Priorities for Enhanced Side Impact Protection in Regulation 95 Compliant Cars

P. Thomas, Chair EEVC WG 21 Accident Studies
R. Welsh
Loughborough University, UK
E. Lenguerrand, G. Vallet
INRETS, France
D. Otte
Medical University of Hanover, Germany
J. Strandroth
Swedish Roads Administration, Sweden

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Abstract

This paper summarises the main results of an analysis of accident data conducted for the European Enhanced Vehicles Committee (EEVC) WG13 "Side Impact" to inform the further development of side impact test procedures for cars. The analysis of data from three countries was coordinated by EEVC WG 21 “Accident Studies”.

The national datasets of the UK, France and Sweden from the year 2005 were analysed containing a total of 411,311 cars. In each country side impacts typically represented 33% of all fatalities but less than 25% of casualties of all severities. Struck-side occupants represented typically 60% of all side impact casualties regardless of injury severity while the remainder of the casualties were seated away on the non-struck-side.

Amongst single vehicle side impacts, collisions with poles were most commonly specified, although there was considerable variation between countries. In multi-vehicle crashes the collision partner was a car in about 75% of cases. The relative involvement of each type of collision partner varied by casualty severity and in both the UK and France there were similar numbers of fatalities in collisions with poles as with cars. A comparison of injury risks suggested the risk of serious injury in newer cars struck by other newer cars was similar to older, pre-Regulation 95, cars struck by older cars. This indicates the improvements in side protection since the introduction of Regulation 95 may have been at least partially offset by increases in front stiffness of cars due to the introduction of Regulation 94 and EuroNCAP.

The paper presents other details on the circumstances of side impacts and the different driver populations involved in loss-of control and intersection collisions. It links to two other papers concerning car-to-car and car-to-pole side collisions using in-depth data.

Background

This paper is a summary of the key findings of an analysis of accident data concerning side impacts. The analysis has been conducted by the European Enhanced Vehicle Safety Committee, Working Group 21 Accident Studies and has been requested by EEVC Working Group 13 Side Impact as part of its work to raise the level of side impact protection of cars.

This paper describes the results of an overview analysis focussing on the accident data from the UK, France, and Sweden. A related paper [1] summarises the results of the analysis of side impacts of cars with poles using in-depth data from Germany, GB and Sweden while a second paper [2] summarises the equivalent results of an analysis of car to car side collisions.

The European side impact test procedure is enacted within Directive 96/27/EC[3] and requires cars to maintain a specified level of protection when struck in the side by a mobile barrier travelling at 50km/hr. There have been a number of previous studies[4 5 6] that have evaluated the frequency and characteristics of side impacts although few have covered more than a single member State. The EU Directive included a requirement that it be evaluated after two years and Edwards et al [7] did this under the auspices of the EEVC. They concluded that the test speed should be increased and that the use of a pole test be considered. Similar conclusions were reached by Hassan et al [8] who examined both UK Co-operative Crash Injury Study (CCIS) data and US national Automotive Sampling System (NASS) data files. Frampton et al[9] highlighted the frequency of injuries to non-struck (far) side occupants. Thomas et al[10] reviewed UK in-depth accident data and confirmed that more car occupants died as a result of side

impacts than frontal crashes, impacts with poles were nearly as frequent as car to car side collisions and that the side impact test speed was substantially below that of the majority of fatal crashes.

Data sources

The task of EEVC WG 21 is to conduct accident data studies and incorporate as wide a range of EU accident data sources as possible compatible with the objectives of the research focus. Data from three countries, UK, France and Sweden was used for this analysis. Each of these datasets defined "fatality" as death within 30 days of the crash but differences exist for the "serious" category. These are defined below.

GB accident data – STATS 19
The British national accident database, STATS 19, is based on the reports for every police reported crash in Great Britain. Data for the year 2005 was used with a total of 271,017 casualties. Side impacts were defined on the basis of the police assessment of the first point of impact and seriously injured casualties are defined as those with a facture or an overnight stay in hospital. Accident data for Northern Ireland is stored separately so the dataset refers to Great Britain rather than the United Kingdom.

