SAFETY OF VEHICLES OVER THE WHOLE LIFETIME

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ABSTRACT

The NCAP (New Car Assessment Program) initiatives and most media reports are focussing on new cars. The roads paint a different picture. The average age of passenger cars is e.g. in Germany about 8 years. Only one third of all cars in Europe have an age of 5 years or less.

Little is known about the safety level of cars used for several years. Wear of safety relevant components, more and more rarely inspections, an increasing number of non original spare parts. These few examples make clear that the new cars' safety level cannot be kept over the years.

The decrease in safety leads to increasing risks – the risk of causing an accident due to technical problems like reduced braking power and the risk for the occupants in an accident due to problems like not working airbags.

But how can such problems be solved or at least be minimised? Which starting points are most promising to achieve the best benefit for society and road safety?

According the European harmonization regulation 2010/48/EG every passenger car has to be tested along its lifetime in service after registration and type approval. DEKRA is doing more than 20 Mio vehicle inspections every year in Europe as well as in other countries outside Europe. The over all results have been evaluated out of these test reports.

Additional results of a special project named SafetyCheck are used to learn more about the technical status of cars of young (inexperienced) drivers. SafetyCheck is a free of charge offer for an inspection of safety relevant components for young drivers.

The third pillar of the study is the DEKRA "technical defects" database (TD) based on in depth investigations. The database contains information of more than 10,000 vehicles involved in accidents caused or influenced by technical defects within the last 10 years.

The combination of the three sources periodical technical inspection (PTI), TD and SafetyCheck is a unique combination to illustrate the influence of the vehicle age against the road safety.

The safety degradation over lifetime is obvious and significant even starting with the 5th year in service and drastically after 7 years. The SafetyCheck initiative confirms the PTI results showing mayor problems of young drivers' cars. There are also indications that some problems of older cars are related to ADAS like ESC. The analysis of the TD database is also confirming the results of the PTI. One striking component mentioned in all three data sets is the braking system.

The final consequence might be an advanced program especially focused on cars with high mileage and on older cars. This program should also include an education of the society to show the need of qualified service to retain the implemented safety level.

Besides a high safety level of new cars the preservation of the safety during the vehicles' lifetime is an important goal. Results of inspections can thus be used to further improve new car testing methods to minimise life time safety losses.

1 INTRODUCTION

The discussion about vehicle safety is normally focussed on new vehicles. What are the safety improvements in relation to the previous model? How good is the safety of this vehicle in relation to other models on the market? Especially for passenger cars the last years include an increasing interest on the NCAP classification. The manufacturers are enjoying to show how good the safety features of a new vehicle model are. Currently there is a big focus on advanced driver assistance systems (ADAS).

Unfortunately (or fortunately?) there are not only new cars on the road. The average age of passenger cars is e.g. in Germany about 8 years. Only one third of all cars in Europe have an age of 5 years or less. How is the situation after the vehicles are used some years? Is the implemented safety in the same condition as at the time of the registration date? The knowledge of the safety condition of used cars is limited. There are several factors which are influencing the implemented safety level when the first owner is using his car on the road. Some components become less safe because they grow old. Some others abrade because of the normal use. One other influence is resulting from the more and more rarely inspections. Sometimes the worn parts are replaced by not allowed spare parts. The mentioned influence examples show why the new cars' safety level cannot be kept over the years. One way to hold the safety level as close as possible to the origin level could be done by mandatory inspections.

It is not only a question for the single car owner. It is also important for all other road users. They become endangered by an unsafe vehicle used on the road. The more the safety decreases the more the risk to be involved in an accident increases. A reduced braking performance may end in a collision because the driver was not able to reduce the speed of the vehicle as far as necessary.

This paper is concentrating on the vehicle category passenger car (PC).

2 GERMAN ACCIDENT STATISTICS

The German Federal Statistical Office (StBA) is publishing every year several analysis of accident data.

A view to these accident figures shows that there is an influence of the vehicle age to the accidents, **Figure 3**. It is shown by the share of main accident causing party. This share is resulting from the number of main guilty parties and the accident involved parties. The advantage to analyze it in this way is that the different kilometrages or other conditions of use are automatically

One may say that this increasing share for higher cars ages results from the influence of younger drivers. In Figure 4 the share is increasing where young drivers (younger than 25 years) are excluded. A more detailed analysis shows an increasing risk for older PC ages for all driver age groups, Figure 5. The increasing risk has nothing to do with the driver age. Based on these figures it could be said that the sometimes mentioned possible influence of younger drivers is less than the influence of very experienced drivers (> 64 years). The difference between the first share value (PC < 1 year) and the last share value (PC > 11 years) is for younger drivers less than 5 percent points and for experienced drivers more than 6 percent points.

The police is fixing the obviously existing accident causes shortly after the accident happened. These statements are the basis of the accident statistics. It is interesting to have a look to those accidents where a technical defect (TD) was mentioned as an accident cause. The analysis of the published German accident data of 2011 is showing that the accident cause TD is existing more often in older cars, Figure 6. A half (50.6%) of the 1012 TDs was found at PCs which were older than 11 years (70.9% older than 7 years). A special analysis of the StBA shown in **Figure 7** gives a more detailed information to the single ages. It is shown that passenger cars with an age of 11 until 16 years have the highest absolute frequency of an accident cause TD. This result is remarkable in relation to the less driven kilometrage of older cars.

So one can say the technical defects are one influencing factor why older cars have a higher risk to be responsible for an accident.

GIDAS is the German In-depth Accident Study which is collecting accident data in two areas of Germany. An examination of GIDAS data allows similar analysis which are shown in this contribution based on the German general accident data coming from the StBA. The additional information coming from GIDAS is showing the influence from the remaining time until next PTI. It is visible, that the share of the main guilty party is increasing when then time until next PTI is decreasing, **Figure 8**. There is also a difference between older (=> 7 years) and younger (< 7 years) PCs. The observed share is at a higher level for older cars.

3 PERIODICAL TECHNICAL INSPECTIONS (PTI)

DEKRA is a private company which is also acting in the area of mandatory inspections on behalf of the government. DEKRA is doing approximately 22 million inspections per year worldwide including 10 million inspections in Germany.

The periodical inspections (PTI) show for passenger cars a share of 54.6% without any defects, Figure 9. Roughly every fourth PC (26.4%) has slight defects. The remaining 19.0% offer serious defects. A separation of the categorisations slight and serious to the vehicle age shows increasing shares for older PCs. Only 14.4% of all PCs with an age of less than 4 years have defects (9.8% slight + 4.6% serious), Figure 10. These values increase step by step by the listed age groups. PCs with an age of more than 9 years include more than 75% with defects (36.5% slight + 29.8% serious). The three most important of detected assemblies with defects are lights (28.9%), braking system (24.7%) and axle/wheel/suspension (19.5%), **Figure 11**.

A view of the vehicle age in the PTI area shows an increasing share of serious defects for older PCs up to an age of 18 years, **Figure 12**. An analysis of the PTI location shows a higher share of serious defects for the non-workshop locations. This is independent from the vehicle age. The explanation is that PCs which were inspected in a workshop have often got a repairing in front of the PTI. The PTIs done at locations which are no workshops show the results which are more close to the situation which is on the road. The PCs inspected at the non-workshops have a minor share of repairing.

4 SAFETYCHECK

Since the year 2000 DEKRA is doing a special yearly action called SafetyCheck. This action is focused on young drivers. The background is that younger less experienced drivers drive often with older PCs with a minor safety standard and a not perfect maintenance condition. DEKRA wants to show the young drivers where their PCs have defects. The offer of DEKRA is an inspection free of charge for the target group young drivers. This inspection includes some parts of the usual PTI (in Germany named §29 inspection). The driver gets after the inspection the information about the defects. The results of this action are coming from PCs which were not prepared for an inspection (like PTI). The drivers do have an interest on safety. Otherwise they would not spend some time to come to the inspection centre.

In 2012 this action was done at 14.700 PCs, Table 1. This PCs include 55.6% drivers between 18 and 24 years (average age 23.74 years). Roughly one third (32.4%) of the drivers were female. Most of the PCs (71%) were older than 7 years (average age 11.3 years) and the mileage was more than 130,000km. The PCs with an age of 8 years or older include 86.1% with defects. In average were 3.3 defects detected per PC. Defects at the assemblies suspension, tyres or body were found at 49.9 of all cars. These assemblies show a very high increasing share with the increasing vehicle age. The inspected PCs show also 11% of inoperable ESP/ASR systems (ASR – traction control).

5 DEKRA DATABASE REGARDING TECHNICAL DEFECTS

DEKRA has published since 1977 more than 25 reports regarding technical defects (TD) which influenced accidents. These influence by TD could the only accident cause or it could act together with at least one other cause. These causes together are named as accident relevant causes. The DEKRA accident relevant causes correlate to the accident causes TD found by the police. The database contains results of 42,000 examined vehicles with roughly 200,000 technical defects.

An analysis of 2,267 PCs examined in the period from 2007 until 2011 includes 772 PC with TD. These 772 PC with TD contain 166 PC with accident relevant TDs. The most often accident relevant TD were found for PC between 9 and 17 years, **Figure 13** + **Figure 14**. This result is very similar to the adequate analysis from the PTI and the accident statistics from Germany.

6 SUMMARY

It was shown that older passenger cars do have more often technical defects than newer PCs. The most frequent vehicle age groups with technical problems are in the vehicle age area from 10 until 17 years. This is shown from analysis of general German accident statistics, periodical technical inspections and DEKRA investigations done after an accident happened. It is known that there is a difference between a defect found in a PTI and a defect found in a inspection done after an accident. A PTI is always a visual inspection without demount any parts of the vehicle, whereby an inspection done after an accident is normally including the demounting of parts. The results of both investigations show an age related dependency.

The results of safety check show the technical condition of older unprepared PCs. The results show a higher frequency of PCs with technical problems. This third perspective is giving an impression how high is the share of vehicles with defects on the road. Many PCs will be prepared in front of an expected mandatory inspection. The vehicles on the road do have more defects as vehicles which come to a PTI. The frequency of vehicle with defects will increase from the PTI until the preparation in front of the next PTI.

7 CONCLUSIONS

The fix the vehicle implemented safety level as far as possible over the whole lifetime is in interest of every road user. The results show that there are more problems of older cars concerning technical defects. One reason for this higher share of defects is coming from the minor attendance of those vehicle owners pay for the inspections foreseen from the manufacturers.

In the year 2012 there was a discussion in the European Union to reduce the PTI steps for older PCs to one year steps. This may balance the reduced number of inspections in the workshops. The analysis results shown in this report seem to support this proposal. The open question what is a vehicle age where this changed PTI steps should start. Is it the best point to start after the PC finished the 7th year of vehicle age? It would be a good idea to start a research project to get more detailed results.

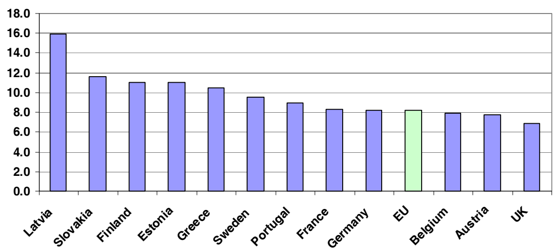

Figure 1 Average age of passenger cars in different European countries, source ANFAC [1]

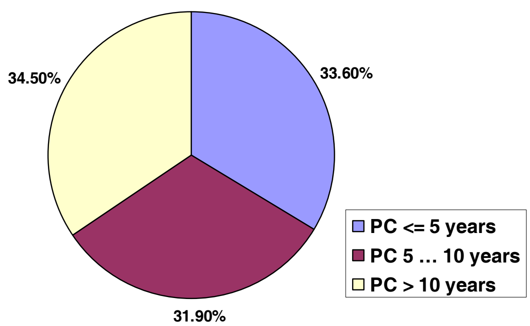

Figure 2 Passenger car (PC) fleet by age for available countries as listed in Figure 1, source ANFAC [1]

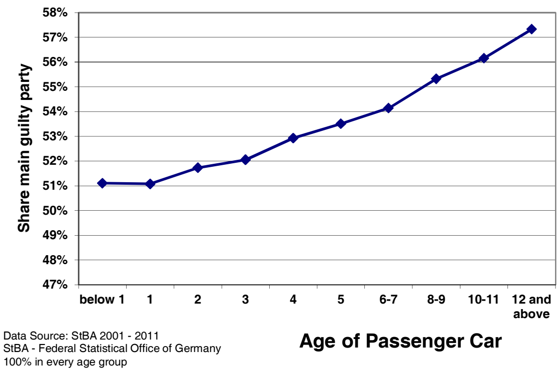

Figure 3 Share of main accident causing party by age of passenger car, [2]

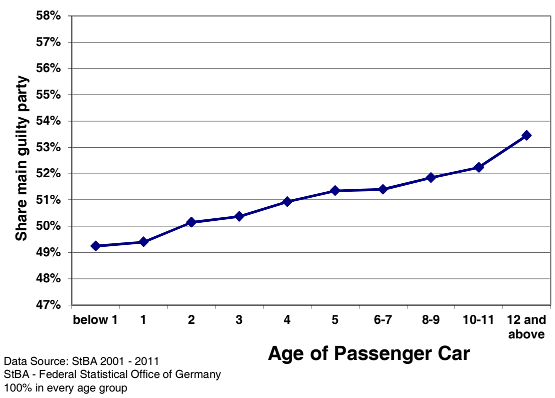

Figure 4 Share of main accident causing party by age of passenger car excluding young drivers (18 … 24 years), [2]

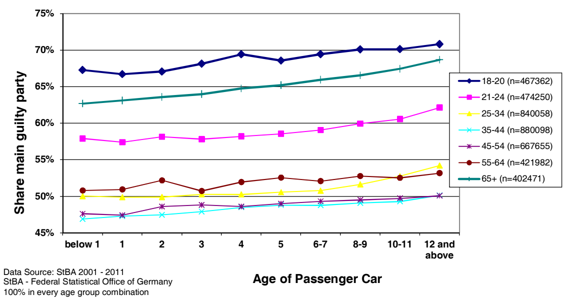

Figure 5 Share of main accident causing party by age of passenger car (parameter driver age), [2]

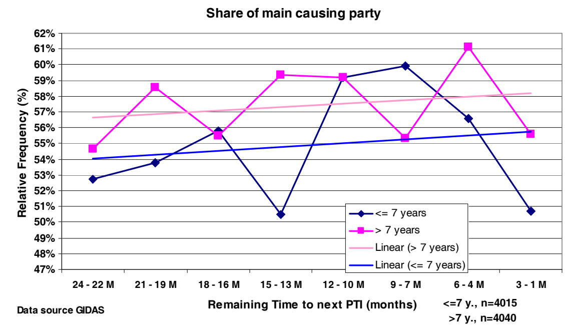

Figure 8 Share of main accident causing party by remaining time until next PTI (parameter age of passenger car), source GIDAS data

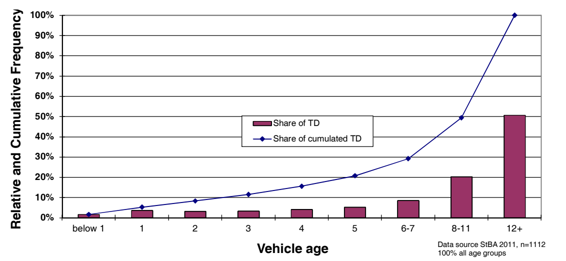

Figure 6 Relative and cumulative Frequency of technical defects (TD) of passenger cars by published vehicle age groups, [2]

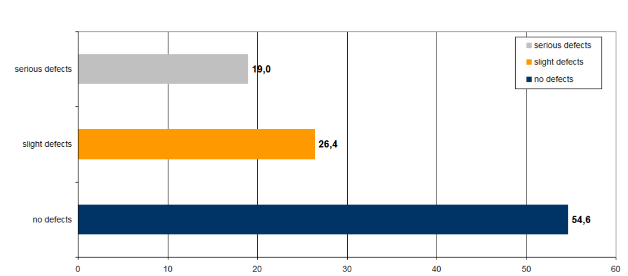

Figure 9 PTI results on passenger cars in Germany (all vehicle ages), data base: DEKRA 2011

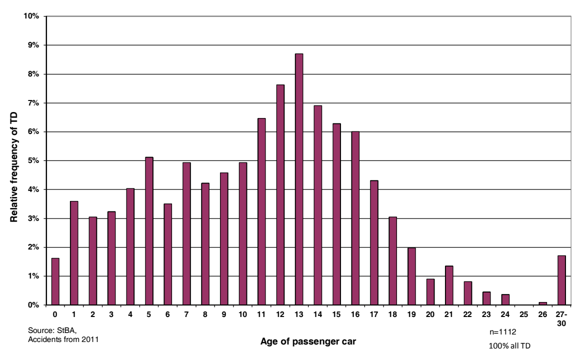

Figure 7 Relative frequency of technical defects (TD) of passenger cars by vehicle age, [3]

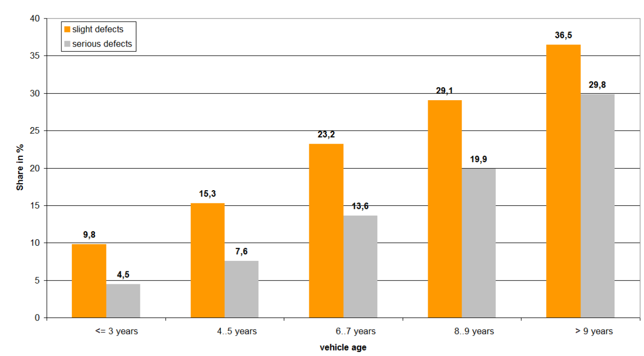

Figure 10 PTI results on passenger cars in Germany by vehicle age, data base: DEKRA 2011

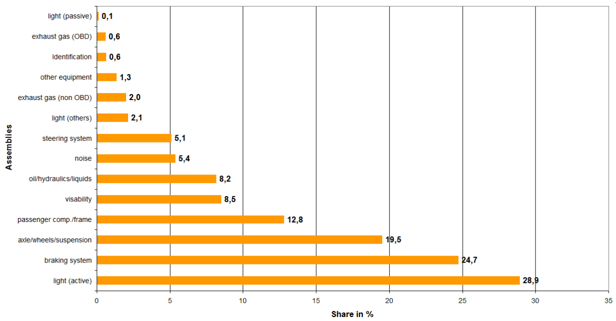

Figure 11 Defects on passenger cars in Germany by assemblies (all vehicle ages), data base: DEKRA 2011

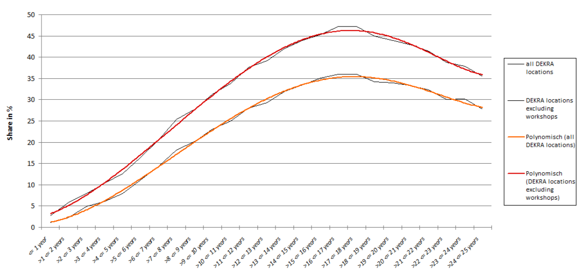

Figure 12 Comparison of PTI results by vehicle age, cars with serious defects in all locations compared with locations excluding workshops, data base: DEKRA 2011

Table 1 Results of safety Check 2007 … 2012, source DEKRA investigation

	2007	2008	2009	2010	2011	2012
period	15 Weeks	6 Weeks	7 Weeks	7 Weeks	7 Weeks	6 Weeks
inspections	> 14.000	>10.000	> 15.000	> 17.500	> 15.600	> 14.700
Defects in total	37.000	25.474	42.687	45.105	43.078	37.956
Ø defects / PC with defect	3,3	3,2	3,4	3,3	3,4	3,3
Ø PC age [years]	10,8	11,1	11	10,9	11,2	11,3
Ø PC mileage [km]	115.000	121.000	126.000	125.888	130.007	130.324
PCs > 8 years	77 %	74 %	72 %	69 %	71 %	71 %
Assemblies with defects						
Braking system	10.910	6.980	10.320	10.886	9.658	8.357
Suspension, Tyre	10.323	6.876	13.356	14.246	13.425	11.753
Lighting	7.943	5.857	8.559	9.223	9.978	9.115
Sight	3.317	3.292	3.597	3.619	3.411	2.828
Safety/Environment	4.815	2.469	6.855	7.131	6.606	5.903

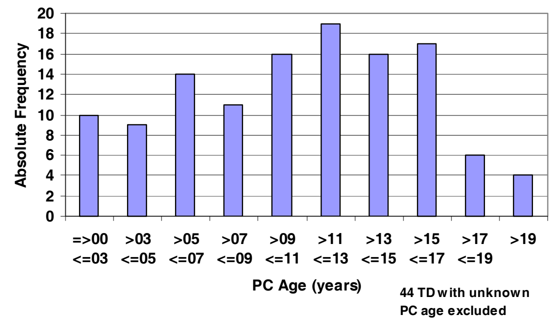

Figure 13 Absolute frequency of accident relevant TDs by PC age, Source DEKRA database

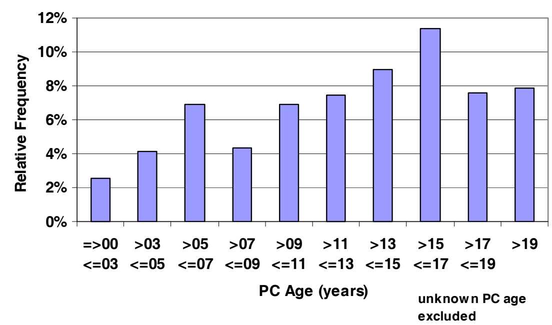

Figure 14 Relative frequency of accident relevant TDs by PC age, Source DEKRA database, (100% all examined PCs of one age group)

REFERENCES

[1] ANFAC, Vehicles in Use, Brussels, ACEA 2010

[2] Federal Statistical Office of Germany, Fachserie 8 Reihe 7, Verkehr Verkehrsunfälle, yearly published analysis of accident data.

