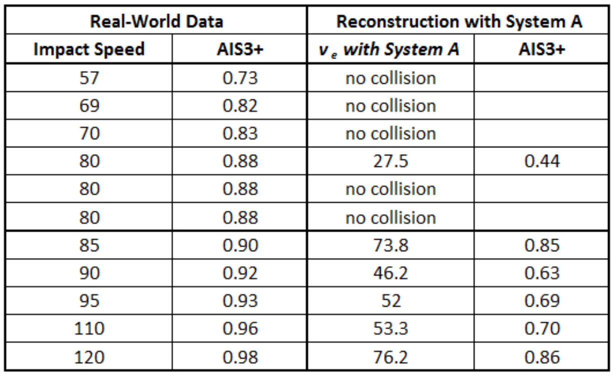
Real-World Data		Reconstruction with System A	
v_e	AIS6	v_e *with System A*	AIS6
57	0.37	no collision	
69	0.52	no collision	
70	0.53	no collision	
80	0.65	27.5	0.12
80	0.65	no collision	
80	0.65	no collision	
85	0.70	73.8	0.58
90	0.75	46.2	0.26
95	0.79	52	0.32
110	0.89	53.3	0.33
120	0.93	76.2	0.60

Figure 10. Comparison of risk of AIS6 injury with and without System A



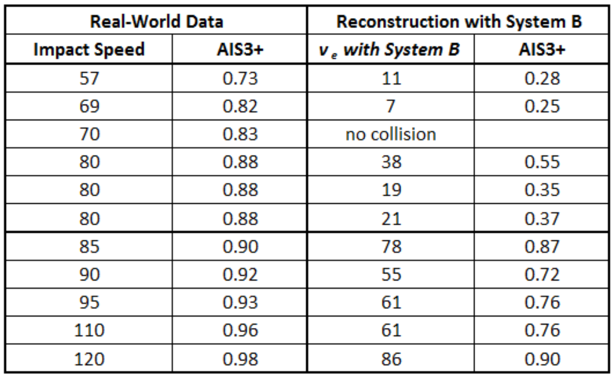
Real-World Data		Reconstruction with System B	
v_e	AIS6	v_e *with System B*	AIS6
57	0.37	11	0.06
69	0.52	7	0.05
70	0.53	no collision	
80	0.65	38	0.19
80	0.65	19	0.08
80	0.65	21	0.09
85	0.70	78	0.62
90	0.75	55	0.35
95	0.79	61	0.42
110	0.89	61	0.42
120	0.93	86	0.71

Figure 11. Comparison of risk of AIS6 injury with and without System B



Real-World Data		Reconstruction with System A	
Impact Speed	AIS3+	v_e *with System A*	AIS3+
57	0.73	no collision	
69	0.82	no collision	
70	0.83	no collision	
80	0.88	27.5	0.44
80	0.88	no collision	
80	0.88	no collision	
85	0.90	73.8	0.85
90	0.92	46.2	0.63
95	0.93	52	0.69
110	0.96	53.3	0.70
120	0.98	76.2	0.86

Figure 12. Comparison of risk of AIS3+ injury with and without System A



Real-World Data		Reconstruction with System B	
Impact Speed	AIS3+	v_e *with System B*	AIS3+
57	0.73	11	0.28
69	0.82	7	0.25
70	0.83	no collision	
80	0.88	38	0.55
80	0.88	19	0.35
80	0.88	21	0.37
85	0.90	78	0.87
90	0.92	55	0.72
95	0.93	61	0.76
110	0.96	61	0.76
120	0.98	86	0.90

Figure 13. Comparison of risk of AIS3+ injury with and without System B

The advantage of installing system A was established from the fact, that for impact speeds less than equal to 80 km/h, collision was avoided in 5 out of the 6 reconstructed simulations. Significant reductions in the risk of AIS6 injuries for impact speeds greater than 80 km/h was also observed with the implementation of System A.

The performance of system B was equally comparable to System A. For impact speeds less than equal to 80 km/h, the risk of AIS3+ injury was less than 10% except for 1 of the cases where it was 19%. The average risk of AIS6 injury for impact speeds greater than 80 km/h with system B was ~50% whereas with system A was estimated as ~42%.

The average risk of AIS3+ risk for impact speeds greater than 80 km/h with system B was ~80% whereas with system A was estimated as ~75%. The percentage risk reduction of AIS6 injury was about ~38% with system B and with system A the reduction was about ~49%. The percentage risk reduction of AIS3+ injury was about 14% with system B and with system A the reduction was about 20%.

Limitation

This present study made an attempt to establish the benefit of autonomous emergency braking system for the accident data set. However, the study was carried with the below limitations and assumptions.

Currently, though there are AEB systems capable of detecting pedestrians, the present study did not consider pedestrian accidents due to lack of conclusive evidence about the pedestrian overlap time and the systems' ability to detect them. Also, authors had to leave cases where actor vehicle performed lane change prior to the collision due to the similar reason mentioned above. As a next step to this study, the authors would include also pedestrian accident and evaluate the benefits of AEB systems.

As all the three Systems were hypothetical, authors assumed that systems would be able to detect the actor vehicle before the impact i.e., System A, System B and System C would detect actor vehicle 2.6s, 2.0s and 1.6s before time to collision.

For all the cases, the reconstruction of the cases were performed under the assumption that ego vehicle driver didn't perform any collision avoidance manoeuvers. Eventually from the ego vehicle perspective, the benefit assessment was carried would be the worst case scenario.

CONCLUSIONS

The present study presented the benefit assessment of autonomous emergency braking system in passenger cars using an extracted accident data set from RASSI database. Upon querying the database, a total of 56 cases were extracted where AEB system would definitely impact the outcome of the accident either by mitigating or avoiding.

Based on the past studies, three systems (System A, System B and System C) with different headway warning time, triggering mechanisms and decelerations were defined. For each accident case, accident reconstructions with these three systems integrated in the ego vehicle were performed. To maximize the benefit of the systems, 10% traveling speed variance was also considered in the simulations for both ego and action vehicle. A total of 621 simulation for 23 cases were performed.

The study concluded that System C with no partial deceleration and the least time to collision was the most ineffective system of the lot

This was expected behavior from the system. These kind of systems would be ideal for low speed emergency scenarios where system could deploy full braking and could avoid the accident. As most of the accidents are highway accident where impact speeds are relatively high, therefore, system C achieved only 19% collision avoidance among the 207 simulations performed.

The best fit AEB system was between System A and System B. Both the systems' benefit were comparable when the impact speed of the ego vehicle was greater than 80 km/h. With System A, the average risk of AIS6 injury was 40% and with System B it was 50%. The significant difference was observed when the ego vehicle impact speed was less than equal to 80 km/h. System A was able to avoid collision in 5 out of the 6 cases and System B was able to avoid only one case, but the average risk of AIS6 and AIS3+ injuries for System B was 9% and 36%. However, in the research no criterion for evaluating such systems are defined, i.e. whether the collision avoidance or impact speed reduction is strategy which is adopted for system implementation. Therefore, considering the fact that System B was also able to reduce the injury risk for majority of cases it can also be considered as a potential system to suit the collision avoidance requirements.

Finally, the best fit AEB system depends on radar functionality. System A with greater obstacle detection range is better than system B with lower obstacle detection range. However, the applicability is restricted only to front-rear collision scenarios. The system benefit has to be established further for a wider range of accident scenarios as well.

ACKNOWLEDGEMENTS

Authors would like to thank Uwe Nagel at Daimler AG for his support and guidance with regard to the PC-Crash simulations.

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