French accident data - BAAC
The data for France is also based on the police reports of crashes in the year 2005. The BAAC (Bulletin d'Analyse des Accidents Corporels de la Circulation) classifies impact direction in a similar manner to the UK but the "serious" category is defined on the basis of hospitalisation. The technical basis of BAAC has been revised since the 2005 dataset to minimise issues concerning under-reporting.

Sweden - STRADA
The Swedish STRADA system (Swedish Traffic Accident Data Acquisition) is based on police reports of each crash occurring nationally. Impact direction is based on the police assessment of the first point of impact. The data is enhanced by linkage with hospital files and details of vehicle inspections.

Frequency of side impacts
The total cases for each dataset are shown in Table 1 for all road user types and Table 2 shows the distribution of impact direction of car impacts according to each national definition.

In GB 24.3% of all car occupants were injured in impacts while in France and Sweden they represented 21.9% and 25.9% respectively. In each country the most common impact type was a frontal collision. However amongst fatalities side impacts were more common, in GB they represented 0.4% of all car occupant casualties compared with 0.5% in frontal collisions. In France side impact fatalities constituted 1.5% of all casualties compared with 3.5% in frontal impacts and in Sweden they represented 0.3% of all casualties.

Seating position
Car occupants seated on the struck side are the target of current safety requirements as they may be exposed to intruding structures with higher risk of injury. Table 3 shows the seating position of occupants in side impacts in each of the three countries. In all three countries and irrespective of the severity of injury typically between 54% (Sweden) and 59% (France) of all casualties were seated on the side of the impact with little variation according to injury severity.

Selection of cars compliant with Regulation 95.
National accident databases do not include a record of the regulatory compliance of cars so the selection of this group of cars was achieved by indirect methods. All new cars produced after 2003 were required to meet the side impact regulatory requirements however this would have resulted in a very small number of relevant vehicles in the 2005 dataset. It was not feasible to utilise the Vehicle Identification Number as it was not available on the national accident databases and following consultation with EuroNCAP and the industry

Table 1 National database casualty counts - 2005

	UK		**France***		**Sweden**	
	STATS 19 - GB		**BAAC**		**STRADA**	
Fatal	3,201	1.2%	5,319	4.7%	440	1.6%
Serious	28,954	10.7%	39,811	35.1%	3,915	14.6%
Slight	238,862	88.1%	68,265	60.2%	22,544	83.8%
Total	**271,017**	**100%**	**113,395**	**100%**	**26,899**	**100%**

*serious - in-patient, slight - out-patients

Table 2 - Distribution of car occupant casualties by impact type and injury severity

	GB** (n=169,670)			France* (n=52,634)			Sweden (n=9,180)**		
	Front	**Side**	**Rear**	**Front**	**Side**	**Rear**	**Front**	**Side**	**Rear**
Fatal	0.5%	0.4%	0.1%	3.5%	1.5%	0.3%	0.7%	0.3%	0.0%
Serious	4.9%	1.9%	0.5%	22.0%	6.5%	3.3%	6.5%	2.5%	1.0%
Slight	44.1%	22.0%	25.6%	34.9%	13.9%	14.1%	45.9%	23.1%	20.0%
Total	**49.5%**	**24.3%**	**26.2%**	**60.4%**	**21.9%**	**17.7%**	**53.1%**	**25.9%**	**21.0%**

*serious in-patients, slight out-patients - no multiple impacts
**may include multiple impacts - based on first point of impact

Table 3 Proportion of struck side and non struck side casualties among all side impacts

	GB		France*		Sweden	
	SS	**NSS**	**SS**	**NSS**	**SS**	**NSS**
Fatal	61%	39%	61%	39%	100% n=4	0
Serious	56%	44%	59%	41%	61%	39%
Slight	57%	43%	58%	42%	54%	46%
All severities	**57%**	**43%**	**59%**	**41%**	**54%**	**46%**

*serious in-patients, slight out-patients

members of WG 21 it was considered that the most effective definition was to consider vehicles registered after 1998 to represent the group compliant with Regulation 95. A later part of the analysis, to be reported elsewhere, focussed on the cars registered since 2003.