[3] Federal Statistical Office of Germany, special data analysis of accident data of 2011, requested by DEKRA

The study of Side Structure Optimization of the SUV for New Side NCAP tests

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ABSTRACT

NCAP(New Car Assessment Program) Test will be revised from 2015. For this paper, two types of side impact test have implemented. One was Korea NCAP Side MDB test and the other was Euro NCAP Side Pole Test.Korea NCAP Side MDB test have done two times with old(R95 MDB) and new(AE-MDB) version[1]. And Euro NCAP Side Pole test also have done two times with (90degree side pole test) and new(75degree oblique side pole test) [2]. Thus total amount of test was four times.In case of the side MDB test of Korea NCAP, R95 MDB test and AE-MDB test were compared. And in case of the side pole test of Euro NCAP, 90 degree side pole test and 75 degree oblique test were compared. From the test data and CAE result, structure deformation and dummy injury (ES-2 and SID-2) characteristic were somewhat different by test mode of each. Therefore, the purpose of this paper is to reduce dummy injury data by optimization of structure and stiffness and apply new project.

INTRODUTION

Because enhanced crash test regulations & NCAP, the vehicle manufacturer has responded in several ways to improve the crashworthiness. For instance, to change and reinforce steel material, to insert shock resistant form in door panel are the one of the way. Korea and Euro NCAP have two types of side impact test. Side MDB Test for CAR to CAR Side is the one and Side Pole Test for Car to Pole is the other. Both tests will be revised in 2015 and various institutions such as EEVC/WG13, IHRA, SIWG and APROSIS have been studying for new revised test. Therefore, firstly this paper introduce about AE-MDB Test and 75 degree oblique side pole test which will be revised. Secondly, the result of new test mode will be shown by comparing with old version and then find differences about characteristics of structure deformation and dummy injury. Finally, this study propose SUV side structure optimization plan.

METHOD

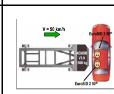
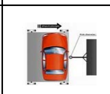
Test Configuration		Korea NCAP		EURO NCAP	
		R95 MDB	AE-MDB	90° Pole	75° Pole
					
Dummy	**FR**	ES-2	ES-2	ES-2	ES-2
	RR	SID IIs	SID IIs	-	
Test Speed		55km/h	55km/h	29km/h	32km/h

Table1. Test configurations and dummies used in side impact crash tests.

In this paper, the side impact tests was performed total four times in respond to the amended NCAP tests(AE-MDB Test & 75 ° Oblique Side Pole Test). and Table1 below shows a summary of the test methods and used a dummy.

R95 MDB test

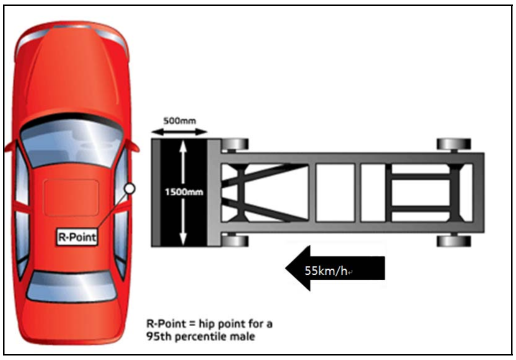


Photo1. R95 MDB test

Photo1 shows the test configurations and conditions In the present study, Impact velocity of The MDB(Movingt Deformable Barrier) was 55 km/h, striking on the R-point as refer to R95 test procedure. ES-2 dummy was placed in the front seat on the struck side, and SID-IIs was seated behind driver to acquire injury data on experimental purpose. [3)]

AE MDB test

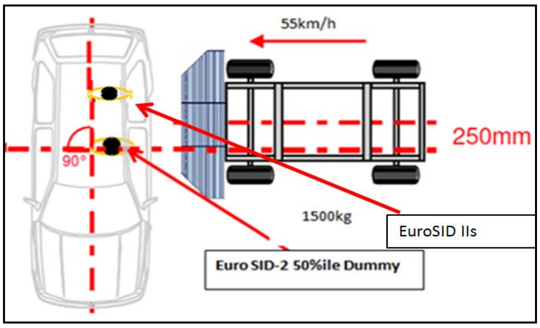


Photo2. AE-MDB test

The AE-MDB(Advanced European Moving Deformable Barrier) developed based on the car dimension, mass and front stiffness in the current vehicle fleet. The test is prepared as to the EEVC(European Enhanced Vehicle-safety Committee) WG13 test procedure. the ES-2 was placed in driver seat and SID-IIs was behind the driver. The impact point is centered on R-point +250mm rearward. (See Photo2) [4, 6)]

90degree Side Pole Test

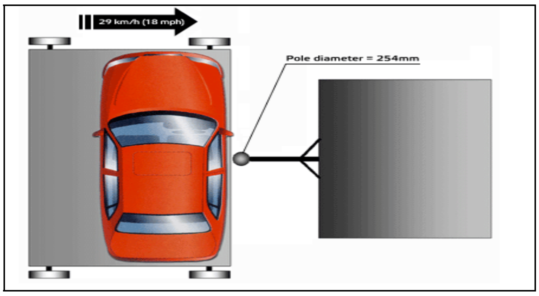


Photo3. AE-MDB test

The 90degree side pole test was according to the car-to-pole test proposed by ECE/R95, where the impact velocity is 29 km/h and the impact angle is 90 degrees. The pole diameter is 254 mm. The ES-2 was placed in the front seat according to the ECE/R95 Draft. When the ES-2 is used, the seat was set in the midway position in the seat slide range. The gravity center of the dummy head in a front seat was in alignment with the center of the pole. (See Photo3)[7)]

75degree Oblique Side Pole Test

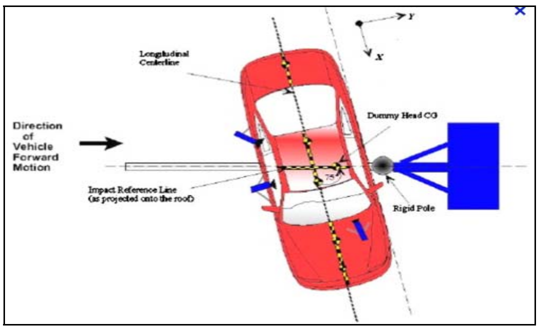


Photo4. 75° Oblique pole test

The 75degree side oblique pole test was according to the car-to-pole test proposed by NHTSA (FMVSS/214 Draft), where the impact velocity is 32 km/h and the impact angle is 75 degrees. The pole diameter is 254 mm. The ES-2re was placed in the front seat according to the FMVSS/214 Draft. When the ES-2re is used, the seat was set in the midway position in the seat slide range. The gravity center of the dummy head in a front seat was in alignment with the center of the pole. (See Photo4) [8)]

Test Vehicle Specifications and Measuring Position

The detailed specifications of the test vehicles and honeycomb barriers are following (see Table2 through 4, Photo5).

.	Korea NCAP (R95 MDB)	Korea NCAP (AE-MDB)
Test Speed	55km/h	55km/h
Test Weight	1845kg	1850kg
Restrain Sys.(1st)	SAB+CAB	SAB+CAB
Restrain Sys.(2nd)	CAB	CAB
Dummy Type(1st)	Euro SID-II	Euro SID-II
Dummy Type(2nd)	Euro SID-IIs	Euro SID-IIs
Impact Line	R-point	R-point+250mm (Vehicle rear direction)

Table2. Comparison of Vehicle Specifications

	90degree Pole	75degree pole
Test speed	29km/h	32km/h
Test weight	1,805kg	1,849kg
Restrain sys.(1st)	SAB+CAB	SAB+CAB
Dummy type(1st)	Euro SID-II	Euro SID-II Re
Impact line	Daylight zone Min.50mm	Head center point of Final Seating Position

Table3. Comparison of Vehicle Specifications

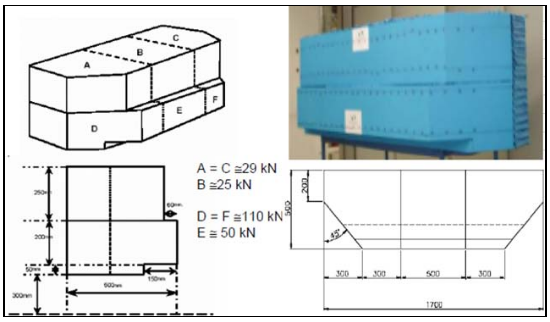


Photo5. AE-MDB Barrier dimensions[5)]

	Weight [kg]	Width [mm]	Depth [mm]	Height from Ground [mm]	Stiffness
R.95 MDB	950	1500	500	300	Low
AE-MDB	1500	1700	500	350	High

Table4. Comparison of R.95 MDB &AE-MDB[5)]

Accelerometers were attached to B-pillar rockers, front and rear door inner panels on the struck side. And 3DMM(3-Dimensional Measuring Machine) was used to measure the deformation of the B-pillar inner panel, C-pillar panel, and Body outer line at the phase of both pre- and post-test.(See Photo6 through 8) [3)]

Photo6. Front & Rear Door Sensor Positions

Photo7. B-Pillar & C-pillar Measuring Positions

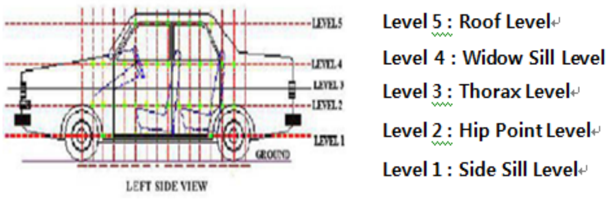


Photo8. Vehicle Measuring Positions

Result Analysis of the Side Impact Tests

These tests (See Table1) carried out the evaluation of the dummy injury value in accordance with the test procedures and the evaluation methods of Korea NCAP, Euro NCAP and FMVSS214. And the test vehicle deformation value was measured with 3DMM (three-dimensional measuring machine).

Analysis of vehicle deformation

The test vehicle was engraved with pattern tapes, that highlight the reference impact lines. Every 100mm steps was measured with 3DMM(hree-dimensional measuring machine), in order to compare displacements of impact lines with pre- and post measurement of each point on the impact lines. (see Photo9,10)

Photo9. AE-MDB Impact Line

Photo10. 75°Oblique Pole Test Impact Line

1. Vehicle deformation(AE-MDB vs R95 MDB) The vehicle outer line deformation of the side impact tests compared through Figure1 through 3. On area "A"(figure 1), on the AE-MDB Test, the vehicle body was prominently deformed more than R95 MDB test. Because the width of AE-MDB is wider, furthermore, even impact point was moved 250mm rearward. As a result of that, the rear wheel housing was damaged significantly. Also, C-pillar, B-pillar and rear door were more severely deformed on AE-MDB test(see Figure2). Door deformation aspect of Level2(See figure2) and Level 3(figure3) are, because door impact beam restrained the door panel's intrusion. Overall deformation aspect of AE-MDB is bigger on Level 2 and 3 (from Figure2 and 3). and one thing that we have to check is that AE-MDB's intrusion value of Level 3 is lower than Level 2. This is because of side impact beam located in Level 3 which absorb impact energy. Section 'B' on Figure2 and Section 'C' on Figure3 show that the deformation aspect of area 'B' is bigger than area 'C'. The reason why is that honeycomb initial height of AE-MDB is 50mm higher so energy distribution by side sill and impact beam was not proper.

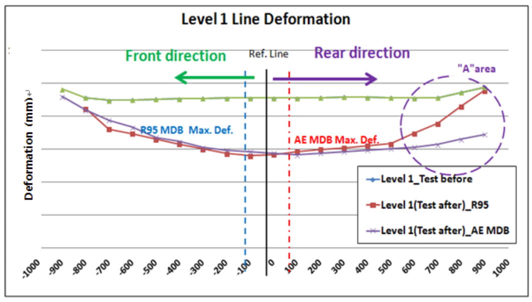


Figure1. Vehicle Level 1 Line Deformation

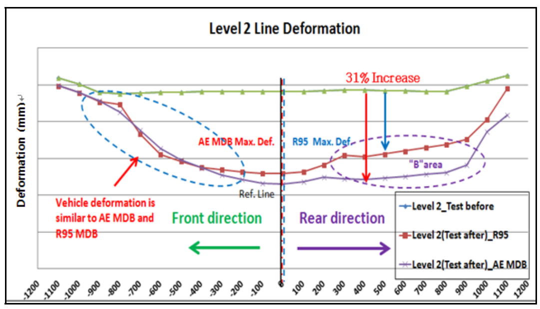


Figure2. Vehicle Level 2 Line Deformation

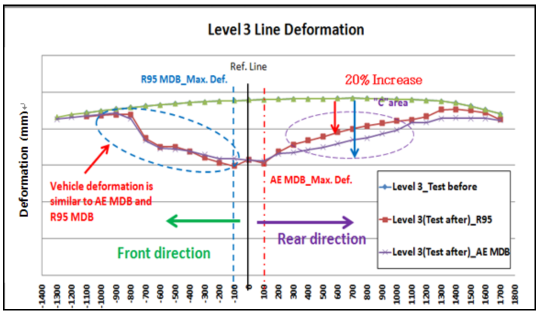


Figure3. Vehicle Level 3 Line Deformation

Figure4 &5 represent The B-pillar and C-pillar intrusion deformation. Two graphs describe that the deformation of C-pillar is 70% higher than that of B-pillar. The deformation of B pillar was slighter, because kinetic energy of AE-MDB was distributed to driver seat and rear wheel housing, however, The C-Pillar has not been influenced.

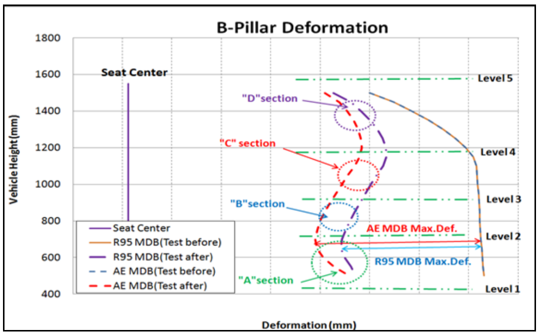


Figure4. Comparison of B-Pillar Intrusion Deformation

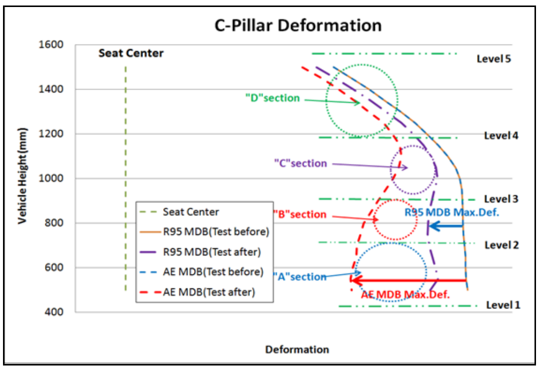


Figure5. Comparison of C-Pillar Intrusion Deformation

2. Vehicle deformation(75degree oblique side pole vs 90degree side pole test) Figure6 and Figure7 show that the deformation between 75degree oblique side pole test and 90degree side pole test. The peak deformation of 90degree side pole test is higher than 75degree oblique side pole test because the side sill of the vehicle generated concentrated load. However, overall deformation of 75degree oblique side pole test tend to be wider than 90degree side pole test. The reason is that impact angle is diagonal. And rood line(See figure8) represents the identical aspect but the deformation of 75degree oblique side pole test shows higher than 90degree side pole test because the roof side structure absorbed separately of the impulse.

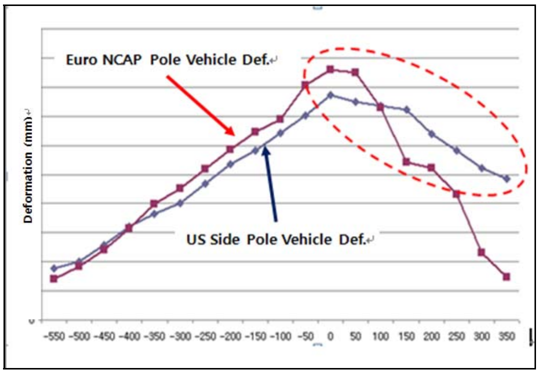


Figure6. Comparison of Vehicle Deformation (Door &H Point Line)

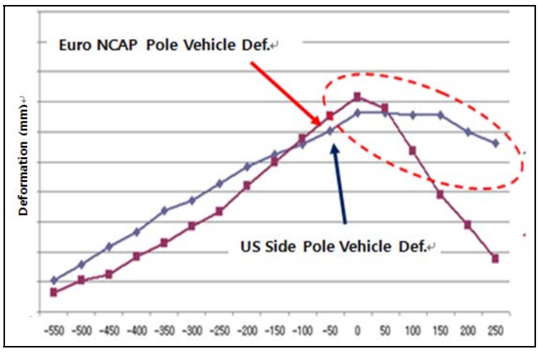


Figure7. Comparison of Vehicle Deformation (Door &H Point Line)

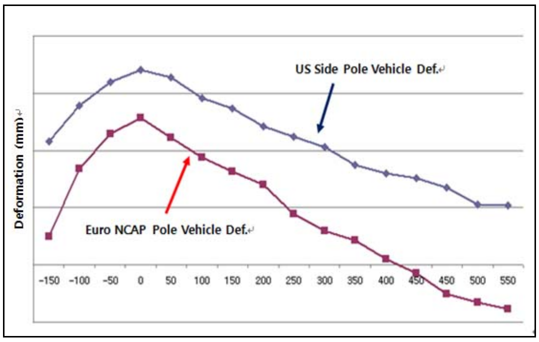


Figure8. Comparison of Vehicle Deformation (Roof Line)

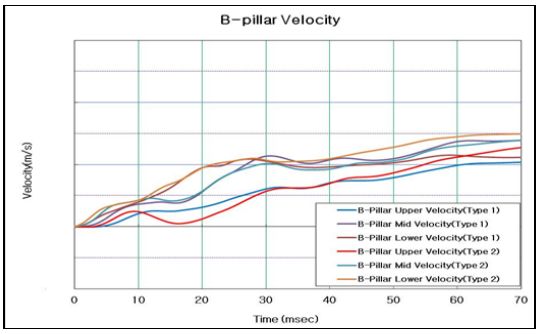


Figure11. Comparison of B-Pillar Velocity

Analysis of vehicle dynamic crash characteristic

1. Dynamic crash characteristic(AE-MDB) Figure9 through 12 below show that the maximum acceleration and velocity of B-pillar. Figure13 trough 16 show that the maximum acceleration and velocity of front and rear door. Type1 is R95-MDB test and type2 is AE-MDB test. Also photo9 shows ruptured part at lower B-pillar.

