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Target Population of Improved Compatibility for Germany

Abstract

In spite of today's highly sophisticated crash test procedures like the different NCAP programs running world-wide, bad real world crash performance of cars is still an issue. There are crash situations which are not sufficiently represented by actual test configurations. This is especially true for car to car, as well as for car to object impacts. The paper describes reasons for this bad performance. The reasons are in principal bad structural interaction between the car and its impact partners (geometric imcompatibility), unadjusted front end stiffnesses (stiffness incompatibility) and collapse of passenger compartments.

To show the efficiency of improving cars' structural behaviour in accidents with different impact partners an accident data analysis has been taken out by members of the European Project VC-COMPAT. Accident data analysis has shown that in Germany between 15,000 and 20,000 of the now severely injured car occupants might get less injured and between 600 and 900 car occupant fatalities might be saved. Similar results arise for the UK.

Introduction

In 2001 there were, according to the European Commission, 39,684 traffic accident deaths in the 15 member states of the EU, out of a population of 377,942,000 (Commission of the European Communities 2003 [1]). These fatalities are defined to the UN/WHO criterion of a death occurring within 30 days of the crash. This still huge amount of deaths on European roads is the reason for an increasing number of traffic safety policies being initiated at European Union level. Therefore it should be noted that in a number of areas, such as vehicle-safety design, the European Commission has total competence, in other words, total responsibility to introduce directives which have the power of law behind them.

In October 1998, the first European Frontal and Side Impact Directives became effective. It is widely recognised that improved vehicle crash compatibility is the next greatest potential benefit for improving car occupant safety. Moreover the European Commission has set a target for traffic fatalities to be reduced by 50% by 2010 (compared to 2000) and improving passenger car compatibility is thought to be one major step towards that aim.

The general objective of the European research project 'Improvement of Vehicle Crash Compatibility through the Development of Crash Test Procedures' (VC-COMPAT) is to contribute in reducing the number of injured and killed car occupants involved in frontal passenger car collisions. Therefore a suite of crash test procedures is to be developed, which once implemented in legislative and/or consumer testing will lead to an improved vehicle crash compatibility.

In a first step a benefit estimation of compatibility has been made, by assessing the target population. This is the number of road casualties which are going to benefit from taking compatibility measures. Details of the methodology as well as first results for Germany and the UK are presented in the subsequent chapters.

Methodology

Accident data from the GIDAS (German In-Depth Accident Study) and from the CCIS (Cooperate Crash Injury Study) sample have been used. Detailed information regarding both databases can be found elsewhere [2].The car occupant casualty data were broken into categories by impact partner and first point of impact. It was assumed that there would only be potential benefit for casualties, involved in frontal impact collisions, i.e. no potential benefit for casualties in side, rear and other impact collisions.

The reason for breaking down the data in this manner was that it was thought that the relative potential benefit of improved compatibility for each of these groups would be quite different, therefore they needed to be treated separately. For example, improved compatibility is expected to deliver its greatest benefit for the frontal impact with another car.

figure 1 therefore shows the portion of different impact partners in fatal frontal car collisions for Germany in the year 2000.

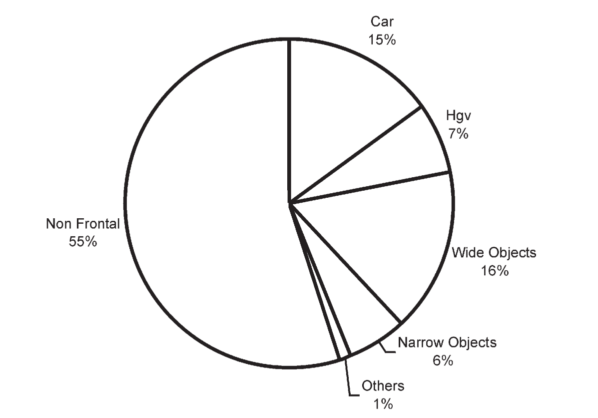

Fig. 1: Impact partners in fatal frontal car collisions for Germany in the year 2000

For each of the frontal impact partners a data subset was derived to estimate the proportion of fatal and seriously injured casualties that were likely to experience a potential benefit from improved car compatibility. This was achieved by considering parameters such as overlap, impact severity and the impact principle direction of force (pdof). For each of these parameters a lower (pessimistic) and an upper (optimistic) estimate was made for which a potential benefit would be expected as a result of implementing improved compatibility. The results were combined to give a somewhat optimistic and a somewhat pessimistic estimate of the accident subset in which the casualties could be expected to experience a potential benefit. The number of casualties in each of these accident subsets was determined. These were compared to the number of casualties in the originally derived equivalent data subset to determine a lower (pessimistic) and upper (optimistic) bound for the proportion of fatalities and seriously injured that would be expected to see a potential benefit from improved compatibility.