Collision partner

The test conditions under consideration by WG 13 relate to car to car and car to pole side impact conditions and the analysis of the datasets was therefore framed around these factors. Table 4 shows the frequency of each main impact configuration for each of the three countries.

Within the complete group of side impact casualties as occupants of cars registered since 1998 car to car side collisions were the most common, between 45% (Sweden) and 65% (France) of crashes were in this category. Collisions involving buses or goods vehicles, possibly within separate phases of the collision sequence, typically accounted for 13% (GB and Sweden). Car to pole collisions only represented between 3% (Sweden) and 6% (France) of all side impacts and collisions with other roadside objects were more common.

Table 5 shows the corresponding table for fatally injured casualties. 24% of GB casualties were killed in car to pole single vehicle collisions compared with 25% in car to car side impacts. Similarly in France there were 30% who died in collisions with poles and 37% in collisions with other cars. Other single vehicle crashes and impacts with trucks or buses were also frequent causes of fatality. There were a total of only 8 fatalities in the Swedish data so these are not presented.

Casualty reduction resulting from Reg 95

The introduction of the European side impact performance requirements included a specification that a consequent casualty reduction be evaluated. An interim evaluation was conducted but there was insufficient accident data available to support an estimate of effectiveness.

To accomplish this the national data from the UK, France and Sweden was analysed separately. Given the relatively low proportion of fatalities in each dataset the killed and seriously injured (KSI) groups of casualties have been combined. It should be noted that the national definitions of “serious” differ so that the countries cannot be directly compared.

Table 4: Collision partner, all side impacts, post-1998 registered cars, all casualties

Collision Partner	GB		France		Sweden	
Pole	764	4%	269	6%	18	3%
Other SVA*	2,176	13%	329	7%	244	37%
Car	9,170	54%	2,989	63%	299	45%
Bus/GV**	2,148	13%	533	11%	86	13%
Other TVA***	748	4%	340	7%	21	3%
Three + vehicles	2,029	12%	250	5%	0	0%
Total	**17,035**	**100%**	**4,710**	**100%**	**668**	**100%**

*SVA – Single Vehicle Accident
** GV – Goods Vehicle
*** TVA – Two Vehicle Accident

Table 5: Collision partner, all side impacts, post-1998 registered cars, fatally injured casualties

Collision Partner	GB		France	
Pole	50	24%	95	30%
Other SVA	42	20%	37	12%
Car	52	25%	116	37%
Bus/GV	25	12%	41	13%
Other TVA	6	3%	8	3%
Three + vehicles	30	15%	18	6%
Total	**205**	**100%**	**315**	**100%**

Table 6 shows the rates of killed and seriously injured casualties (KSI) comparing vehicles registered after 1998 with those earlier. Vehicles registered on or after 2003 will all comply with the side impact requirements and the KSI rates of these vehicles are also compared with the rates experienced by older cars. To represent the conditions of the test configuration, the dataset was restricted only to the crashes involving side impacted cars struck by other cars.

Table 6 - KSI rates % (sample size) by vehicle registration year

	GB	France	Sweden
Pre 1998	4.2 (1244)	27.8(909)	11.0 (91)
1998 onwards	3.5 (1921)	20.0(904)	5.2 (116)
Pre 2003	3.8 (2448)	25.0(1523)	10.0 (130)
2003 onwards	3.7 (677)	18.6(290)	3.9 (77)

Data from each of the three countries showed a reduction in the rate of killed or serious injury comparing the modern vehicles against the older cars although the magnitude of the reduction varied. The UK showed a reduction of 17% comparing the post-1998 cars with earlier models and reduction of 3% comparing post-2003 with earlier models. Reductions in France and Sweden were larger ranging from 26% to 61% (post-2003 cars).