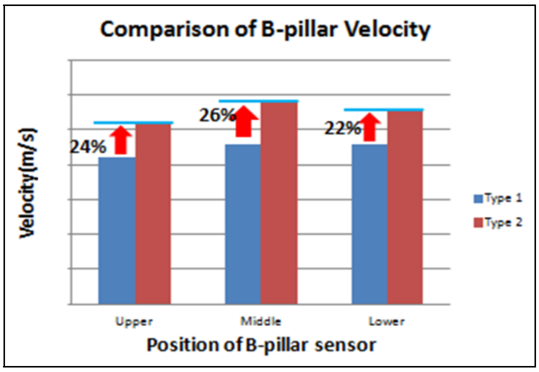


Figure12. Comparison of B-Pillar Velocity

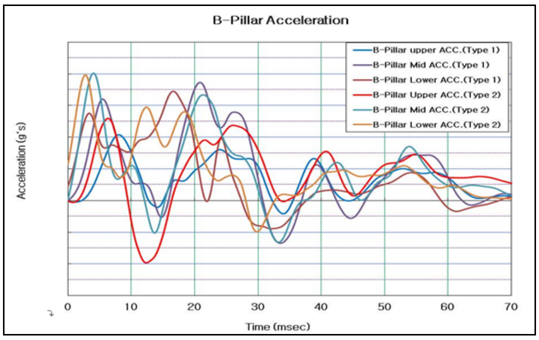


Figure9. Comparison of B-Pillar Acceleration

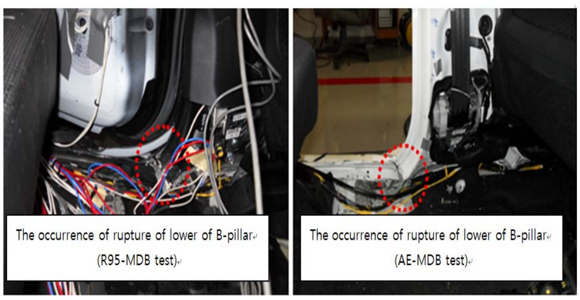


Photo11. Comparison of B-Pillar Acceleration

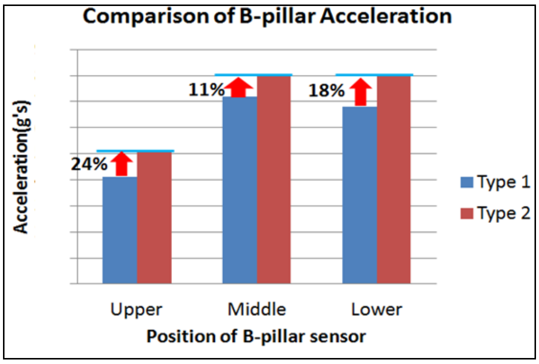


Figure10. Comparison of B-Pillar Acceleration

The graphs above show the maximum acceleration (See Figure9, 10) and velocity (See Figure11, 12) on B-pillar upper, middle, lower position. The max value of B-pillar acceleration and velocity tend to be higher than R95-MDB test and the colliaion energy of both test is concentrated on middle and lower B-pillar. Therefore the lower position of the B-pillar was ruptured (see Photo11).

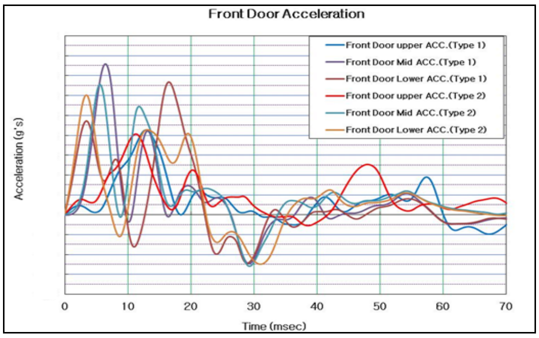


Figure13. Comparison of Front Door Acceleration

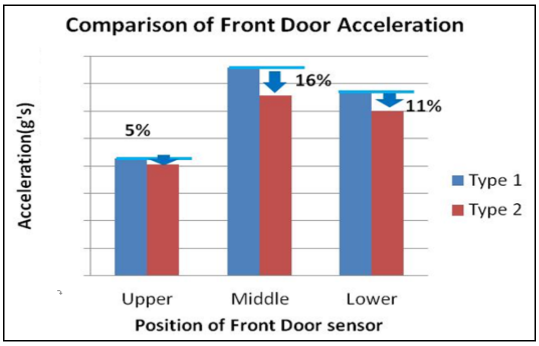


Figure14. Comparison of Front Door Acceleration

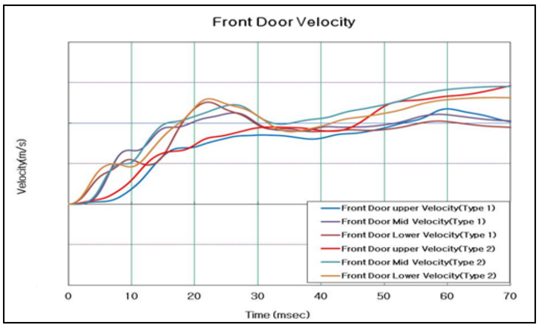


Figure15. Comparison of Front Door Velocity

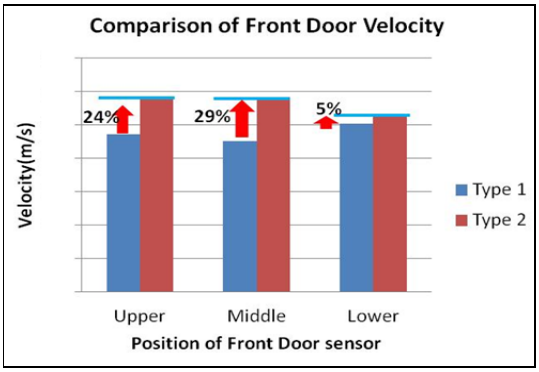


Figure16. Comparison of Front Door Velocity

The graphs above show the maximum acceleration (See figure13,14) and maximum velocity (See figure15, 16) on B-pillar upper, middle, lower position. From figure13 through 16, AE-MDB test instantaneous velocity of front door is increase 29% but the max peak acceleration value is decreased 16% compare with R95-MDB. The reason is impact base line moves to 250mm rearward and AE-MDB contact directly to B-pillar and rear wheel housing. Therefore the energy of front door is distributed..

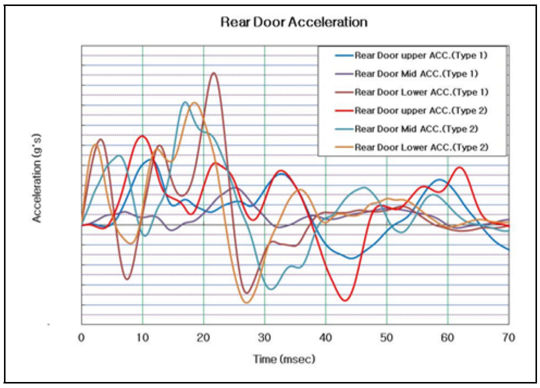


Figure17. Comparison of Rear Door Acceleration

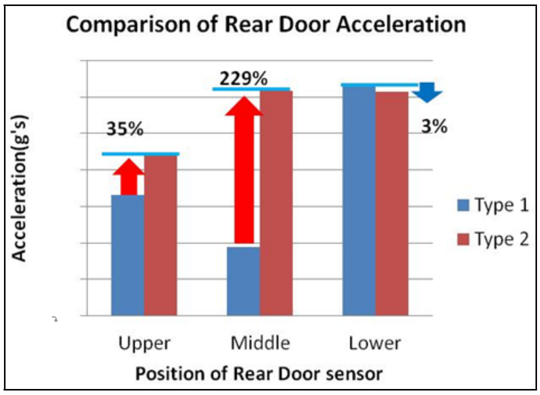


Figure 18. Comparison of Rear Door Acceleration

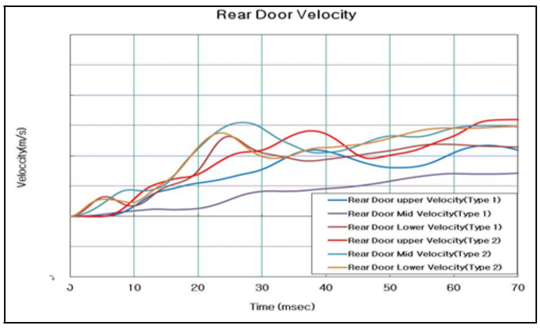


Figure19. Comparison of Rear Door Velocity

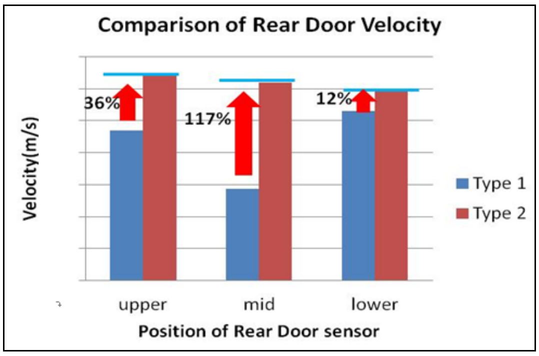


Figure20. Comparison of Rear Door Velocity

The graphs above show the maximum acceleration (See Figure17,18) and maximum speed (See Figure19,20) on B-pillar upper, middle, lower position. From figure17 through 20, acceleration and velocity of upper, middle and lower on rear door are increased except lower acceleration value. It shows that the distribution energy on rear wheel housing, side sill and C-pillar is huge. As a result depending on the setting location of the sensor as shown in the Photo12 below, the acceleration and velocity were increased to maximum 220% and 117%.

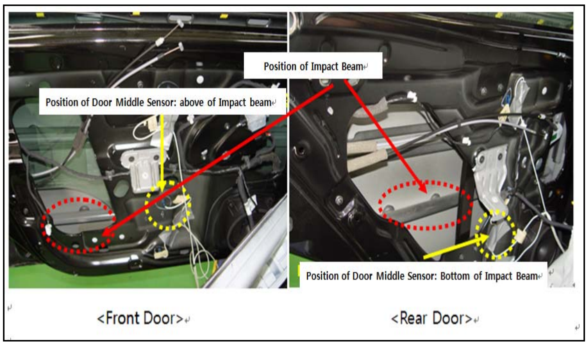


Photo12. Comparison of Door Side Impact Beam & Sensor Position

2. Dynamic crash characteristic(75° oblique pole test) The below graphs show the acceleration of B-pillar, deceleration of B-pillar and the deceleration of front door middle position.(see Figure20,21,22).

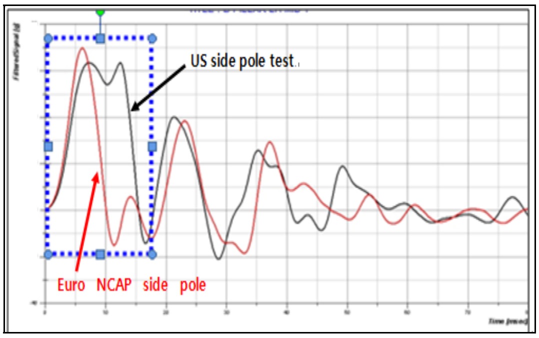


Figure20. B Pillar LH Mid Y Deceleration

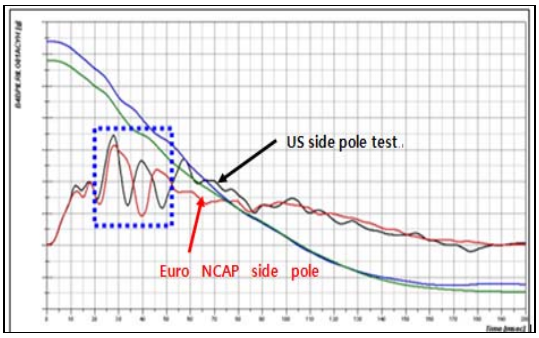


Figure21. B Pillar RH Y Deceleration & Velocity

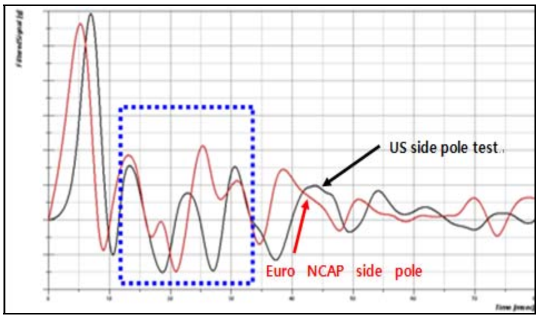


Figure22. FRT Door Mid Y Deceleration

Comparing the results of the B Pillar LH deceleration graph after the pole crash, the sudden deceleration which occurs between 5 and 20msec. The 75degree side pole test is characterized in maintaining for long time of the maximum value than 90degree side pole test. As a result, the vehicle of US side pole test will be a constant force for a period of time by the pole. And comparing the results of the B-pillar RH deceleration graph after the pole crash, the graph of US side pole test represents to large deceleration and velocity in the range of approximately 30msec. Because concentrated load on B-pillar RH occurs. When comparing the results of the front door deceleration graph after the pole crash, the initial deformation by pole crash represents as similar deceleration patterns, because the door structure is not able to absorb the shork compared to the B-pillar. But The deformation of US side pole test was occured twice large deceleration in range of approximately 30msec, but the deformtaion of Euro Side pole test was occured the deceleration as the characteristics of shock absorption. Accordingly the U.S. side polet test occurs crash acceleration continuously, and the deformation appears as a wide range. Therefore US side pole test is considered to the aspect of vehicle deformation in adverse condition.

Analysis of Dummy Injury Value

To study the dummy, injury values with respect to vehicle deformation patterns, induced from the vehicle accelerometer.

1. Dummy injury value(AE-MDB)

The table5 & table6 below showed the value of the driver's seat and front passenger seat Dummy Injury.

			R95 MDB	AE-MDB	Rate (%)
Head	HIC		30.1	60.7	101
Chest	Defection (mm)	Upper	18.1	20.5	13
		Middle	21.9	25.2	15
		Lower	23.5	27.5	17
	VC(m/s)	Upper	0.13	0.13	0
		Middle	0.17	0.21	23
		Lower	0.20	0.28	40
	Back Plate(kN)	Fy(kN)	0.77	1.39	80
	T12	Fy(kN)	0.73	0.95	30
		Mx(Nm)	0.06	0.06	0
Abdomen(kN)			0.33	0.37	12
Pubic(kN)			0.96	1.28	33

Table5. Driver Dummy Injury(Euro SID II)

			R95 MDB	**AE-MDB**	**Rate (%)**
Head	**HIC36**		86.6	192	
Chest	**Defection (mm)**	**Upper**	9.5	11.3	
		Middle	6.8	7.3	
		Lower	12.1	14.5	
Sum of Acetabular and iliac force (N)			1714	3076	79%↑
Individual Probability of Injury			0.009	0.034	
Relative Risk (P/base)			0.06	0.23	

Table6. 2nd Rear Passenger Dummy Injury(SID IIs)

Dummy head injury value The dummy head injury value of AEMDB test increased 101% than the dummy head injury value of R95-MDB, but it is difficult to judge as increase because the dummy head injury value is lower compared to the injury performance limit values. For the reason, the dummy injury values of the test are not high because the dummy head has been well protected by the curtain airbag.

Dummy chest injury value The below Figure23 is accelerometer value of B-pillar rockers, and The Photo13 is a modified photo by the crash between B-pillar lower position and seat frame. The Figure24 is dummy chest maximum injury graph, and The Figure25 is a graph to analyze to relation between the B-pillar and dummy behavior. Figure23 graphs are shown to occur the reaction force due to the contact of B-pillar rockers inner panel and seat frame at between 25msec and 40msec. In case of the AE-MDB test, the maximum chest deflection is showed at 40msec, and the maximum chest deflection of R95-MDB test is showed at 43msec. The Figure25 graphs are shown to transfer sequentially faster and higher the B-pillar velocity of AE MDB test from lower to middle due to the crash energy of MDB. In case of the chest middle velocity value, R95 MDB and AE-MDB are occurred to the maximum value at 20msec and 40msec respectively. The reasons for the maximum dummy chest middle velocity difference, R95 MDB test are well protected to the dummy at 20msec by the side airbag. But AE-MDB test is not performed to perfectly the function of side airbag at 17msec due to the dummy behavior, and so that is occurred to the maximum chest velocity value at 40msec by the contact of dummy chest and door inner panel. As a result, the dummy behavior of AE-MDB test is seen to the faster than R95 MDB test because of the contact of B-pillar lower and seat mounting frame. So the dummy injury value of AE-MDB is increased to 15% than R95 MDB. The chest injury value of 2nd seat dummy is not considered because the injury performance limit values lower (See Table6).

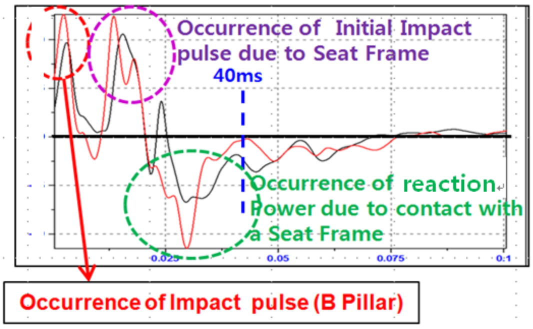


Figure23. Comparison of b-pillar lower ACC.

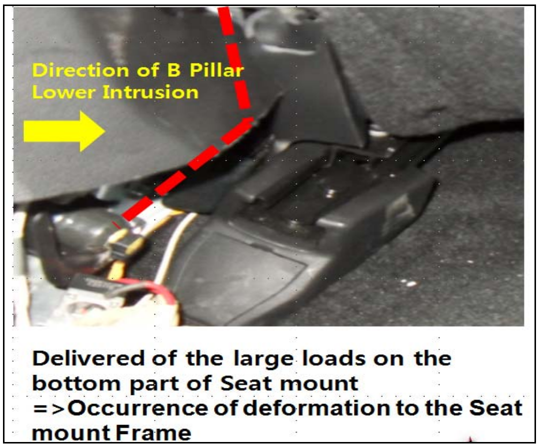


Photo13. Deformation to the seat mount frame(AE-MDB)

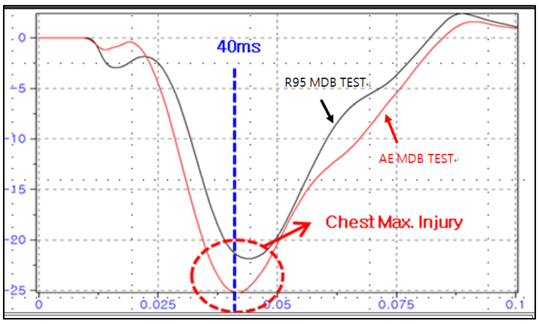


Figure24. Comparison of driver dummy chest ACC.

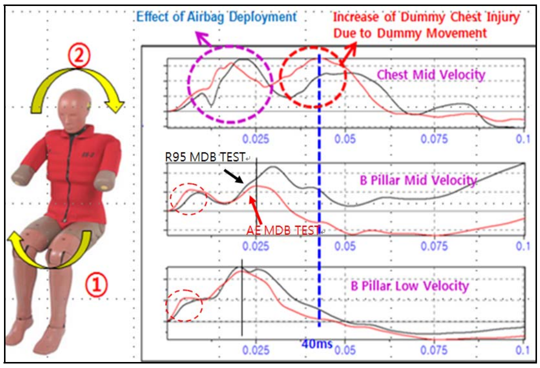


Figure25. Analysis of driver dummy movement

Dummy pelvic injury value Below Photo14 is the rear dummy seat position and c-pillar measurement areas. The table7 is C-pillar maximum deformation on each position, and the Photo15 is a picture to capture high-speed video of rear seat dummy position. The Figure26 through 28 is shown to each graph of the dummy pelvic velocity, pelvic displacement and acetabular & iliac force.