An upper and lower estimate of the number of fatalities and seriously injured casualties that would be expected to see a potential benefit for improved compatibility, annually in Germany and GB, was determined by scaling the results obtained from the analysis using the GIDAS data subset to the national accident data.

Definition of Data Subsets According to Impact Partner

Car to Car Collisons

The definition of a suitable data subset by some accident parameters (like overlap, impact severity, etc.) is fully illustrated for the car to car frontal accidents.

Selection criterion	optimistic limit	pessimistic limit
impact location	frontal	frontal
overlap	>20%	>30%
pdof	10..2 o'clock	11..1 o'clock
EES/ETS	all accidents up to 56kph + 50% of them up to 80kph	all accidents up to 48kph + 50% of them up to 80kph
mass ratio	all mass ratios	>1 : 1,6
belt usage	only belted occupants	only belted occupants
occupants	only frontal occupants	only frontal occupants
multiple impacts	no subsequent signifi-cant side impact	no subsequent significant side impact or rollover; exclude cases where the side impact or the rollover is judged to be more injurious than the frontal impact

Tab. 1: Upper and lower limits for accident parameters used to identify proportion of fatalities and seriously injured expected to experience a potential benefit for car to car collisions

The accident parameters considered for the category, car frontal impact with another car or van, were: impact direction, overlap, multiple impacts, rollover and accident severity. The lower (somewhat pessimistic) and upper (somewhat optimistic) limits, showed in Table1 below, were chosen and used as selection criteria to determine the proportion of fatalities and seriously injured in the GIDAS/CCIS equivalent data sample sub-set that would be expected to experience a potential benefit. Some reasoning to why the particular limits used were chosen is given below.

It is expected that improved compatibility should offer some potential benefit for frontal collisions with nearly all impact directions, except possibly those with a substantial side component. Therefore, an upper limit to include impacts with 10, 11 12, 1 and 2 o'clock principle direction of force (pdf) and a lower limit of 11, 12 and 1 o'clock pdf were chosen. In considering the limits for overlap, it is not expected that improved compatibility will offer significant benefits for side-swipe or low overlap accidents where the main structure of the car, such as the lower rails, is not involved. This is because it would be difficult to obtain good structural interaction in these cases. However, there are also approaches to overcome that problem [3]. So to exclude these accidents the upper and lower limits were set at 20 and 30 percent, respectively. Due to the high importance of multiple collisions, in particular with regard to fatal and serious casualties [4], multiple collisions have been included in the analysis, but treated in a

Selection criterion	optimistic limit	pessimistic limit
impact location	frontal	frontal
overlap	>20%	>30%
pdof	10..2 o'clock	11..1 o'clock
EES/ETS	all accidents up to 56kph + 50% of them up to 80kph	all accidents up to 48kph + 50% of them up to 80kph
delta v	all values	>56kph
underrun	exclude 80% of underruns	exclude 100% of underruns
belt usage	only belted occupants	only belted occupants
occupants	only frontal occupants	only frontal occupants
multiple impacts	no subsequent significant side impact	no subsequent significant side impact or rollover; exclude cases where the side impact or the rollover is judged to be more injurious than the frontal impact

Tab. 2: Upper and lower limits for accident parameters used to identify proportion of fatalities and seriously injured expected to experience a potential benefit for car to hgv collisions

Selection criterion	optimistic limit	pessimistic limit
impact location	frontal	frontal
overlap	>20%	>30%
pdof	10..2 o'clock	11..1 o'clock
EES/ETS	all accidents up to 56kph + 50% of them up to 80kph	all accidents up to 48kph + 50% of them up to 80kph
belt usage	only belted occupants	only belted occupants
occupants	only frontal occupants	only frontal occupants
multiple impacts	no subsequent significant side impact	no subsequent significant side impact or rollover; exclude cases where the side impact or the rollover is judged to be more injurious than the frontal impact

Tab. 3: Upper and lower limits for accident parameters used to identify proportion of fatalities and seriously injured expected to experience a potential benefit for car to wide object collisions

special way. Multiple impact accidents are those, where a car has impacted e.g. a roadside obstacle following a frontal impact. In some cases this secondary impact may be a side impact and more injurious than the frontal impact. Improved compatibility will probably not benefit these types of cases. To take this into account an upper limit to exclude all cases in which a significant[1] side impact occurred and a lower limit to exclude cases in which a significant side impact occurred and cases in which the other impact was judged to be more injurious than the frontal impact[2] were used. The accident data subset will also include some cases where the car has rolled over following the frontal impact. In some cases it is possible that the rollover was more injurious than the frontal impact. To take this into account an upper limit to include all accident cases in which rollover occurred and a lower limit to include only rollover cases where the rollover was judged to be less injurious were used. Finally, impact severity was considered. Some potential benefit will be expected at almost all impact severities, but obviously this will be very small or zero in accidents of very high severity. To attempt to take this into account an impact severity limit was used, up to which all occupants are expected to experience potential benefit, but above which only half the occupants are expected to experience potential benefit. The upper value chosen for this limit was 56km/h ETS as this is widely believed to be a good approximation of the severity of the 64km/h ODB test, the severity up to which a 'compatible' car is expected to offer 'good compatible' performance. However, recent work has estimated the average ETS for a number of EuroNCAP tested cars (a 64km/h ODB test) to be 48 km/h. Hence, this value was used as the lower limit.