Other factors relating to injury rates

Regulation 94 side impact was introduced in the same year as Regulation 96 frontal impact and over the period of the comparisons of KSI rates it is possible that other changes to vehicles, such as the stiffness of the car front, may have occurred. Tables 7 and 8 by registration year groups, pre-1998, post-1998 and post-2003 for cars struck in the side by the front of the opponent cars.

Table 7 UK - KSI rates % (sample size) by struck and bullet car age.

Bullet car / Struck car	Pre 1998	Post 1998	Post 2003
Pre 1998	4.3 (441)	3.8 (533)	3.9 (179)
Post 1998	4.0 (659)	3.5 (879)	3.5 (258)
Post 2003	4.6 (219)	3.6 (330)	4.1 (97)

The GB STATS 19 data shows that the reference rate of killed and seriously injured casualties of pre-regulation cars when struck by a similar aged car was 4.3%. The KSI rates for this oldest category of car

when struck in the side by the newest cars, post-2003, was reduced to 3.9%. However the rate for the newest cars when struck on the side by the front of the newest cars was little changed from the reference category at 4.1%.

Table 8 France - KSI rates (sample size) by struck and bullet car age

Bullet car / Struck car	Pre 1998	Post 1998	Post 2003
Pre 1998	26.3(498)	29.7(411)	28.9(128)
Post 1998	16.7(450)	23.4(454)	24.5(151)
Post 2003	14.7(143)	22.5(147)	26.8(56)

The French BAAC data, shown in Table 8, indicated a similar pattern. The reference group of older cars struck in the side by the front of older cars showed a KSI rate for the occupants of 26.3%. The newer groups of car, when struck by the same oldest car group, showed decreasing rates down to 14.7%. However when this same category of cars was struck by the front of more recent cars the KSI rates did not reduce and the rate for the post-2003 cars struck by the front of post-2003 cars was marginally greater than the reference group.

Matched samples

The characteristics of the drivers of cars varies according to the age of the vehicle reflecting the social groups that purchase new and used cars. In many countries, including the UK and Sweden, many new cars are bought for business use. Older cars are generally cheaper and may more often be bought by drivers who are less well off, such as younger drivers. It is therefore possible the drivers of the newer cars in the sample may have a different gender, age and other distributions from those in older cars and that these differences could account for the different KSI rates.

Tables 9 and 10 show the age and gender distributions of the drivers of the side impacted cars in GB and France. The distributions of these factors for each of the vehicle age groups in each of the countries showed that the characteristics of drivers of newer cars were generally similar to those of older cars..

Table 9 Struck vehicle GB

		Struck Vehicle Age			
		Pre 1998	1998 onwards	Pre 2003	2003 Onwards
Driver Gender	Male	62%	55%	58%	56%
	Female	37%	44%	41%	43%
	N/K	1%	1%	1%	1%
Driver Age	17-40	61%	53%	58%	49%
	41-60	20%	29%	24%	31%
	61+	15%	14%	14%	16%
	N/K	4%	4%	4%	4%

Table 10 Struck vehicle France

		Struck Vehicle Age			
		Pre 1998	1998 onwards	Pre 2003	2003 Onwards
Driver Gender	Male	60%	59%	58%	66%
	Female	40%	41%	42%	34%
	N/K	0	0	0	0
Driver Age	17-40	55%	49%	53%	49%
	41-60	28%	34%	30%	37%
	61+	17%	16%	17%	13%
	N/K	0.1%	1%	0.2%	1%

Discussion

The availability of representative accident data is fundamental to the development of relevant performance criteria for cars to reduce the impact of crashes. Whenever changes are introduced to test criteria it is essential that the social impact, including changes in casualties, is assessed. Where the test requirements are intended to reduce fatalities then these crashes should be assessed in detail.