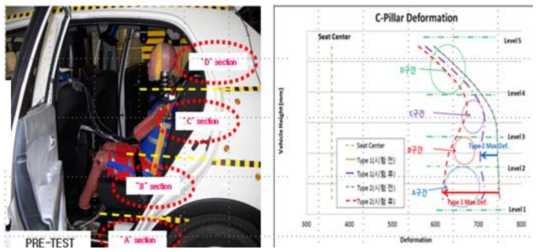


Photo14. Rear Seat Dummy & C pillar measuring Position

위치	ECE R95	AE-MDB	변위 증가량
D section	16mm	40mm	250% ↑
C section	26mm	77mm	296% ↑
B section	40mm	120mm	300% ↑
A section	32mm	133mm	415% ↑

Table7. Static deformation of C Pillar

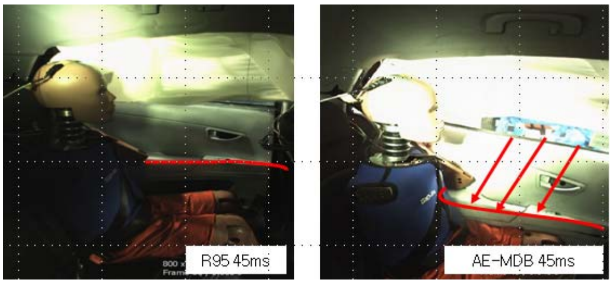


Photo15. Comparison of High Speed Video(SID IIs)

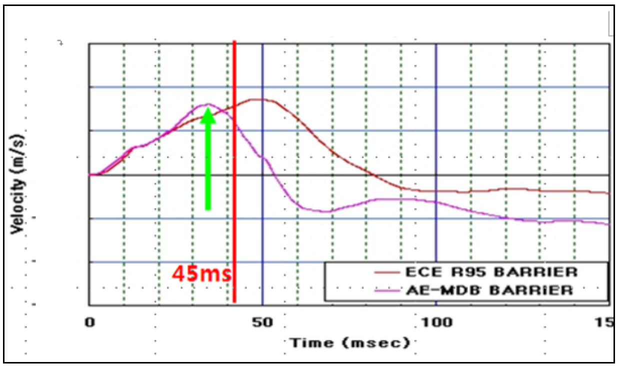


Figure26. Dummy Pelvic Velocity(SID IIs)

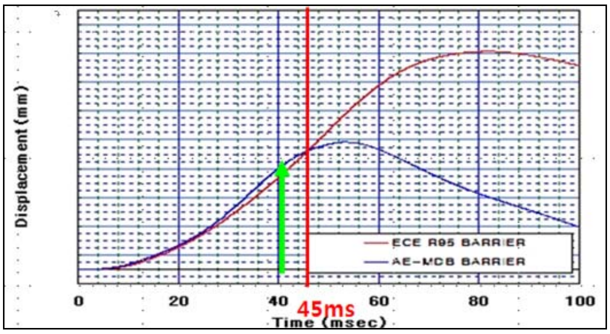


Figure27. Dummy Pelvic-Y Displacement(SID IIs)

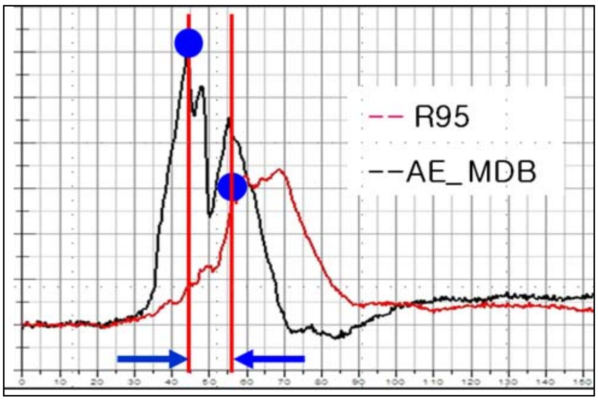


Figure28. Comparison of Sum of Acetabular and iliac force (Rear Seat Pass. Dummy, N)

On the Photo12 and Table7 above, AE-MDB test is increased more 415% and 300% respectively the static deformation in the "A" section and the "B" section than R95 MDB test. and, in the case AE-MDB test, the pelvic load of 2nd passenger is increased to higher maximum 79% in the previous 45msec because of the sharp increase of door inner trim, dummy behavior velocity and dummy behavior deformation (See Figure26 through 28). But the pelvic injury value driver dummy is lower than the injury performance limit values due to the dispersion of crash energy by the rearward 250mm movement of reference line and rear wheel housing contact.

2. Dummy injury value(75degree oblique side pole test vs 90degree side pole test)

The Table8 compared to the test results of two type side pole, and the Figure29 through 32 compared to the injury value of each part of the ES-2 injury value.

Position	Euro SID II re	Position	Euro Pole	US Pole	Difference
Head	HIC		245	276	12% ↑
Chest	Def. (mm)	Upp	28.6	56.0	96% ↑
		Mid	26.7	51.5	93% ↑
		Low	27.4	49.4	80% ↑
	V.C (m/s)	Upp	0.26	1.46	460%↑
		Mid	0.22	0.89	300% ↑
		Low	0.25	0.59	136%↑
Abdomen	Force	Abdomen	0.69	0.95	37% ↑
Pubic	Force	Pubic	2.08	0.93	44% ↓

Table8. Comparison of Side Pole Test Result

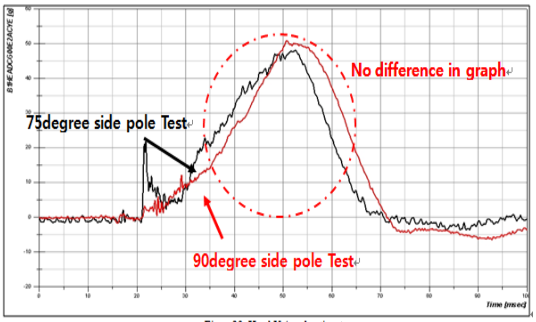


Figure29. Head Y Acceleration

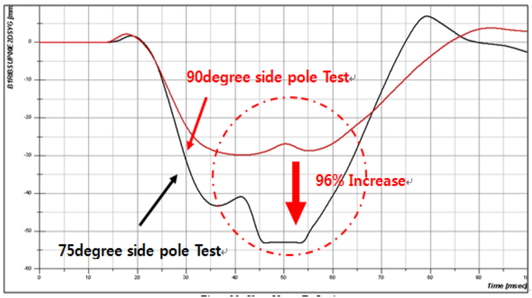


Figure30. Chest Upper Deflection

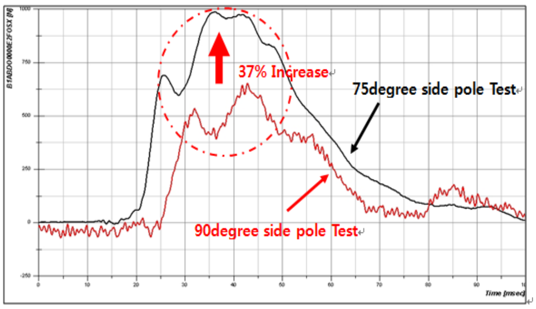


Figure31. Abdomen Force Sum

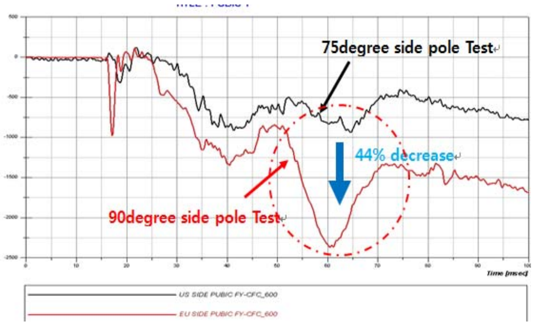


Figure32. Pubic Force

Dummy head Injury value The dummy head injury value of 75degree side pole test increased 12% than the dummy head injury value of 90 degree side pole test, but it is difficult to judge as increase because the dummy head injury value is lower than the injury performance limit values. The dummy injury values of the test are not high because the dummy head has been well protected by the curtain airbag.

Dummy chest Injury value In case of the 90degree side pole test, the maximum chest deflection is showed at approxirately 40msec, and the maximum chest seflection of 75degree side pole test is showed at approximately 50msec. Acoording the chest defflection & VC injury values of 75degree side pole test occurred to more high maximum approximately 96%, 136% respectively than 90degree side pole test. As a result, as shown in the vehicle crash characteristics and CAE analysis(See Photo16), the crash energy of 75degree oblique side pole test were able to confirm to transfer widely in the vehicle body than 90degree side pole test.

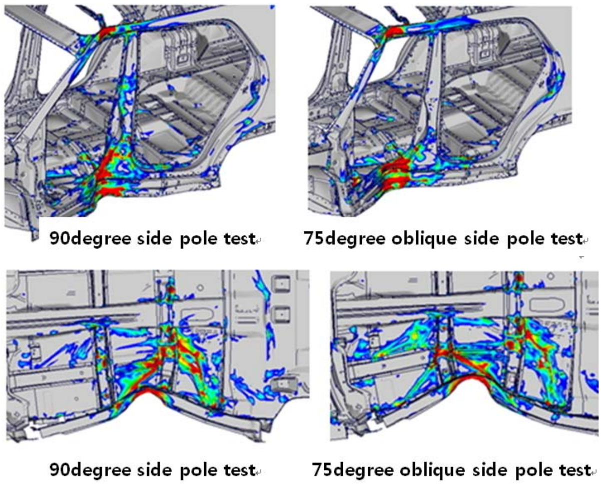


Photo16. Deformation Shape of CAE Model Structure

Dummy abdomen & pubic Injury value The abdomen injury value of 75degree oblique side pole test occurred to more high maximum approximately 37% than 90degree side pole test, but the pubic injury value of 75degree oblique side pole occurred to more low maximum approximately 44% than 90degree side pole test. Because the dummy behavior is changed in accordance with the test mode and force acting on the dummy thighs.

SUMMARY AND CONCLUSION

Corresponding to the newly amended NCAP(New Car Assessment Program), the following conclusions could be confirmed.

1) Reviewing the vehicle body deformation characteristics in the event of AE-MDB test, the vehicle body is increased the stiffness of B-pillar bottom and rear door impact beam, so as to diminish the deformation of the doors and the B-pillar Because the position of a crash base line and the weight of moving deformation barrier was changed. And, in the front door, the pulse traces of the 75 degree oblique pole test showed deceleration and velocity, higher than 90degree side pole test, and the aspect of vehicle body deformation was conformed to show large and widely through CAE analysis. Therefore, the vehicle body of 75degree oblique pole test should be improved the structure stiffness of the front door, side sill and underbody cross member of the direction of Front Door.

2) In case of the AE-MDB test, the maximum deformation, acceleration and velocity of B-pillar increased 31%, 24% and 26% respectively more than R95-MDB test. Also although the crash energy is distributed by the contact of the driver seat and rear wheel housing, the B-pillar rockers is likely to be torn and the dummy behavior occurred by the contact of driver seat frame. On the 75degree oblique side pole test, the concentrated load of collusion energy generated at the side sill, underbody frame and the B-pillar rockers through CAE analysis(See photo14). Therefore it is necessary to optimize B-pillar rockers, side sill stiffness and underbody frame to reduce dummy injury value from the collusion energy of moving barrier.

3) In case of AE-MDB test, the C-pillar deformation characteristic increased to maximum 315%, compared to R 95 MDB test. Also the deformation increases of the rear door and C-pillar cause to increase the injury values of the chest and pelvic of 2^{nd} seat passenger dummy. Therefore the optimization of vehicle structure is required to increase the stiffness of rear door side impact beam as well as C-pillar.

4) The dummy head injury value increased slightly both the AE-MDB test and 75° oblique pole test, but it is difficult to judge as increase because the dummy head injury value is lower compared to the injury performance limit values. The dummy head injury values of the test are not high because the dummy head has been well protected by the curtain airbag.

5) In case of AE- MDB test, the driver dummy chest injury value were increased the maximum deflection 17% than R95 MDB, and 75degree oblique side pole test increased the maximum 96% and 460% respectively for chest deflection and VC than 90degree side pole test. The dummy chest injury value of the tests are high because the dummy behavior occurred by the contact of seat mounting frame and B-pillar lower panel. Therefore the lower panel is required to increase the stiffness and structure of B-pillar lower panel to prevent the behavior of driver dummy. And in the case of the 2^{nd} seat dummy, AE-MDB test will necessary to optimize deployment of the side airbag and vehicle structure to reduce chest injury value.

6) Focusing on the pelvic injury value of the dummy on the driver seat, Even though the injury values from AE-MDB test are comparatively higher than the injury values of R95 MDB test. However, the increase is regarded as not big change with respect to injury performance limits. The pelvis injury of 75degree oblique pole test was reduced to 44% due to the large movement of the dummy(See Table5, 8). On rear seat passenger dummy, pelvic injury value from AE-MDB test increased to 79% more than R95 MDB Test results, but the pelvic injury value of the driver dummy is lower than the injury performance limit values due to the dispersion of crash energy by the 250mm rearward movement of impact base line and contact of rear wheel housing. In sum, on AE-MDB test, the rear

door impact beam, the C-pillar, the side sill and the rear wheel housing, of which position and stiffness should be optimized. On 75degree oblique side pole test, the methods to reduce of the pelvic movement are following
a. geometric dimension and stiffness of the vehicle body should be optimized.
b. side & curtain airbag should be finely tuned.

As a results, to reduce dummy injury chest value for the newly amended NCAP(New Car Assessment Program), the manufacturers should investigate to the preceding interpretation and optimizer work such as door trim materials, the position of door trim & impact beam, the stiffness of C-pillar & door impact beam, passengers resident spaces etc. Through this work propose SUV side structure optimization plan.

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PREDICTING A VEHICLE'S DYNAMIC ROLLOVER INJURY POTENTIAL FROM STATIC MEASUREMENTS

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ABSTRACT

The purpose of this research was to demonstrate a methodology for deriving a real world dynamic rollover injury potential rating system from static measurements. The methodology consists of an evaluation of vehicle strength to weight ratio (SWR), roof structure elasticity from static testing, major radius, minor radius, and major radius extension to predict residual roof crush. In addition to providing a hypothesis for evaluating the vehicles the major radius extension (MRE) will be looked at to provide insight for correcting existing anomalous static SWR measurements. These parameters are important because a 43 nation Global NCAP has been established to rate vehicles in all crash modes. Rollover performance is to be rated by SWR. Global NCAP will be responsible for reducing the 1,200,000 vehicle fatalities per year of which 25% can be rollovers when comparing rollover fatality proportionality to U.S vehicle fatality statistics.

Based on our rollover research of the past 12 years structural and occupant protection countermeasures can be used to significantly counter those fatalities. Disseminating the dynamic injury performance provides a world-wide opportunity to save many tens of thousands of lives annually. Jordan Rollover System (JRS) vehicle rollover dynamic testing apparatus has identified a significant number of vehicles which meet the most rigorous static roof strength criteria, but fail to provide occupant protection from injury risk.

Manufacturers can reduce the injury risk within size class by minimizing geometry effects and the likelihood of a high pitch rollover. While large, tall, heavy vehicles are protective in frontal and side impact accidents they are very high injury risk vehicles in rollovers for the very same reasons. This paper provides a prediction method for assessing dynamic injury probability from static test data and measurements.

INTRODUCTION

The establishment of a Global NCAP community provides an opportunity to help save tens of thousands of lives lost in rollovers worldwide by identifying dynamic rollover injury risk performance rather than statistically-derived static SWR measurements. The JRS research has identified geometric vehicle parameters, which significantly affect dynamic injury risk performance. Similarly consensus dummy injury criteria and measurements can correct the current grossly-understated dummy injury measures which mislead manufacturers as a result of dummy components that are not biofidelic. As a conclusion we are able to identify the significant number of vehicles which meet the most rigorous static roof strength criteria, but fail to protect human occupants. Figure 1 identifies the worldwide distribution of the 1.2 million people who die every year in vehicle accidents.

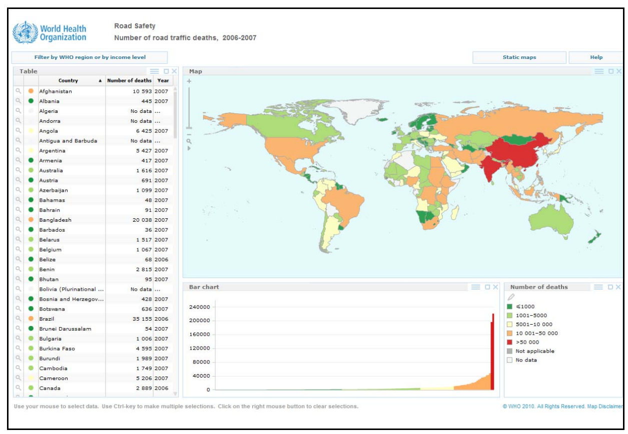

Figure 1. Distribution of Road Safety number of traffic deaths, 2006-2007.

Rollover fatalities and injuries have been a significant problem since identified in the hearings preceding the 1966 Traffic Safety Act. The problem was addressed in two regulatory efforts of the 1970 United States Federal Motor Vehicle Safety System (FMVSS) 208 and 216. FMVSS 208 addressed the ejection problem and FMVSS 216 addressed the roof crush problem. These regulatory efforts were rejected by the auto manufacturers because the production vehicles of the era could not meet the requirements. The auto manufacturers sued the US National Highway and Safety Board to squash FMVSS 208 (and lost in 1974) and offered a test variation for FMVSS 216 justified by geometric considerations which reduced the performance criteria by a factor of two, such that 1970 era vehicles could pass the test. The internal industry research that thwarted the change in these standards for 39 years has been documented [1-11].

Then in 2005 through 2008 the JRS was developed shown in Figure 2. Results of JRS testing revealed the misconceptions as well as roof strength solutions that were available to avoid window breaking and ejection portal creation [12].

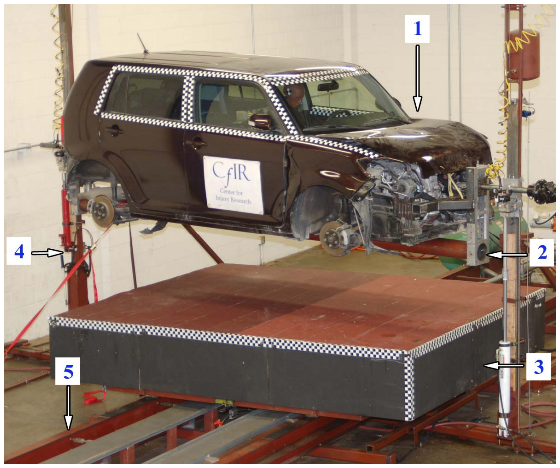

Figure 2. Key Components of the JRS: (1) Vehicle, (2) Cradle/Spit Mount, (3) Moving Roadbed, (4) Support Towers, (5) Coupled Pneumatic Roadbed Propulsion and Roll Drive.

Then in 2008 IIHS released a study which supported the JRS dynamic test results. IIHS found that incapacitating and fatal injury rates could be reduced by half if roof strength was doubled as shown in the composite IIHS and C*f*IR chart of Figure 3[13].

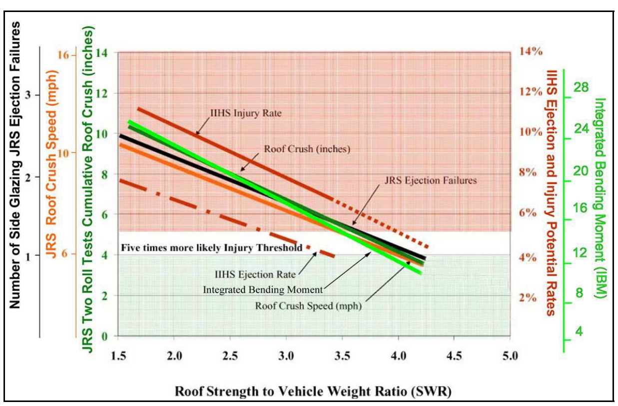

Figure 3 . CFIR and IIHS composite chart.

In 2009 NHTSA issued a final rule that required a two-sided static test with a minimum SWR requirement of 3 [14]. In 2010 IIHS established a three tiered static SWR level of good, acceptable and poor performance by SWR (SWR=2.5 is poor, SWR =3.25 is acceptable, SWR= 4 is good [15]. CfIR attempted to validate IIHS criteria (using JRS dynamic test data) by an injury risk criteria and analysis. Data was collected with the JRS of Figure 3. The JRS found IIHS to be mostly valid with serious exceptions that produced large amounts of roof crush such as the 2008 Scion xB with an SWR of 6.7 and the 2010 Ford F150 Supercab with an SWR 4.7. The Scion xB had a residual roof crush of 11" and the Ford F150 Supercab had a residual crush of 4.6". These vehicles had severe dummy neck injury measures relative to consensus injury criteria. The only consensus injury measures were roof crush and roof crush speed based on criteria developed by McElhaney [16]. The map of the injury measures submitted to NHTSA in 2008 is shown in Figure 4.