This methodology was repeated for cars that suffered an impact with a Hgv, with a wide object and with a narrow object. Similar accident case selection parameters and limit values were used. The following paragraphs give an overview.

Car to hgv Collisons (tabel 2)

In car to truck accidents the car is supposed to interact with some underrun protection system. A special "underrun criterion" was introduced to account for this. An additional crash severity ("delta v") criterion restricts the deceleration of the occupant to reasonable values.

Car to Wide Object (Diameter ≥41 cm) Collisons (tabel 3)

The selection criteria for car to wide object impacts look quite similar to those for the car to car accidents. Obviously there is no mass ratio criterion taken into account (Tab. 3).

Car to Small Object (Diameter ≤41 cm) Collisons (tabel 4)

No overlap criterion has been applied in the event of car to narrow object impacts. Instead another

1 "Significant side impact" is defined as having a CDC extent code of at least 2.

2 "Less injurious" assessment is based on the vehicle examiners' judgement of the relative likelihood of a particular part of the accident causing the serious injuries.

selection criterion	optimistic limit	pessimistic limit
impact location	frontal	frontal
pattern criterion	exlude cases with damage width less than 750mm, unless mid-point offset is less than 700mm	exclude all cases with damage width less than 750mm
pdof	10..2 o'clock	11..1 o'clock
EES/ETS	all accidents up to 56kph + 50% of them up to 80kph	all accidents up to 48kph + 50% of them up to 80kph
belt usage	only belted occupants	only belted occupants
occupants	only fronal occupants	only frontal occupants
multiple impacts	no subsequent significant side impact	no subsequent significant side impact or rollover; exclude cases where the side impact or the rollover is judged to be more injurious than the frontal impact

Tab. 4: Upper and lower limits for accident parameters used to identify proportion of fatalities and seriously injured expected to experience a potential benefit for car to small object collisions

criterion has been constructed, capable to describe the interaction with the car frontal structure. This criterion is the "pattern criterion" and it uses the damage width along the frontal damage contour.

Results

These accident selection parameters with the upper and lower limits were applied to the appropriate GIDAS/CCIS data subsets to estimate an upper (optimistic) and lower (pessimistic) bound to the number and proportion of fatalities and seriously injured casualties that are likely to experience a potential benefit as a result of improved compatibility. The results for Germany are shown in table 5 and table 6 below. The proportion of fatalities estimated to experience a potential benefit adds up to 14% to 21% of all car occupant fatalities. This corresponds to a number of 600 to 900 fatally injured occupants who might be saved by taking compatibility measures. It is also interesting to see, that there is a rather high potential benefit within the car to wide object category.

The proportion of seriously injured estimated to experience a potential benefit adds up to 29% to 39% of all seriously injured car occupants. This corresponds to a number of 15,000 to 20,000 occupants who might get less severely injured or even not injured. The highest potential benefit in this group is in the car to car category.

imact partner	weighted target population (belted occupants) using	
	pessimistic limits	opitmistic limits
ca.	4%	8%
hgv	2%	3%
wide object	8%	10%
narrow object	0%	0%
others	0%	0%
Sum	14%	21%

Tab. 5: Target population for Germany regarding fatal car occupants

imact partner	weighted target population (belted occupants) using	
	pessimistic limits	opitmistic limits
ca	20%	22%
hgv	2%	4%
wide object	3%	7%
narrow object	4%	5%
others	0%	1%
Sum	29%	39%

Tab. 6: Target population for Germany regarding seriously injured car occupants

A similar analysis of CCIS data gives slightly higher numbers for the target population in the UK. 20% to 31% of the fatally injured car front occupants might be saved in the UK by taking compatibility measures. This corresponds to a number of 340 to 540 casualties. Regarding the seriously injured car occupants 41% to 52% might have their injury reduced or even receive no injury. This corresponds to a number of 8,000 to 10,500 car occupants.

The differences between the German and British analysis seem to be caused by a different proportion of frontal collisions. In the UK frontal collisions have been responsible for 60% of all car occupant fatalities in the year 2000, while in Germany this proportion is about 45%. In addition various definitions of accident severity [5], in particular with regard to the term "seriously injured", might be a reason for inconsistencies.

Although the mentioned figures are quite promising, a next step has to show exactly which injuries can be prevented by improving cars' compatibility. Due to better structural interaction accompanied by a sufficiently stiff compartment cell the hope is to prevent most kind of intrusion-caused injuries. However, further detailed research has to justify this assumption.

References

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