As part of the development of new test requirements EEVC WG 13 has asked EEVC WG 21 to review the conditions of side impact across as broad a number of EU Member States as possible. The objectives were specifically to asses the overall frequency of side collisions amongst the wider crash population and also to examine the characteristics of crashes of all injury severities including those killed and seriously injured. WG 21 has responded by bringing together a range of accident sources for analysis and has particularly focussed on three aspects in direct relation to the considerations of future test procedures – the overall importance of side impacts, the characteristics of car to car collisions and the characteristics of car to pole crashes. This paper is based on the first of these three analyses and specifically examines the national accident datasets, the other reports are based on the analysis of in-depth

accident data. The full reports will be published at http://eevc.org/publicdocs/publicdocs.htm.

The national accident databases of EU Member States only have a limited comparability. The work of the European Commission CARE programme within the European Road Safety Observatory[11] has done much to harmonise data but there are still many differences in practise and the use of relatively untrained data gatherers normally determines further constraints. Nevertheless the national accident data can give very useful indications about the details of crash characteristics.

The data from the GB, France and Sweden all indicate that side impacts remain an important crash configuration, especially when serious or fatal injuries are sustained. In the three countries side impacts accounted for between 28% (France) and 40% (GB) and between 20% (France) and 26% (GB) of seriously injured. In GB in 2005 there were a total of 679 casualties who died in a side collision, 790 in France and 28 in Sweden.

The existing side impact test procedures, defined in ECE Regulation 95, represent the conditions of a car struck mid-door by the front of another car. The injury risks are evaluated for the front seat occupant on the struck side, immediately impacted by intruding side structures. Despite this the data from the three countries demonstrates that typically 40% of casualties in side impacts are seated away from the collision on the non-struck (far) side of the car regardless of injury severity. There is no published information available on the relationship between improved performance in regulatory side impact tests and changes in non-struck side injury risks, it cannot be therefore concluded that reductions in struck side injury risks as a consequence of Reg. 95 will automatically result in the same changes to non-struck side occupants.

Within the population of post-1998 side impacts collisions with other cars were substantially the most common, being between 45% (Sweden) and 63% (France) of the total. Impacts with poles ranged between 3% and 6%. Collisions with buses and trucks represented between 11% and 13% of side impacts while other types of single vehicle crash accounted for between 7% (France) and 37% (Sweden). The distribution of collision partner for fatal side crashes of post-1998 cars was different. While car to car collisions were the most frequent in France and GB impacts with poles were also frequent as were other single vehicle collisions. This distribution confirms the emphasis placed on protection in car to car side collisions but also reaffirms the importance of protection in car to pole crashes. Currently there is no European regulatory crash test requirement for pole side impacts and until recently the EuroNCAP test has only examined head injury risks. The characteristics of car to pole collisions are examined in a linked paper.

The data from the three countries indicates that there have been improvements in safety following the introduction of Regulation 95, although there is little consistency between countries. Reductions ranged from 3% to 61% and it is believed these are in part a consequence of different sampling practises. However closer scrutiny of this positive picture reveals the possibility that other changes in vehicle characteristics may have had unintended consequences, although at a non-significant level statistically. In particular the French data indicates that the injury risk to occupants of a newer car (post-2003) when struck in the side by another newer car are slightly larger than those when an old (pre-1998) car is struck by another old car. A similar, although less pronounced, pattern was observed in the GB data. This contradicts the hypothesis that injury rates would be lower in newer cars. It is possible from the results that improvements in side impact protection have been counterbalanced by increases in aggressivity of car front ends however further experimental research is required to clarify the factors. On the other hand when a newer car was struck by an older car, on which the mobile deformable barrier was based, injury risks were lower in both GB and French data.

Conclusions

Examination of the national accident databases of Sweden, France and GB have been undertaken in support of the development of revised crash test procedures for side impact conducted by EEVC WG 13. The main conclusions are:-

1. Side collisions remain a frequent cause of fatal and serious injury
2. Non-struck side occupants are a frequently injured group who are not covered by existing test procedures.
3. Impacts with other cars are marginally the most common type of side collision.
4. Although rare overall, pole impacts are a frequent cause of death.
5. There are indications that improvements in side protection may have been counterbalanced by other changes in car structural performance, one of which is an increase in car front stiffness although these need to be evaluated

experimentally together with an identification of any differences in driver factors.

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WG21 Membership at time of review

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