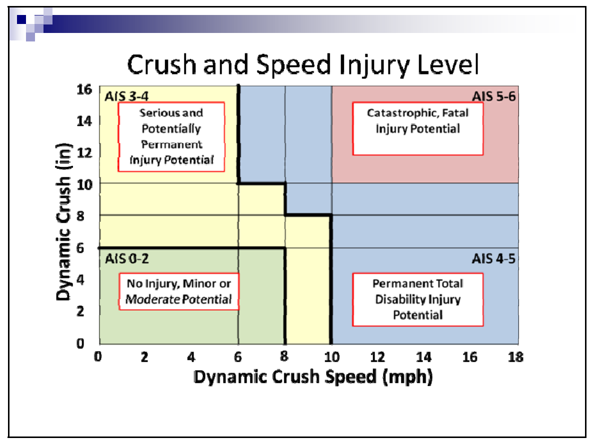

Figure 4 . Consensus injury criteria map of dynamic crush injury risk criteria

Published analyses of more than 50 comparable dynamic JRS rollover tests shown in Figure 5 has identified the major sources of increased injury and fatality risk in rollovers as measured by residual roof crush and correlated to consensus momentum exchange dummy injury measures [17]. In 2009, a statistical analysis of NASS and CIREN files evaluated to provide a probability of a rollover fatality by providing a rating of good, acceptable, and poor for 3 bands of roof crush as discussed in a companion paper [18]. This shows increasing probability of fatality with increasing vehicle residual crush. Figure 5 is a chart showing injury potential relative to roof crush. The chart is normalized to the 1st roll of a 2 Roll rollover representing 95% of all rollovers and AIS 3+ rollovers.

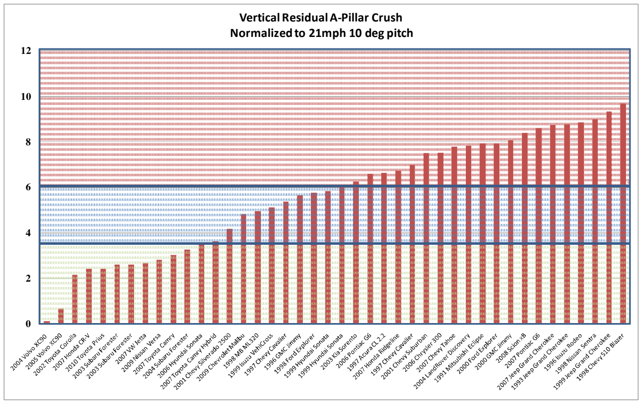

Figure 5. Residual crush on normalized test with named vehicles.

Figure 6 shows the 9 vehicles which were chosen for predicting dynamic performance. The Volvo XC90 is the best performing vehicle in a rollover and the Ford F150 is the worst performing vehicle when basing injury risk on residual roof crush.

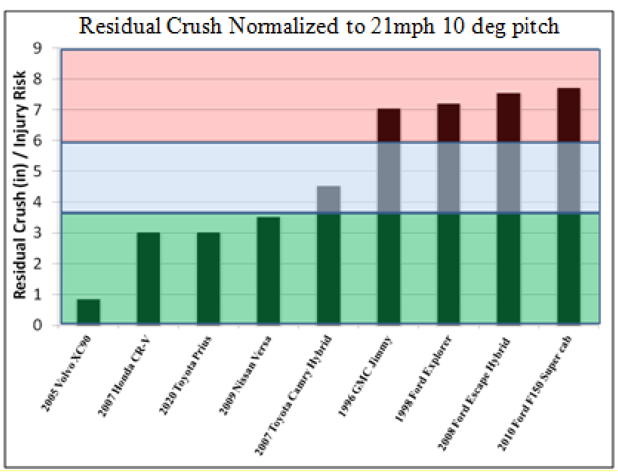

Figure 6. Nine vehicles shown on the normalized chart.

Above data (Figure 6) is taken after a 1 Roll using the first Roll in a 2 test protocol. The vehicles were normalized to extrapolate a 2 roll condition which is representative of real world crashes found in NASS, CIREN. Static measurements were taken before and after the first roll.

STATIC TEST METHODS

The basis for the predicted dynamic injury risk calculations should be with a common static test. The static test would measure the SWR as specified in the single sided FMVSS 216 test as shown in Figure 7. Roll 1 of the 2 Roll dynamic test protocol resembles the FMVSS 216B test the best.

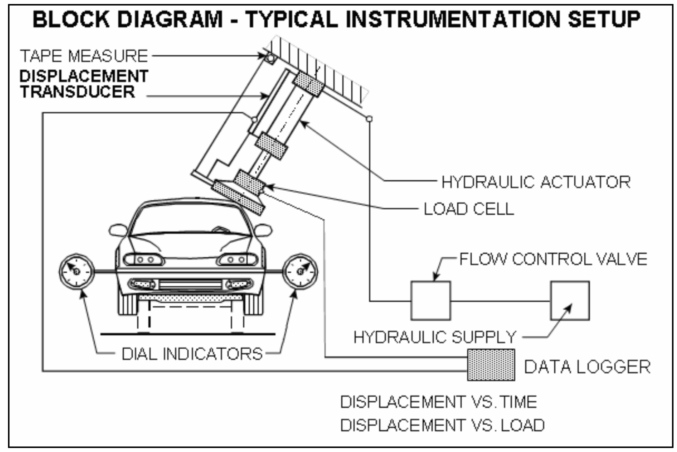

Figure 7. FMVSS 216 Quasi-Static Test Apparatus

Measuring SWR

The platens for the FMVSS 216 Machine should be at least 18 by 24 inches, set to 5 degrees of pitch and 25 degrees of roll. When measuring load and displacement the speed of the hydraulic ram in this quasi-static test is limited to 13 mm/sec until the displacement of the ram reaches 127 mm from initial contact with the roof. SWR is the maximum force in the system divided by vehicle curb weight for heaviest trim level within the model line.

Measuring Elasticity

A second measurement would be added to the existing FMVSS 216 test criteria by measuring load and displacement (using the 13mm/sec speed) as the ram reverses direction until the load reading approached some number close to zero. This displacement value would then represent the elasticity of the roof structure.

ELASTICITY

The injury risk of residual crush was based on NASS investigations of 1993 to 2006 vehicles such that residual crush and elasticity were characterized for a vehicle fleet population of the late 90's. The SWR of production vehicles improved after 2005 by the substitution or addition of high strength steel in the roof structure. Late model vehicles are deforming less and as a result the materials with the same characteristics are providing less residual crush as a result of increased column profiles.

Since injury risk is related to residual crush, an elasticity correction is necessary. The NASS-CIREN files (Mandel probability of injury charts) are based on fleet average vehicles of the 90's with SWR's of about two and an elasticity of about 30%. Post 2005 vehicles have SWR's greater than four and an elasticity of 60% as shown in Table

1. Elasticity is a function of roof structure elements being less deformed as a result of a stronger roof structure. This does not mean necessarily that materials are vastly

GEOMETRIC EVALUATION

There are 2 important geometric measurements – major radius and minor radius. From the two measurements major radius extension (MRE) can be calculated to predict residual roof crush.

Below is the list of vehicles used for evaluating the affect MRE can have on residual roof crush.

Table 1.
Major Radius Extension for Large Roof Widths

VEHICLE TYPE	SWR	MAJOR RADIUS	MAJOR RADIUS EXTENSION	ELASTICITY (%)	RESIDUAL
1998 Ford Explorer	1.6	45.3	5.03	38.6	4.3
2005 Volvo XC90	4.6	42.6	0.53	70.6	0.5
2010 Ford F150 Supercab	4.7	50.3	5.98	31.3	4.6
2007 Toyota Camry Hybrid	4.3	42.7	7.47	46.0	2.7
2008 Ford Escape Hybrid	2.6	44.3	2.83	44.4	4.5
2009 Nissan Versa	3.7	43.7	6.89	56.3	2.1
2010 Toyota Prius	4.2	39.9	3.7	59.1	1.8
1996 GMC Jimmy	1.6	43.3	3.63	33.3	4.2
2007 Honda CR-V	2.6	42.1	2.43	47.1	1.8

The major radius (MR) is the distance from the vehicle's longitudinal center of mass to the intersection of the header, roof rail and A- pillar. Minor radius is measured from the C.G height of the vehicle to the top of the roof.

The major radius is always larger than the minor radius and therefore the difference between the two radii is the major radius extension (MRE). MRE is a characteristic that is typical of larger roof vehicles. While Major Radius Extension can be associated with large roof width as shown in Figure 8, MRE is not always associated with large vehicles.

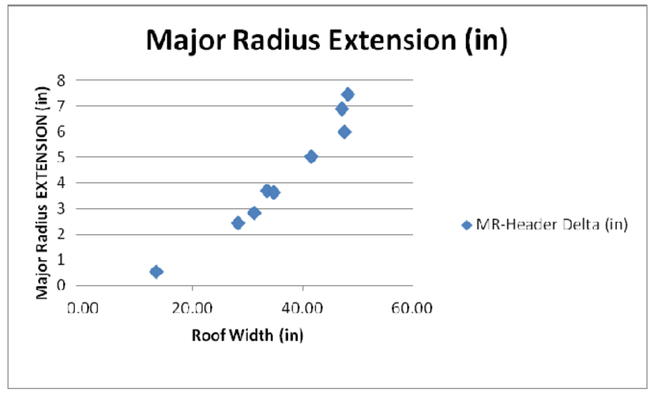

Figure 8. Major Radius Extension for Large Roof Widths.

The 2005 Volvo XC90 (lower left hand corner of the plot) is a large vehicle with a curb weight of 4,500 pounds (close to that of a same year Chevy Suburban) performs extremely well in a rollover and has the smallest Major Radius Extension in comparison to the other vehicles in this evaluation.

Loading force on the far side roof structure is proportional to MRE. MRE's that are large in relation to small MRE vehicles produce large forces on the roof as the vehicle rolls from the near side A-Pillar to the far side A-Pillar. This is caused by the roof structure having to lift the C.G up a distance Δh over the same time interval when comparing vehicles at same tangential velocities. Δh is equal to the Major Radius Extension. See Figure 9.

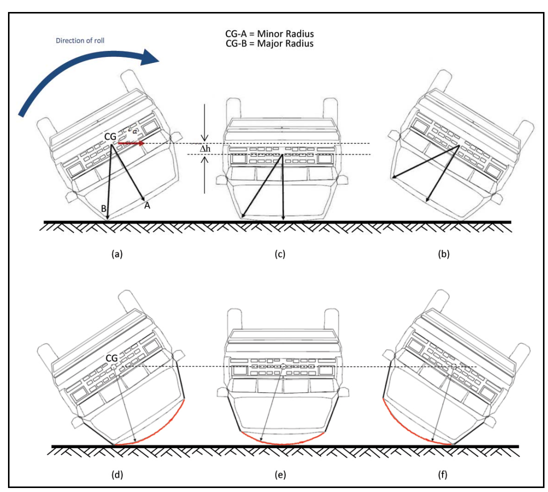

Figure 9 . Major Radius Extension relative to Minor Radius.

RESIDUAL ROOF CRUSH

This section provides a means for predicting residual roof crush in high SWR / high residual roof crush anomalous vehicles using both static test measurements and geometric considerations. The F-150 vehicle (upper right hand corner) in Figure 10 is an anomalous vehicle that has performed well in static testing, given their SWR values, but has performed poorly in a dynamic environment.

The paper that accompanies this is *Correlating Human and Flexible Dummy Head-Neck Injury Performances*. In this paper a 3 tier injury risk is developed for vehicle residual crush in bands (in inches) of 0 to 3½, 3½ to 6, and 6 and above. Correspondingly the rating in order would be good, acceptable and poor. The acceptable probability is roughly 30% greater than good and the probability of poor is 2.5 times greater than acceptable.

For vehicles that are anomalous like the 2010 Ford F150 Supercab that is shown in the upper right hand corner of Figure 10 a correlation value can be provided to account for high residual roof crush in a high SWR vehicle.

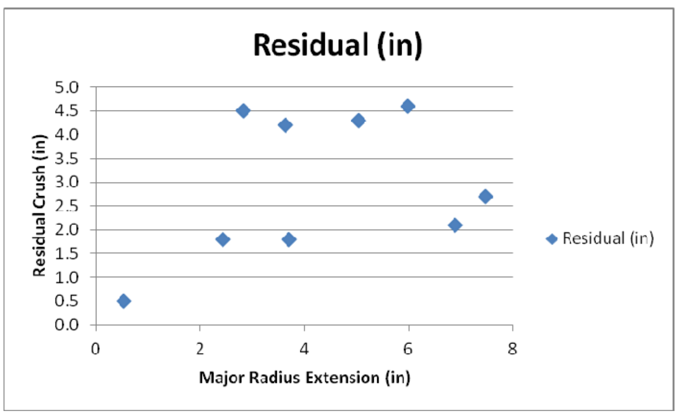

Figure 10. Residual Crush as a function of MRE.

The vehicles in Figure 10 that have a residual crush value of 4 inches or greater are either vehicles with small SWR values or vehicles with a large major radius extension.

ROLLOVER INJURY RISK

The benefit of reducing the Major Radius Extension, while maintaining the OEM Major Radius can be shown in the prototype of an alternate design as seen Figure 11.

Figure 11. Minimal Residual Crush with Zero Major Radius Extension.

The 2005 Volvo XC90, 2010 Ford F150 Supercab, and 1996 GMC Jimmy were used to develop 3 values that would correlate SWR, MRE, and Elasticity to acquire residual roof crush. The XC90 and F150 have large SWR (which corresponds to Good) values but different residual roof crush values. The 1996 GMC Jimmy has a Poor SWR value and Poor residual crush value. The equation

$$C_1 \text{x(SWR)} + C_2 \text{x(MRE)} + C_3 \text{x(Elasticity)} = \text{Residual}$$

was solved for the 3 correlation values. The value C_1 corresponds to the multiplier value of -0.65 in/lbs, C_2 equals 1.06 in, and C_3 equals 0.04 in/%.

RESULTS

Further investigation in the future could provide for an accurate correlation for all vehicles in the fleet using static testing and geometric measurements to identify vehicles with high SWR's that will perform poorly in a dynamic environment.

These values can be inserted into the equation to achieve residual crush values to within 2 decimal places for the 3 vehicles

Although the biomechanical community is fixed on its IARV criteria, our investigation indicates that the origin of those criteria was based on young military volunteers of the 1960's whose neck muscle strength in bending is 10 times that of the middle aged typical accident victim. JRS dynamic test results using IARV criteria and existing static testing injury risk criteria did not correlate very well. On the other hand there has been consensus on biomechanical head impact speed (which is independent of musculature and based on PMHS testing) that leads to neck and head injury [19-20]. Two injury measurements were derived.

The bending criteria, integrated bending moment (IBM) from lower neck My and Mx momentum exchange and the integration of the resultant head acceleration to measure head impact speed and displacement. Figure 12 illustrates the percent of criteria correlation of the injury risk parameters, IARV and head injury measurements of the 2010 Ford F-150 [21]. Clearly IARV underestimates the injury potential.

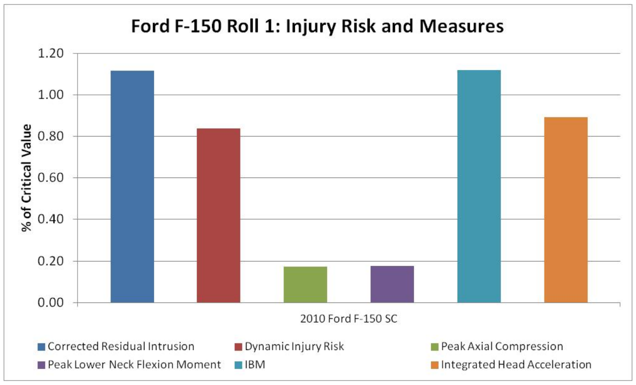

Figure 12. Injury Risk and Measures for Ford F-150.

The probability and odds ratio of a fatality, head, spinal and spinal cord injuries can be determined for each vehicle. Comparative ratings in a three tiered hierarchy provide consumers and manufacturers with quantified injury potential performance. Such predictions eliminate the unacceptable performance of many strong roof vehicles rated favorably by static SWR alone such as the F-150.

DISCUSSION AND LIMITATIONS

The original NASS / CIREN injury probability study was based on the fleet population of 1993 to 2006. The moving average vehicle model year is about 10 years older than the average study years. The correlation with residual crush was adjusted by the structural elasticity of new vehicles which has doubled in that time, and by the experimental results and criteria for injury based on dynamic roof crush and speed.

CONCLUSIONS

Accurate predictions of dynamic injury probability can be made from static test data and measurements. While large, tall, heavy vehicles are protective in frontal and side impact accidents they are very high injury risk vehicles in rollovers for the very same reasons. Manufacturers can reduce the injury risk within size class by minimizing the MR, the aspect ratio, other geometry effects and the likelihood of a high pitch rollover.

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SEAT DESIGN DIFFERENCES AS A RESULT OF THE VARIETY OF GLOBAL WHIPLASH TEST PROCEDURES

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Paper Number 13-0287

ABSTRACT

Whiplash injuries still are a major vehicle safety issue. Even though the medical community has still not agreed on the question of whether whiplash is a low severity physical injury or merely a physical complaint, the development of testing-procedures were delayed due to the high economic costs. In years past, the procedure development to test for whiplash performance was mainly driven by insurance institutes. Later it was adopted by several national and regional NCAP-Programs and other complete car evaluation programs before finally being adopted by national legislation. Meanwhile, the automotive industry developed different measures to improve seat safety. This paper summarizes the technical solutions for seats with good whiplash performance that manufacturers have in their cars today. It also describes in particular the differences that can be derived from differences in testing procedures. The market-specific differences between these solutions directly tie back to different national and regional rating procedures.

Starting with the IIWPG–initiative, a significant number of different test criteria and procedures have been developed. By now, most of these criteria and procedures have been integrated in complete car safety ratings. Additionally, the test equipment necessary to evaluate whiplash performance has been developed in parallel with the procedures.

This brings up three major influences in procedure definition. First, the definition of criteria from the correlation of robust dummy behavior in specific seats to the data accumulated about the performance of the same seats in accidents. Second, the derivation of criteria from biomechanical injury mechanism while assuming a dummy with sufficient biofidelity. Third the accumulation of measurable dummy-performances to a cumulative low-level force on the dummy's spine. As a result of these different evaluation development processes, the different testing procedures deliver extreme rating differences for the same seat. Thus, the common goal of increasing whiplash performance for human passengers lead to different evaluation schemes and even contradictory criteria being used. At present there are test criteria that have to be actively declined to achieve an increased overall rating according to a different testing procedure.

Regarding these conceptual procedure differences, the actual test proceduresfocus on different results. As a result of these different testing procedures, vehicle manufacturers optimized their seat design based on different criteria. It is important to note that local tests have the strongest effect on design details and optimization differences. Accordingly, many North American seat designs focus mainly on the reduction of head to head-restraint contact time in the test environment. In the meantime, Asian seat designs focus on neck-force minimization during the tests of head to head-restraint contact while the European manufacturers' seat designs focus on robustness with respect to differences in the test pulses.

The common agreed-upon goal has to be one single testing procedure that correlates with accident data and can be reproduced with existing test-equipment.

HISTORY

When professional whiplash performance comparison started in the mid 90ies driven by different insurance institutes , there were few vehicles on the market which showed a statistically significant positive behavior in accident data. With the assumption that the direct correlation of the seat performance in a sled-test to the road data of a vehicle is feasible, a set of fairly repeatable dummy values were derived to distinguish a good seat from a poor one. This background lead to different whiplash tests by different insurance institutes. Since then a lot of effort has been put into research and development on rear impact dummies, seats and crash procedures. These research results produced a continuing stream of updates to the insurance testing procedures of which the IIWPG procedure is the most recent insurance procedure which is still in use.

Figure 1. Optimized passive seat (Renault Scenic)

About ten years after the insurance institutes began their effort in whiplash classification, different NCAP programs started to look at the issue. In a very short period of time, EuroNCAP, K-NCAP and J-NCAP published whiplash testing procedures and rating schemes. All of these show significant differences between each other and (as might be expected) to the IIWPG procedure as well. Finally C-NCAP finalized its whiplash testing procedure in 2011. As we are struggling with a harmonized testing and rating scheme to be used in GTR 7 phase II, the pros and cons of all these existing procedures must be worked out. Since there are some seats that perform better in a first and worse in a second test procedure while other seats perform better in the second and worse in the first procedure, the question arises which of all these ratings and parameters conclusively rate a seat's capacity for whiplash protection while assuming a comparable vehicle environment.

DATA SAMPLES

Just by changing the data sets of a given test, one single set of results can lead to different ratings in whiplash tests:
Comparing the 16 km/h monowave tests, the following parameters influence some rating schemes strongly and others not at all. A contact time above 70 ms leads to a degradation in the IIWPG protocol whilst it has limited effect in other ratings. A rebound velocity above 5.2 km/h zeroes one Euro-NCAP rating and the K-NCAP test, but has no effect on other ratings. The lower forces and torque are completely evaluated in China and Japan. In addition to the ratings, the FMVSS 202a testing scheme forces an entirely different seat behavior from that of the other tests (- this is due to the other dummy).
These sample differences still neglect the main problem of testing whiplash: The variation of results due to the actual repeatability and reproducibility of tests with the BioRID Dummy.

Figure 2. Optimized passive seat (Volkswagen Touran)

SAMPLE TESTS

Tables 1and 2 list the results of several real tests performed at different sleds with the 16 km/h pulse. This shows both single tests with significantly better ratings according to the Euro-NCAP protocol and others with a significantly better rating according to the IIWPG protocol. Table 1 shows seats with a good IIWPG rating while the EuroNCAP rating is worse.

Table 1.
IIWPG-seats

#	1	2	3
NIC	20,9	24,8	18
NKM	0,33	0,24	0,41
V-Reb.	4.68	5.62	4.81
Fx	115	59	107
Fz	509	654	557
HRCT	80	69	68
IIWPG	good	good	good
NCAP	1,02 / 3	1,18 / 3	1,19 / 3
Seat	passive	passive	reactive

The tested seats are different internal prototypes and benchmark seats. Their test results prove that a well performing seat – according to one protocol – does not necessarily do well according to a different protocol. Even more, as the seats do not even reach 40% of the possible Euro-NCAP points in the medium test, a singular rating would probably not even be acceptable.

Figure 3. Active seat
(Hyundai i20)

The other way around, there are seats that perform quite well in the Euro-NCAP rating but inadequate in the IIWPG rating – based on one single test, as shown in Table 2.
Here the rating differences are not as significant as in Table 1, but the Euro-NCAP points are in a range where a seat is usually acceptable to good, whilst its IIWPG rating is merely marginal. This shows that there are no more stringent and difficult vs. less challenging rating schemes, but rather just different competing philosophies.

Similar pictures can be drawn by including other ratings in the comparison. Only the K-NCAP and the Euro-NCAP results are always very close (as the K-NCAP rating resembles the Euro-NCAP medium pulse rating).

CONTINENTAL SEAT DESIGNS

As most manufacturers focus on their home market and the local approach to whiplash testing in these regions, seat designs now begin to differ in particular between European, Japanese and North American manufacturers.

Table 2.
Euro-NCAP-seats

#	1	2	3
NIC	16,6	18,9	18,66
NKM	0,15	0,18	0,28
V-Reb.	4,58	4,2	4,35
Fx	14	1	74
Fz	769	770	10,9
HRCT	72	71	121,62
IIWPG	marginal	marginal	marginal
NCAP	1,57 / 3	1,55 / 3	1,27 / 3
Seat	Passive	passive	passive

These different performance optimizations all result in well performing seats – according to the respective different national criteria. Of course, all markets still show different approaches to good whiplash performances, but the details are different.

Figure 4. Active seat
Nissan Qashqai

In general, good whiplash performance can be achieved with (1) geometrically optimized passive seats, (2) with reactive seats where the accelerated

body initializes a geometry change in the seat or (3) with proactive seats where an external sensor triggers a geometry change of the seat.
For example, in Asia manufacturers tend to bring more and more reactive seats, while North America manufacturers focus on proactive seats and in Europe most manufacturers focus on geometrical optimizations.

Figure 5. Active seat
(Chrysler Town & Country)

SUMMARY

Today good whiplash performance is regarded differently by different testing institutions in various countries. Depending on which test results are the main focus of the local market and the manufacturer, the manufacturers deliver different technical solutions as well performing seats. Due to this focus, these seats that perform well in local test, often do not perform as well once they are tested in a different market. As a result some manufacturers even build different seats for different markets – seats that perform well in the local tests.

CONCLUSION

One solution for harmonizing the seat design for a good global whiplash performance is to create a globally accepted whiplash procedure. Therefore, the approach of the GTR 7 Phase II is one important step towards defining standardized and robust criteria. In a second step a test dummy must be created, which can measure this criteria with a high repeatability and reproducibility.

For a global robust whiplash procedure, only criteria can be used which are both robust and that correlate with to field data.

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SEAT BELT REMINDER INCENTIVES IN NCAP PROGRAMS: A SUCCESS STORY

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Paper Number 13-0306

ABSTRACT

Wearing a seatbelt is considered the most important factor in preventing serious or fatal occupant injuries in a vehicle crash. In order to remind occupants to buckle up, intelligent seat belt reminder (SBR) systems were developed in Sweden in the early 1990s. Since then, many studies have proven that SBR systems are highly effective in raising seat belt wearing rates. About 80% of unbelted drivers will buckle up when reminded to do so [1]. However, in the late 1990s, very few vehicle models offered SBRs.

In order to encourage vehicle manufacturers to install SBR systems, Euro NCAP introduced SBR bonus points into its rating scheme in 2002. In subsequent years, the number of Euro NCAP-tested vehicles that were equipped with SBR systems increased significantly. 2011 was the first year where all of the 51 cars tested were equipped with an SBR system on both front seats. In addition, 50% of the assessed vehicles also had a rear seat SBR system (buckle status monitoring only).

The Australia NCAP rating program adopted a similar approach to Euro NCAP, and implemented the same seat belt reminder protocol into its rating scheme. Other NCAP programs have also introduced their own SBR incentives: China NCAP (2006) and Japan NCAP (2011). ASEAN NCAP, Korea NCAP and Latin NCAP will follow with SBR incentives, starting with the 2013 ratings.

A historical review of the effectiveness of SBR incentives in the NCAP programs that have offered them for a couple of years (Europe, Australia, China) shows a clear trend: the number of vehicles equipped with SBR systems is increasing significantly. In the vehicles tested in 2012 by Australia NCAP, a driver SBR was installed in 98%, a front passenger SBR in 90% and a rear seat SBR in 43%. For China NCAP-assessed vehicles, the SBR installation rates until mid 2012 reached 96% for the driver and 84% for the front passenger seat. For the NCAP regions that have only recently introduced SBR incentives, or those planning on doing so in the near future, a similar trend can be expected.

Although NCAP programs do not test all new vehicle types on the market, an increasing number of SBRs in NCAP-tested vehicles also has an impact on the SBR equipment of all vehicles sold in a specific region. When looking at all new vehicles sold in Europe (EU25) in 2009, only about 15% of the cars did not have any SBR equipment at all. 21.5% only had a driver SBR, 46.5% had an SBR on both front seats and 17% had a rear seat SBR system, in addition to the front seats. The continuously high SBR equipment rates in Euro NCAP-tested vehicle types will obviously have a positive impact on the market penetration of SBR, contributing to the reduction in road traffic fatalities by increasing seat belt wearing rates.

INTRODUCTION

Nils Bohlin is considered the father of the modern three-point seat belt, which was first introduced by Volvo in 1959 as standard equipment. In subsequent years, other vehicle manufacturers also introduced three-point seat belts, either as optional or standard equipment. Bohlin could soon demonstrate the safety benefit of the seat belt in a study based on 28,000 accidents in Sweden [2]. Additional developments such as belt pre-tensioners and belt load limiters have since helped to further improve the safety potential of the seat belt.

Figure 1. Nils Bohlin, father of the modern three-point seat belt (source: Volvo Car Corporation).

The first country to require mandatory fitment of three-point seat belts on the front seats was the

United Kingdom in 1967, followed by Australia and Sweden in 1969, and many other countries in the 1970s. The 1970s also saw the start of mandatory three-point belt fitment on the rear seats.

Mandatory seat belt usage on the front seats was led by Australia (1970, also rear seats), New Zealand (1972) and Sweden (1975). Some countries followed surprisingly late, like the UK in 1983, and also the first US state (NY) only made seat belt wearing mandatory in 1984. Seat belt usage legislation for the rear seat followed for a majority of countries in the 1990s.

Although seat belt wearing is by now mandatory in most countries, many drivers and passengers still do not buckle up. The reasons, motivations or excuses for not using the seat belt are manifold:

- forgetting about it
- only driving a short distance
- am a safe driver
- only drive at low speeds
- uncomfortable
- dangerous
- freedom of choice
- never wear a seatbelt

Road safety statistics, however, show that not wearing the seat belt significantly increases the risk of being killed in an accident, even at impact speeds as low as 30 km/h.

SEAT BELT EFFECTIVENESS

In a crash, the seat belt allows for a controlled deceleration of the occupant and prevents the occupant colliding with rigid vehicle parts or being projected out of the vehicle.

A National Highway Traffic Safety Administration (NHTSA) study [3] has shown that for front seat occupants of passenger cars the three-point seat belt reduces the risk of being fatally injured by 45% and being moderately to critically injured by 50%. For front seat occupants of SUVs, vans and pick-ups the benefit of the three-point belt is even higher, reducing the risk of fatal injuries by 60% and of moderate to critical injuries by 65%.

This safety benefit results in impressive numbers of "lives saved". NHTSA estimates that in the United States, seat belts saved the lives of 12,546 vehicle occupants in 2010. The average seat belt wearing rate was 85%. If the seat belt wearing rate had been at 100%, an additional 3,341 fatally injured occupants would still be alive. [4]

Seat belt wearing also improves the effectiveness of airbags, as the belt controlled upper body forward displacement leads to an ideal interaction with the airbag. The combination of both safety systems offers optimised occupant protection.

SEAT BELT REMINDER SYSTEM

While the level of fines for not wearing the seat belt can have an impact on the belt usage rate, a technical alternative has proven to be highly effective in increasing seat belt wearing rates: the Seat Belt Reminder also called SBR.

Figure 2. Seat belt reminder telltales.

An SBR system monitors the seat belt buckle status and reminds the unbelted occupant via at least a visual, and preferably also an acoustic, warning to buckle up. While driver presence can be assumed, an occupant detection sensor is used on the front passenger seat to confirm the presence of an occupant.

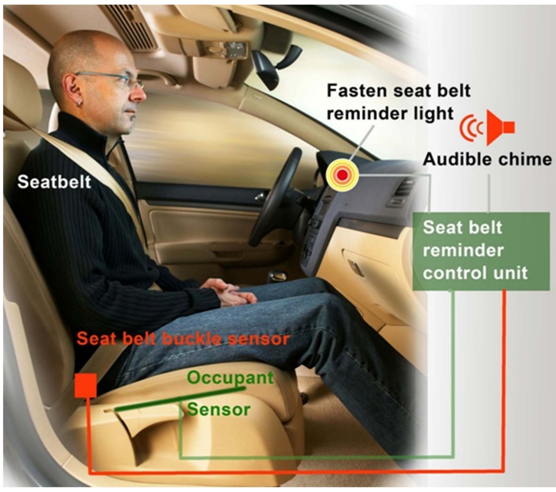

Figure 3. Seat Belt Reminder system for the front passenger seat.

Various occupant detection sensor variants are available. The seat integration can be carried out either on top of the seat foam (A-surface) or at the bottom of it (B-surface), depending on the sensor technology. Sensor design plays a considerable role in avoiding unnecessary sensor activation by objects like handbags or laptops.

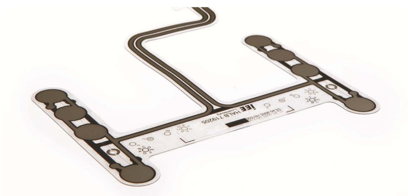

Figure 4. IEE Occupant Detection Sensor

An electronics unit checks the seat belt buckle status of each individual seating position and decides whether a signal needs to be triggered to remind the occupant to buckle up.

As only a minority of people not wearing a seat belt are reluctant non-users (1 - 2%), the potential for increasing the belt usage rates by "reminding" the occupant to buckle-up is very high.

From "mild" to "intelligent" seat belt reminders

In an attempt to increase seat belt wearing rates, the US mandated "seat belt interlocks" in 1973. Such systems prevented the vehicle engine being started when the driver and the front passenger were unbelted. Besides technical problems, the public reaction was extremely negative, so this approach was very short-lived. The interlocks were then replaced by "mild" SBR systems, triggering only a short, four to eight second long, audiovisual alert.

In the early 1990s Swedish research lead to the development of more "intelligent" seat belt reminder systems, which were more effective at reminding vehicle occupants to buckle up.

Intelligent SBR systems, such as defined by Euro NCAP [5], have the following features:

- synchronised audiovisual warning
- warning triggered if the:
    - vehicle is in forward motion exceeding a 25 km/h, or
    - vehicle is in forward motion for more than 60 seconds, or
    - vehicle has driven a distance of more than 500 meters, or
    - engine runs for more than 60 seconds
- warning duration of at least 90 seconds
- warning sound volume increases over time

The warning is not triggered when the vehicle is reversing, e.g. for parking manoeuvres. As seat belt wearing is less important, or can even hinder, during such situations, SBR warnings are dispensable.

Raising seat belt wearing rates

A Swedish study [1] evaluated the effectiveness of "mild" and "intelligent" SBR systems by monitoring driver seat belt usage in the cities of seven European countries. On average, drivers wore the belt in 85.8% of cars without an SBR system, in cars with a "mild" SBR the belted rate increased to 93.2% and in cars with an "intelligent" Euro NCAP type SBR system, 97.5% of the drivers had buckled up. Although the belt wearing levels varied between the different countries, it was observed that everywhere the intelligent SBR systems could reduce the number of unbelted drivers by an impressive 80%!

NCAPS AND SBR

SBR systems have become a rating element in many NCAP programs. This is motivated by the fact that the NCAP ratings are based on belted dummies. As a consequence, a 5-star car can only provide a "5-star protection" if the occupants are belted. Hence the relevance from NCAP's point of view to ensure that occupants are belted when involved in a crash.

The kind of incentives varies between the various NCAP programs. While some award additional bonus points to vehicles equipped with SBR systems, there are others which require SBR equipment as a pre-condition for a top rating. There are also differences in the technical requirements relating to SBR systems.

Euro NCAP

In 2002, Euro NCAP created incentives for seat belt reminder systems, by adding bonus points to the adult occupant protection protocol. One bonus point each was awarded for an SBR functionality for the driver and front passenger seat. Euro NCAP defined requirements regarding the warning signal and its duration, the triggering of the warning and the telltales, leading to the implementation of "intelligent" seat belt reminder systems. Front passenger presence must be confirmed by an occupant detection sensor. For the rear seats, Euro NCAP awarded up to one bonus point for monitoring the status of the rear seat buckles (n/m-point; m: number of rear seats; n: number of monitored buckles) and providing an information to the driver via a display or a text message.

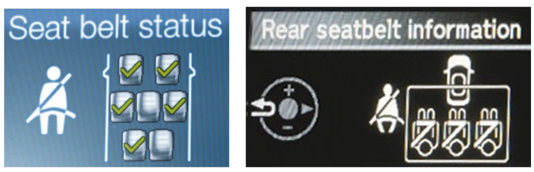

Figure 5. Examples of rear seat belt status information (Ford, Honda).

In the first year, 2002, driver SBRs were fitted to 33% and front passenger SBRs to 21% of the vehicle models tested by Euro NCAP. As shown in Figure 6, the incentives quickly led to an increasing number of vehicle models equipped with SBR systems.

The first cars with rear seat SBR were assessed in 2004, three out of 26 cars (12%) were equipped. Particularly in the early years of the SBR incentives, these bonus points were very helpful in improving the star rating of many cars. Almost all of the first 5-star cars achieved this safety rating level thanks only to the SBR points.

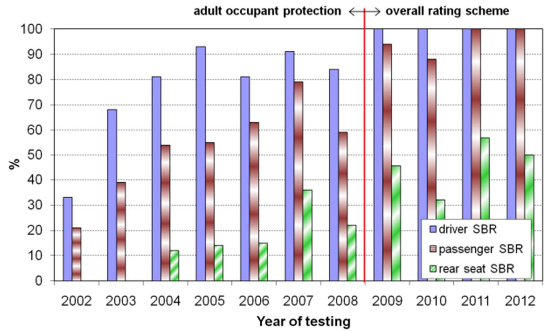

Figure 6. SBR installation rates of Euro NCAP tested vehicle models 2002 - 2012.

With the improving crashworthiness of tested cars, the SBR bonus points became less important and 2008 saw a decrease in the SBR fitment rates for all seating positions.

With the introduction of the overall rating scheme in 2009, Euro NCAP shifted the SBR points to the newly created category of "safety assist" systems (SBR, Electronic Stability Control and Speed Limitation Device).

Figure 7. Euro NCAP overall rating categories.

This reorganisation of the rating increased the relevance of SBR points, and the share of vehicles equipped with SBR increased again. In particular, the front passenger seat and the rear seat equipment with SBRs grew strongly from 2008 to 2009. This rating scheme transition phase is highlighted in Figure 8.

2009 was the first year where all Euro NCAP tested vehicle models were fitted with a driver SBR and another milestone was achieved in 2011 when all tested models were also equipped with a front passenger seat SBR system. And since 2012, Euro NCAP requires SBRs to be installed in 100% of the produced cars of the tested model in order to be eligible for the SBR points.

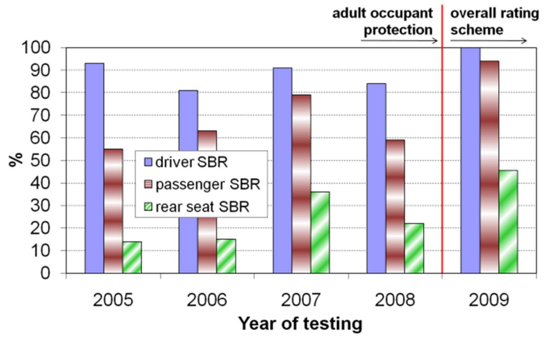

Figure 8. Overall rating scheme impact on SBR fitment.

Further strengthening the importance of SBR, the 2013 protocol only awards two SBR points if both front seats have an SBR system. Single front seat SBR points are no longer available. And, in order to get an SBR point for the rear seat, the buckle status of all rear seating positions must be monitored.

Euro NCAP does not require but recommends the use of occupant detection for the rear seats. However, so far no vehicle has been equipped with such an enhanced rear seat SBR system.

A larger number of Euro NCAP tested cars with SBR systems obviously also has the effect that more and more vehicles on the road are equipped with SBRs. Figure 9 shows the SBR equipment of new vehicles sold in Europe in 2009.

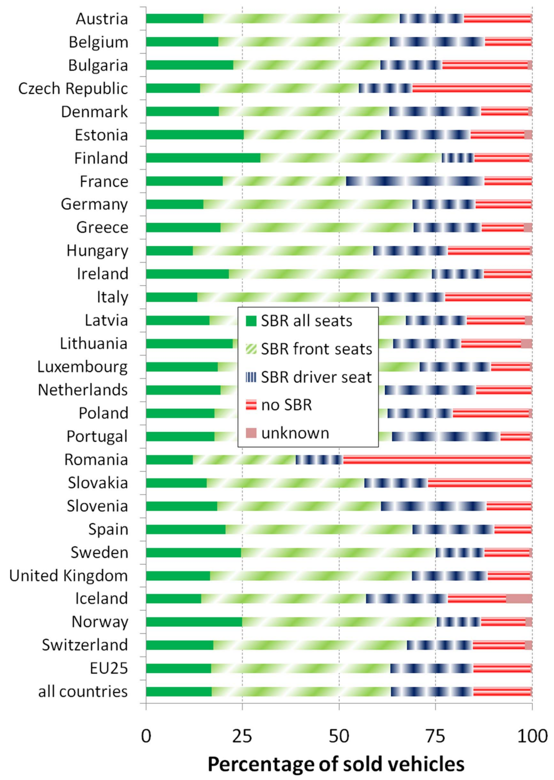

Figure 9. SBR equipment in new vehicles (2009).

There are considerable variations in the market penetration of SBR systems, as well as in the number of seats that are equipped with an SBR in the various countries. This reflects the SBR fitment strategies of the vehicle brands that are the most popular in the corresponding countries. The market obviously lags behind with regards to fitment rates, as Euro NCAP focuses on new vehicle types, while new sales also include many older models. The SBR equipment rate of the new vehicles sold in the EU25 in 2009 corresponds approximately to that of the vehicles tested by Euro NCAP in 2006. So the overall market lags behind Euro NCAP by about three years. Considering the very high SBR fitment on the front seats since the introduction of the overall rating, the fraction of newly sold vehicles in Europe without driver or front passenger SBR should be very small nowadays.

Australasia NCAP (ANCAP)

ANCAP quickly followed Euro NCAP and awarded the first SBR points in 2003, applying the same SBR protocol as Euro NCAP. The incentives started to have a significant effect from 2007 onwards, and the SBR fitment rates are still increasing year to year (Figure 10).

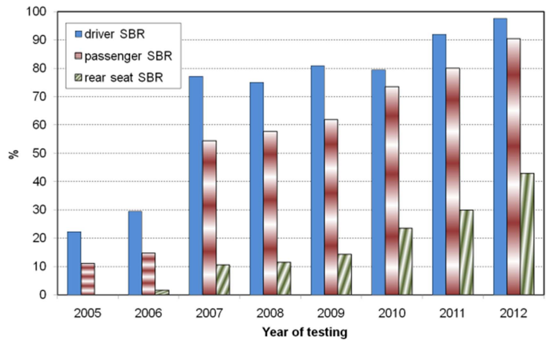

Figure 10. SBR installation rates of ANCAP tested vehicle models 2005 – 2012.

ANCAP is now further promoting the installation of SBR by not only awarding bonus points to the crash test safety rating, but also making SBR equipment a precondition for a certain star rating

- From 2013 on, a car must have an SBR on both front seats in order to qualify for a 5-star rating

- From 2015 on, a car must have an SBR on both front seats in order to qualify for a 4-star rating and a rear seat SBR to qualify for a 5-star rating

- From 2017 on, an SBR system for the driver and the front seat passenger is a pre-condition also for a 1, 2 or 3-star rating, and rear seat SBR becomes a must for a 4-star rating

So the ANCAP message for 2017 is: No SBR, no stars!

China NCAP (C-NCAP)

China NCAP was next, introducing SBR bonus points for the front seats in 2006. Figure 11 shows how the SBR installation rates have evolved since. The SBR protocol recently underwent some changes. While the driver SBR was initially worth a full point, this incentive was reduced to 0.5 points in 2010. A front passenger SBR with occupant detection is worth one point.

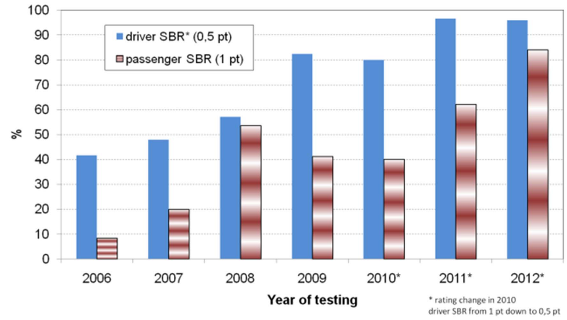

Figure 11. SBR installation rates of C-NCAP tested vehicle models 2006 - 2012.

So, China NCAP was also successful in promoting the installation of SBR systems in vehicles sold in China. The C-NCAP SBR protocol, however, is less stringent than that of Euro NCAP. China NCAP only requires an audible signal for the driver but does not define a minimum warning duration. The type of warning signal for the front passenger is not specified, so a simple telltale is sufficient. Therefore the effectiveness of such an SBR system in raising the seat belt wearing rates is likely to be limited, as a telltale can easily be ignored.

The protocol also allows for the installation of a front passenger SBR system without an occupant detection sensor. However, the incentive for such a system is halved to 0.5 points. This option without occupant detection is not compatible with an audible warning, as it would trigger the acoustic alert for an empty seat. As SBR systems are most effective when combining a visual and an audible warning, it might be worth taking into consideration deleting this option without occupant detection in the future. This would then allow the protocol to define more effective warning signals.

Japan NCAP (J-NCAP)

In 2009, Japan NCAP started to monitor whether vehicles are equipped with seat belt reminder systems or not. As driver SBRs have been mandatory in Japan since 2005, J-NCAP focused its evaluation on the front passenger seat and on the rear seats. However, at that point in time, no SBR points were allocated. SBR fitment and functionality were only listed as information on the vehicle test datasheet and did not have an impact on the vehicle rating.

Upon introducing an overall rating scheme in 2011, SBR points became part of the evaluation. The overall rating score is based on the sum of three elements: occupant protection (up to 100 points), pedestrian protection (up to 100 points) and seat belt reminder (up to four points for the front passenger seat and up to four points for the rear seats).

The new incentives had a significant impact and in 2012 already 80% of the tested vehicles were equipped with a front passenger SBR system.

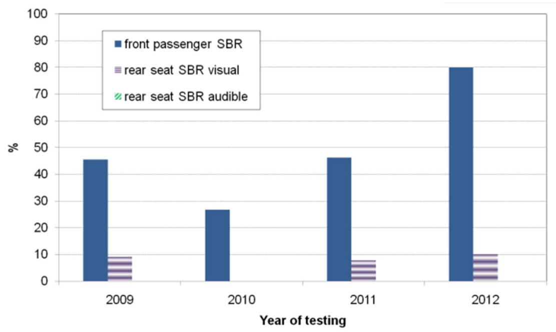

Figure 12. SBR installation rates of J-NCAP tested vehicle models 2009 – 2012.

J-NCAP is the first NCAP program to have created an incentive for occupant detection on the rear seats. Two of the four rear SBR points are only awarded if the rear SBR warning signal includes an audible warning of at least 30 seconds. Such a warning, however, can only be triggered if passenger presence information is available. So far, as no such advanced system has been evaluated, rear SBR functionality is limited to telltale/display-type information.

Latin NCAP

Latin NCAP, launched in 2010, will upgrade its rating with SBR incentives for the front seats in 2013. Latin NCAP has decided to apply the Euro NCAP SBR protocol. The SBR points are allocated in the adult occupant protection category. The incentives are very strong:

- The front passenger and driver SBR function are coupled, so both front seats must be equipped with an SBR system in order to score bonus points

- The weight of the SBR points is very high in the adult occupant protection rating – two out of 18 points (16 points frontal crash test, two points SBR)

- SBR function for the driver and front passenger is a precondition for a 5-star rating

Korea NCAP

Korea NCAP will start to introduce SBR incentives in 2013, together with an overall rating scheme. Upon calculation of the overall score, active safety systems can help to add one bonus point, with SBR contributing here with 0.3 points. Other active safety candidates are Forward Collision Warning (0.4 pts) and Lane Departure Warning (0.3 pts).

ASEAN NCAP

ASEAN NCAP published a first safety rating for cars available in the ASEAN region in early 2013. When setting up the rating protocol, ASEAN NCAP decided to implement SBR incentives from the beginning. An SBR on both front seats is a precondition for a 5-star rating. To assess the SBR functionality, ASEAN NCAP applies the Euro NCAP SBR protocol. In the first rating launch, two of the assessed vehicle models got a 5-star rating for their variants available with seat belt reminders and other safety equipment like frontal airbags and ESC.

IIHS

The Insurance Institute for Highway Safety (IIHS), is a strong supporter of seat belt reminder systems even though they do not include SBR incentives in their "Top Safety Pick" rating. The importance and effectiveness of SBR systems is frequently highlighted in the institute's "Status Report". The January 2013 edition [6] includes a study that surveyed drivers regularly transporting children aged 8 - 15 on the rear seats. A large majority of these drivers (82%) want their vehicle to alert them when the child is not buckled, and more than three quarters want this warning signal to be audible (chime or buzzer). Notifying the driver about children removing their safety belt during the trip is also considered an important feature, as this might otherwise easily remain unnoticed.

CONCLUSIONS

Wherever NCAP programs have implemented incentives for seat belt reminder systems, they had a positive effect on the number of new vehicle models being equipped with SBRs. The same is expected in the regions of the world where NCAP programs have recently started, or are about to start, awarding SBR points.

So NCAP programs can not only have a positive effect on the crashworthiness of cars, they can also help to influence user behaviour by awarding incentives to safety technologies that are able to do so.

The NCAP SBR incentives have an important impact on road safety statistics, as the positive effect of SBR systems on the belt wearing rate has been proven, and as wearing a belt significantly reduces the risk of being fatally or severely injured in a crash. In other words, NCAP incentives can effectively save lives.

However, it is important that the incentives are "rating-relevant" in order to be successful in promoting a technology. As seen in the past, SBR equipment in Euro NCAP tested vehicle models temporarily dropped when SBR points became less important to achieve a 5-star rating.

While current front seat SBR systems have proven to be highly effective, this is not the case for the relatively simple rear seat SBR systems. The time may have come to extend the concept of intelligent SBR to the rear seats and to address the issue of occupant detection in an environment with a higher variability than on the front seats. Incentives like the one from J-NCAP could help to promote such enhanced rear seat SBR systems.

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Back seats also should have belt reminders, parents say

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IIHS: www.iihs.org

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Korea NCAP: www.car.go.kr/jsp/kncap/result.jsp

Latin NCAP: http://latinncap.com/en/

TAC SAFECAR PROJECT – DEMONSTRATION OF NEW AND EMERGING VEHICLE SAFETY TECHNOLOGIES

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Paper Number 13-0413

ABSTRACT

The vital role of vehicle safety, one of the main pillars of the Safe System approach, in combating road trauma is well recognised. The Transport Accident Commission (TAC) has undertaken a number of campaigns and projects to increase public awareness and demand for safer vehicles and vehicle safety technologies. One project that the TAC is involved in, is the research, development and demonstration of new vehicle technologies via the SafeCar Project. This project is a demonstration of new and emerging technologies that have promising road safety potential. The technologies selected for demonstration target some of the key issues associated with road trauma such as speed and fatigue. The technologies currently installed include Driver Drowsiness Detection, Lane Departure Warning, Intelligent Speed Assist, Seatbelt Interlock, Top Speed Limiter and Daytime Running Lights. The aim of the project is to further develop, demonstrate and promote these technologies to the community and key decision makers. This paper will discuss the rationale in selecting these technologies for demonstration and the communication strategy for the project.

INTRODUCTION

The Transport Accident Commission (TAC) in Victoria, Australia is a government owned compulsory third party injury insurer. Its role is to pay for treatment and benefits of people injured in transport crashes and to promote road safety in Victoria. In order to meet its legislative responsibility to reduce the incidence and severity of transport injury on Victorian roads, the TAC invests heavily in road safety initiatives, including vehicle safety.

The TAC recognised the potential that improving the crashworthiness and preventative capacity of vehicles could have in reducing road trauma. This is supported by research which indicates that if every vehicle could be upgraded to the safest in its class, serious trauma can be reduced by a third [1]. The TAC has undertaken a number of campaigns and projects to increase public awareness and demand for safer cars [2] and certain safety technologies such as ESC and curtain airbags [3]. In addition, the TAC also invest in the research, development and demonstration of vehicles safety technologies via its SafeCar project.

SAFECAR I

The TAC SafeCar project was a world first partnership between Ford Australia, Monash Univeristy Accident Research Centre (MUARC) and the TAC. The aims of the project were to evaluate the safety benefits, technical operation and driver acceptability of a number of Intelligent Transport Systems (ITS). The technologies investigated included:

- Intelligent Speed Assist (ISA)
- Following Distance Warning
- Seatbelt Reminder
- Reverse Collision Warning

In addition, each of the project cars were equipped with daytime running lights (DRLs).

The results of the project were positive and some of the main findings were:

- Mean speed of drivers was reduced
- Mean time headway (following distance) increased in most speed zones
- Reduction in the time vehicle occupants spent unbuckled

- Drivers liked the systems and found them useful [4].

The project was succesful in promoting seatbelt reminders, with Ford placing the system in the new BA Falcon [4], and in creating interest in ISA across Australia.

SAFECAR II

Since the conclusion of the initial SafeCar project, the TAC has embarked on a second generation, SafeCar II, project. While the aim of SafeCar I was to evaluate ITS technologies in terms of safety, useability and acceptability, the main objective of SafeCar II is to demonstrate and promote new and emerging technologies that have promising road safety potential.

The technologies selected for demonstration in SafeCar II target some of the key issues associated with road trauma such as speed and fatigue. The aim of the project is to further develop, demonstrate and promote these technologies to the community and key decision makers. In 2008, the TAC commissioned a study to assess a range of vehicle safety technologies in terms of road safety benefits, readiness of the technology, regulatory and infrastructure requirements, costs, user acceptance and the potential influence of government initiatives on the uptake rate [5]. From this study, a list of technologies that would deliver the best returns for government promotional effort was developed [5]. In deciding which technologies to install in SafeCar II, the TAC took into consideration the findings of this study.

The technologies installed in SafeCar II are ISA, Seatbelt Interlock, Lane Departure Warning, Driver Drowsiness Detection, Top Speed Limiter and DRLs.

Figure 1. SafeCar II

Intelligent Speed Assist (ISA) – ISA is a safety technology that alerts drivers when they exceed the speed limit. ISA activates when a driver exceeds the posted speed limit for a section of road by a predetermined limit (eg. 2km/hr or more). There are three categories of ISA systems: advisory, supportive and limiting. With advisory ISA systems, audio and visual warnings sound to remind the driver that they are going too fast. Supportive ISA systems prevents the vehicle from travelling above the speed limit but will allow for the function to be overriden, and in the limiting system, the override function is not an option. The ISA in SafeCar II incorporates the advisory and supportive functions of the technology, however, at this stage, the TAC is only promoting advisory ISA.

Speed continues to be a major cause of trauma on Victorian roads and a technology such as ISA can assist in reducing the mean travel speed. The road safety benefits of ISA has been demonstrated in a number of studies in Australia [4][6] and internationally [7]. Both advisory and active (supportive and limiting) versions of ISA feature highly on the list of technologies that would deliver good returns for government efforts [5]. However, despite the great potential of ISA in reducing trauma, penetration of the technology in the market has been limited. Further development and promotion of the technology is required

Seatbelt Interlock – The seatbelt interlock is a technology that takes the existing seatbelt reminder systems one step further and prevents the driver from starting the ignition of a vehicle unless seatbelts are engaged. The technology in SafeCar II is active for the driver and front passenger seats.

The safety benefits of seatbelts is well recognised and is one of the top performing safety features in the list of technologies that provide good return for government efforts [5]. Victoria was the first jurisdiction in the world to legislate the wearing of seatbelts in 1970 and boasts a high compliance rate with drivers and passengers (approximately 95%) [8]. However, approximately 15% of vehicle occupants killed are still unbelted, with many also intoxicated [9]. Seatbelts interlocks may have an important role to play in this regard, where intoxicated drivers who forget to put on their seatbelts are unable to start the vehicle. Anecdotal information received from manufacturers indicate that a seatbelt interlock is a simple and cheap technology to implement where there is already an existing seatbelt reminder system.

Lane Departure Warning (LDW) – The LDW uses a camera mounted inside the vehicle windscreen to scan the road for lane markings and give the system an indication of where the vehicle is positioned on the road. Visual, audible and haptic warnings (eg. vibration of steering wheel) are given to the driver when they begin to move outside of the lane if the indicator is not used.

In Victoria, run off road crashes account for approximately 40% of fatal crashes [10]. Some of the common causes of run off road crashes include driver fatigue, speed and inattention/distraction. LDW has the potential to reduce run off road crashes by providing drivers with a warning to correct any unintended lane movements before a crash occurs.

Driver Drowsiness Detection (DDD) – DDD utilises a driver's steering input to calculate their level of drowsiness. An alert driver in general will have more frequent movements, whereas a driver experiencing drowsiness will have less frequent inputs. When drowsiness is detected, a visual and/or audible alert is delivered to the driver to warn them of fatigue

In Victoria, approximately 20% of fatal crashes involve driver fatigue [11]. In the absence of an effective fatigue enforcement tool, vehicle safety technologies such as DDD will have a significant role to play in helping reduce fatigue related crashes.

Top Speed Limiter – In Victoria, the top legal speed limit is 110km/h, yet vehicles have the ability to travel up to more than double the limit. Recognising the discrepancy between what is legally permited and what vehicles are able to do, the TAC implemented a top speed limiter to SafeCar II. The top speed limiter allows for SafeCar II to travel up to 120km/h. The extra 10km/h was included as a 'comfort' to drivers who believe they might need to use the extra speed in certain situations. Top speed limiting has the potential to limit the number of crashes involving excessive speeds and is a technology that can be implemented at point of manufacture.

Figure 2. Reconfigured speedometer showing top speed of 120km/h

Daytime Running Lights (DRLs) – DRLs are headlights that are illuminated during the day in order to make vehicles more visible and thus reduce their involvement in crashes. DRLs have the potential to reduce multiple vehicle daytime fatalities in Victoria by approximately 16% [12]. It is possible to fit vehicles with a device that will automatically activate DRLS when the ignition is switched on but is overridden by full strength headlights. DRLS can increase driver's peripheral perception of vehicles. It is also easier for drivers and pedestrians to see and estimate the distance to vehicles with DRLs. DRLs was the top performing technology on the list of technologies which would provide the best return for government efforts [5]. As DRLs are considered relatively cheap, simple and maintenance free [5], the technology warrants further promotions.

ANCAP Road Map

The ANCAP Road Map sets out the details of what is required year by year between 2011-2017 in order for a passenger vehicle to achieve a 1-5 star safety rating [13]. The requirements become more stringent year on year and vehicles will need to have a certain number of Safety Assist Technologies (SAT) in order to meet the requirements. The Road Map lists out the technologies that are considered SAT. All the technologies installed in SafeCar II are included in the list of technologies that manufacturers can incoporate in order to achieve a 5 star rating.

COMMUNICATION STRATEGY

The aim of the SafeCar II project is to further develop, demonstrate and promote new and emerging technologies with road safety potential. The TAC, along with its road safety partners, have been successful in creating awareness and consumer demand for Electronic Stability Control (ESC) and Curtain Airbags (CA) via a range of public education and partnership approaches [3]. In the first stage of the promotion of the new technologies available in SafeCarII, the partnership model utilised for the promotion of ESC and CA will be adopted. At this point in time, a mass media public education campaign is not warranted.

Promotion to Fleet Managers

Every new vehicle purchased without the best safety rating and features is an opportunity lost, as that vehicle will be operating at an increased risk to its occupants for its life on the road, which can be up to 20 years. With vehicles for commercial purposes accounting for over 50% of new vehicles sold, cited in [14], fleet managers can play a vital role in increasing the safety of the Victorian fleet by purchasing the safest cars possible and with the best safety features. This will also ensure cars that flow on to the second hand market are of a high safety standard, where some of the most high risk road users such as young drivers, are likely to purchase their car from. In addition, the mass buying power of fleet managers can influence the types of technologies manufacturers include as standard on their vehicle range.

Based on the above considerations, the TAC has been involved in a number of events to promote the SafeCarII project to fleet managers, educating them about the importance of vehicle safety and also technologies that they should be considering when making their fleet purchasing decisions. The TAC has also hosted a vehicle safety day to allow fleet managers to experience first hand on track, how some of the new technologies work. Opportunities to further promote new technologies to fleet managers will be investigated, with the aim of encouraging them to consider and request for some of these new technologies in future fleet purchases.

Promotion to Consumers

One of the first steps in creating consumer demand for a new vehicle safety technology is education. For consumers to start purchasing the technologies, they need to know the technology exists, its availability, how it works and the safety benefits. The TAC, VicRoads and RACV were able to effectively educate consumers and raise awareness of the safety benefits and availability of ESC through the use of the Bosch ESC simulator. With ESC now legislated to be in all new cars sold in Australia, the simulator will be reconfigured to allow demonstration of some of the new technologies available in SafeCar II. The simulator will be invovled in public demonstrations at events such as the Melbourne International Motoshow, with the aim of educating the public about the availability and safety benefits of the new technologies. The long term objective is to create enough consumer demand for manufacturers to start incorporating the technologies as standard at the point of manufacture.

Demonstration to Manufacturers and Key Decision Makers

The quickest way for new technologies to penetrate the vehicle fleet is for manufacturers to include them as standard features in their vehicle range. In Australia, road safety agencies have a history of working closely with vehicle manufacturers to improve the safety of their cars, such as through ANCAP. In developing SafeCar II, the TAC also consulted with manufacturers regarding the development and installation of some of the technologies. The TAC regularly makes SafeCar II available to its partners and providers to allow for demonstration of the technologies to manufacturers and key decision makers, with the aim of influencing the uptake of the technologies in as broad a range of vehicles as possible.

CONCLUSION

The aim of the TAC SafeCar II project is to further develop, demonstrate and promote new and emerging technologies with road safety potential. To date, SafeCarII has been fitted out with ISA, Seatbelt Interlock, Lane Departure Warning, Driver Drowsiness Detection, Top Speed Limiter and DRLs. The TAC will work closely with its road safety partners to further develop and actively promote the technologies to the identified audiences. Further work will also be undertaken to identify additional technologies with good road safety potential (eg. autonomous emergency braking) to be included as a part of the SafeCar II project.

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An Overview on Establishing Safety Assessment Standard of Longitudinal Active Safety System in Korea

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ABSTRACT

Recently, each country's political efforts and nongovernmental researchs have been continued world widely to induce development and propagation of driver assist active safety system. In case of Korea's domestic situation, so far as technical development of the related systems is concerned, although it sounds like it's too late compared to other countries(European, Japan and US), Korea is now concentrating energies to enlarge market penetration and correspond to international trend through a assessment standard establishment.
As part of an this endeavor, a research was organized what is called 'Development of Safety Assessment Technology of Advanced Safety Vehicle' that is being carried out with 3-step approach(1st step : 2009~2012, 2nd step : 2012~2015, 3rd step : 2015~2018), and as the 1st step being closed, safety assessment requirement of a Commercial vehicle AEBS & LDWS including passenger vehicle ACC system was drawn, and the 2nd step is now being in progress.
Presently, in its 2nd step, a study to establish safety standard for passenger vehicle AEBS & LKAS is being carried out and, after 2015, assessment standard for the related items will be drawn with keeping pace with international test standard and guideline e.g. NCAP
This study considered, in addition to the technical development and standardization procedure of advanced active safety system, how it will be reflected to Korea's system, and such a political approach will lead domestic industries including customer to be interested with the active safety system and help the result to be utilized as an internal standard

INTRODUCTION

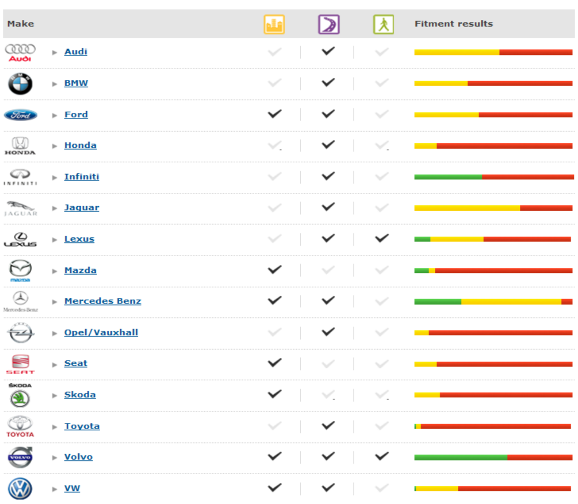
In the past, chassis stiffness and reliability of components were given priority in the development of cars and safety and convenience were main considerations as well. However, in recent years, accident prevention and casualties minimization efforts call for a more active and comprehensive concept of safety devices. In order to reduce fatigue due to long duration driving, advanced driver assist system(ADAS) was developed. Starting out as a mere convenience device, it is gradually being developed into an active safety system, targeted at accident prevention and mitigation. Representative examples of longitudinal control system such as ACC, AEBS and FCWS, with their excellent effectiveness in accident prevention and casualty reduction, are being developed under government sponsorship in countries like Japan, US and Europe. For example, e-Safety and PReVENT in Europe; Mobile 2000, PATH, IVI and VSCC in the US; and AHS and ASV in Japan. In particular, under the umbrella of the United Nations Economic Commission for Europe (UN/ECE), at the World Forum for Harmonization of Vehicle Regulations (WP29), the 2002 ITS Informal Group was created to review standards associated with the safety of vehicles, passengers and related active safety system[1]. Created in 2009, the AEBS (LDWS) informal group, submitted in Feb 2011 the AEBS Regulation draft for commercial vehicle which was approved and adopted in Nov 2012. In the case of Korea, apart from technology development in the industry, the government is making parallel efforts at institutionalizing early adoption of related technology and keeping pace with international standards and regulations.
This paper reviews the status of national and international regulation and standards, and researches

performed to produce domestic safety standards and evaluation requirements. In addition, the author wishes to release a government policy guideline on active safety system for vehicle manufacturers and consumers, to encourage the production of safer vehicles.

Overseas Markets and Policy Trends

Active safety systems for preventing frontal and rear collisions, along with development of sensor technology, are spreading rapidly. According to the AEB fitment survey[2] conducted in 2012 at Euro NCAP, vehicle manufacturers in the Europen region are currently mounting AEB as a standard or optional feature.

Figure. 1
Euro NCAP AEB firment survey in 2012



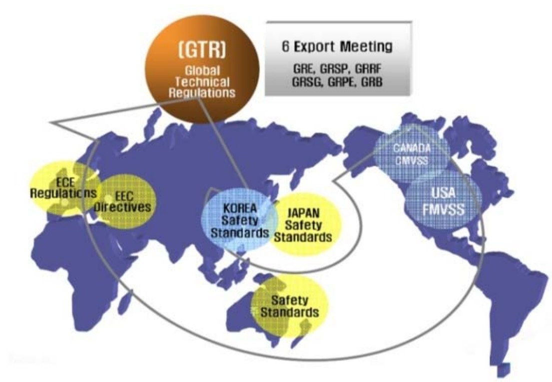
Separately, GM is scheduled to release in 2013 three Cadillac models that come standard with Front and Rear Automatic Brake, ACC, LDWS and BSD. At Toyota, the PCS system, which has been improved to operate up to a relative vehicle speed of 60km/h, will now come standard with the Crown luxury sedan. Crash avoidance system that can automatically stop at 60km/h is scheduled to be fitted in Honda models this year. In addition, Continental Teves, a representative system manufacturer, forecasted that within the next 5 years, the proportion of state-of-the-art components in vehicles less than $35,000 will increase to 10-50% of production cost, and by 2015, car manufacturers in countries such as US, Japan and Korea will collaborate in more than 50 projects to develop advanced auto technology.
As the market for longitudinal active safety system expands and the resulting effect of actual reduction in forward collision gradually emerges, the associated institutional policy approach has also strengthened. The Decade of Action for Road Safety[3] 2011-2020 was officially proclaimed by the United Nations General Assembly in March 2010. Accordingly, research and development for collision avoidance and safety enhancement are being actively pursued, through the expansion of UN Regulation's International harmonization, the NCAP institution and active safety technology application.
Aside from this UN-wide effort, each member country is separately drawing up and implementing their own separate policies for the introduction of active safety system. In Germany, for example, the number of city and suburban rear collision accidents is approximately 20 million each year, with about 25% of drivers reporting it happening in totally unexpected condition. Subsequently, emergency brake assist(EBA) is scheduled to be installed in compact-sized vehicles as a standard feature. According to the German Road Safety Committee, EBA that automatically monitors its surroundings and brakes when necessary can prevent or mitigate the impact of rear collision accidents by up to 28%.
On the other hand, due to AEBS market expansion, testing requirement for assessing the safety of AEBS is becoming a necessity. At the end of a 2-year long study at UN's WP29, AEBS Regulation for November 2012 commercial vehicle was approved and awaiting enforcement by the EC Directive (General Safety Regulation) within the EU beginning November 2013. Ahead of this in Japan, replacing the AEBS Technical guidelines that were enacted and enforced since 2003, UN Regulation that mandates the installation of safety features targeted at heavy commercial vehicle is scheduled to be adopted from 2014 onwards. In the US, Confirmation Test standard[4] for 2006 FCW and LDW was made, and with the domestic introduction of NCAP, vehicles equipped with the appropriate devices are producing results.

Figure. 2
Technologies for additional scoring in US NCAP and Euro NCAP[5]

In the EU, recognizing the potential for these AEB systems, insurers and other road safety stakeholders are supervising research into the evaluation and rating of AEB conducted through the AEB group, of which results can be used by consumer test organizations such as the Euro NCAP, IIHS and Thatcham.

At the Beyond Euro NCAP, divided into the categories of warning system, active safety system and emergency call System, vehicles equipped with technology relevant to active safety system such as AEBS will be granted additional score based on test protocol derived from the AEB group. The 2012 Euro NCAP performed fitment survey on vehicles equipped with features like AEB and FCW according to the AEB assessment plan, and is scheduled to conduct evaluation test and assign an overall rating to Car-to-Car Rear Collision and Car-to-Pedestrian from 2014 and 2016 onwards respectively. Separately, depending on future market trends, AEB global technical regulation for small sized passenger vehicle is being reviewed for the revision of the EC directive after 2016[6].

Figure. 3
UN/WP.29 / 1998 Agreement configuration



Additionally, in Japan, research for the addition of ACC, ESC and such is being performed at JNCAP to encourage the expansion of active safety system. Similarly, the Australian NCAP has aimed for a 30% reduction in deaths and injuries by 2020 due to the high expectations in active safety system for transportation safety[7].

Table. 1
Introducing as active safety technology in each country's NCAP

Countries	Related active safety technology
Korea (KNCAP)	AEBS, FCW, ACC, LDWS, BSD, LKAS
Europe (Euro NCAP)	AEBS, ESC, SBR, SLD
USA (US NCAP)	FCWS, ESC, LDWS
Japan (JNCAP)	ACC, DMB, ESC
Austrailia (ANCAP)	AEBS, SBR, ESC

Domestic policy and institutional trends

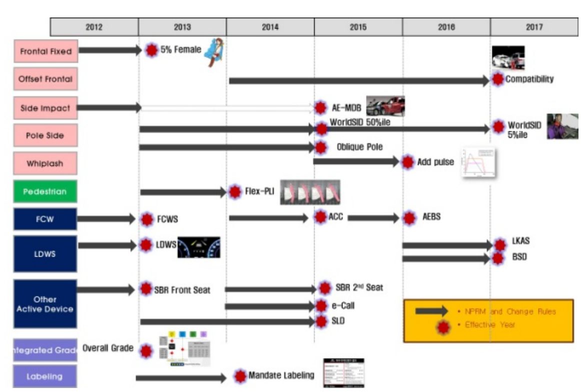
The National Policy statistics in Korea reported that the total number of deaths in 2010 caused by traffic accidents in Korea is 5,505, about 2.6 per 10,000 cars and twice the OECD average of 1.3.

According to the 7th General plan for Transportation Safety which has been enforced since 2012, the establishment of strategies to make full use of active safety system is the key project to reduce road casualty by 3,000 (40% 0f 2010's level) to achieve middle level ranking among OECD countries by 2016.

To this end, the government of Korea is urging the introduction of active safety system through proper obligation(Safety standard) and inducement (NCAP), first by participating in the enactment of UNECE/WP29's AEBS new Regulation as part UN WP29's agreement contracting country. The AEBS international standard will be introduced in this year(2013) through the establishment of Korea's safety standard and is mandatorily scheduled to be applied step-by-step to heavy commercial vehicles and buses after 2016.

According to future KNCAP strategy for inducing the production of safer vehicles, taking into consideration the domestic level of technology and NCAP roadmap of other major countries for active safety system, the sequential introduction of FCWS, ACC, AEBS, LDWS, LKAS, BSD, ASLD is currently under review.

Figure. 4
KNCAP Roadmap (2012-2017)



Specifically, with the introduction of KNCAP overall rating system in 2013, FCW and LDW, whose level of technology and market trends have matured to some extent, will first be granted additional score through evaluation. Thereafter, through international social trends and cooperation, expansion of ACC, AEBS and such is scheduled.

National standards Highlights

Forward Collision Warning System

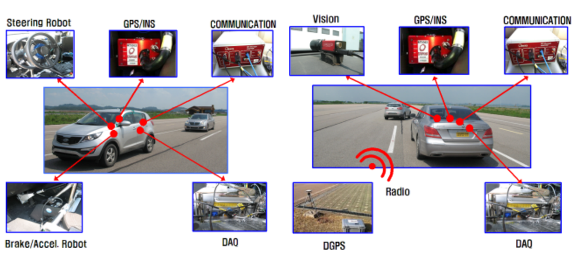
In th FCW testing, refers to the NHTSA's Confirmation Test Protocol.
The test is composed of 3 scenarios: target vehicle is stationary in front of driving lane, braking through constant deceleration and driving with slower speed in front.

Table. 2
FCW Assessment Requirement

Scenario	Test conditions	Requirement
Stationary target vehicle	· Speed : 72kph(SV)	Warning before TTC 2.1s
Delelerating target vehicle	· Speed : 72kph(SV&TV) · Initial clearance : 30m · TV decel.:0.3g	Warning before TTC 2.4s
Slower speed target vehicle	· Speed : 72kph(SV), 32.2kph(TV)	Warning before TTC 2.0s

System configuration for evaluating FCW is shown in the following figure.

Figure. 4
Test equipment for FCW Assessment



As evaluation criteria, similar to the NHTSA Confirmation Test, the FCW system must satisfy the time to collision(TTC) requirements for at least five of the seven test trials, and must not fail two consecutive trials to successfully pass. In this case, if the first five of the seven individual test trials satisfy the requirements, it is not necessary to perform additional trials to verify that two consecutive failures not take place.

Adaptive Cruise Control

ACC, an automatic follow control system to reduce driver fatigue based on the speed set by the driver and of the forward vehicle, along with convenience features, provides minimal safety feature that include some of FCW and AEB features.
Thus, in order to grant additional score for ACC equipped vehicle, first a minimal structural requirement draft is proposed to judge whether the ACC system is appropriate for the specification or not. Thereafter, performance evaluation requirements will be added step by step.
The ACC structural requirement draft referenced UNECE/WP29 ITS Informal group's HMI guideline, ISO 15622 & 22179, and the Japan Technical guideline.
The currently proposed ACC structural requirement draft includes mainly provisions for acceleration/deceleration control, stop lamp, HMI for the normal operational condition and failure condition, safety measure in the event of failure, user manual, and low speed following.
In the future, weighted value will be considered to be applied to hazard situation in real road-driving condition for various test scenario such as curve way, cut in, lane change and identification distance, and ACC rating is being reviewed through carring out assessment test.

Table. 3
Example of ACC Assessment Method(Draft)

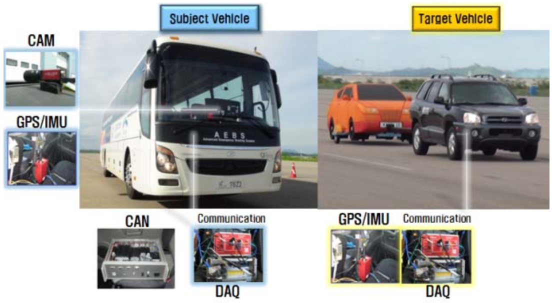
		Result fo Assessment Test										ACC System Grade
		Scenario					Subtotal	Weighting	Total	Record		
		(1)	(2)	(3)	(4)	(5)						
Test scenario	Test No. 1 Curve road	7.5	8.0	7.0	6.8	8.0	37.3/50	0.3(15%)	11.2/15	74.6%		★★★★☆
	Test No. 2 Cut In	6.5	7.0	7.2	-	-	20.7/30	0.8(24%)	16.7/24	69.0%		★★★★
	Test No. 3 Lane-Change	6.4	-	-	-	-	6.4/10	1.5(15%)	9.6/15	64.0%		★★★☆
	Test No. 4 Detecting range	9.2	-	-	-	-	9.2/10	0.6(6%)	5.5/6	92.0%		★★★★★
	Test No. 5 Clearance control	6.5	-	-	-	-	6.5/10	4(40%)	26/40	65.0%		★★★☆
Total record							86.7/120	-	69.0/100	69.0% (72.0%)		★★★★ (★★★★☆)

Record	~ 30%	30~35%	35~40%	40~45%	45~50%	50~55%	55~60%	60~65%	65~70%	70~75%	75%~
Rating	0★	0.5★	1★	1.5★	2★	2.5★	3★	3.5★	4★	4.5★	5★

Autonomous Emergency Braking System

For AEBS test requirement in commercial vehicle, as a WP29 1958 agreement contrancting party for the International technical standard harmonization, we are now in the process that the standards are being enacted with the same requirements as AEBS Regulations of the UN.

Figure. 5
AEBS Assessment Testing for Bus

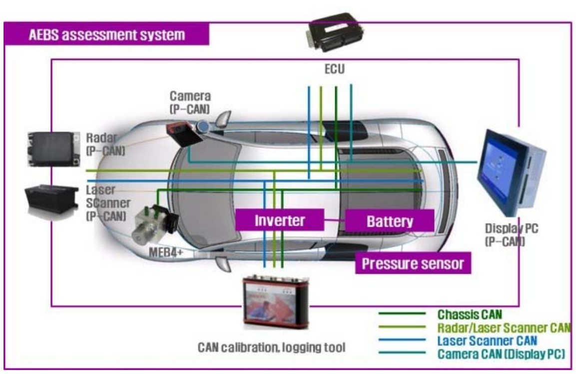


The same as US, domestic regulation certification system adopted self certification by car manufacturer. By that nature, through joint researches from a consortium of a domestic car manufacturer, an university, one of korean research institute and such, the KMVSS AEBS requirement draft that includes detailed specification draft relevant to current test procedure was made, with regulation enactment from early 2014 and step-by-step enforcement starting with heavy commercial vehicles from early 2016 targeted.

Unlike commercial vehicle, in the case of small size passenger vehicles, rather than forced installation from regulation enactment, future standardization and compulsory enforcement are under consideration after encouraging manufacturer's voluntary participation through raising consumer awareness with Euro NCAP.

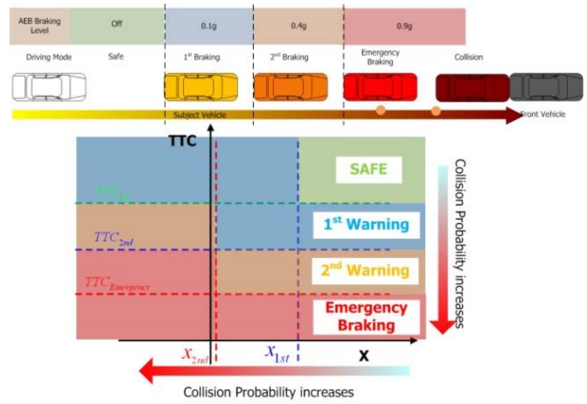
At this stage, for Car-to-Car Rear Collision scenarios currently under consideration in the Euro NCAP, measures and evaluation procedures for 2015 introduction into the KNCAP are under review. Through the hazard situation risk index in real road-driving condition, research is underway for granting AEBS grades.

Figure. 6
AEBS Assessment Test System



A clear assessment test protocol has yet been submitted for Car-to-Pedestrian. In this case, studies for pedestrian target selection is in progress, and for three years from 2012-2014, through self researches by national consortiums, assessment criteria that is right for domestic situations will be presented.

Figure. 7
Hazard situation index in driving



CONCLUSIONS

According to Korea's traffic accident statistics, when accidents caused by driver's condition are classified, nearly more than 60% was proved to be closely related to negligence in keeping the eyes forward[8]. Currently, among driver assist systems being actively developed and deployed, longitudinal active safety systems like FCW, ACC and AEBS are expected to greatly reduce accidents caused by negligence in keeping the eyes forward. In order to facilitate these systems, the government in many countries has been devoting a lot of effort into regulations and institutionalizations. By promoting enactment and research into regulation and notification draft for FCW, ACC and AEBS that are currently being promoted, Korea is also trying hard to achieve its government policy goal of reducing traffic casualties to 3,000 by 2016, to get within OECD's average.

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