Analysis of accident data for test scenario definition in the ASSESS project

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Abstract - The overall purpose of the ASSESS project is to develop a relevant and standardised set of test and assessment methods and associated tools for integrated vehicle safety systems, primarily focussing on currently available pre-crash sensing systems. The first stage of the project was to define casualty relevant accident scenarios so that the test scenarios will be developed based on accident scenarios which currently result in the greatest injury outcome, measured by a combination of casualty severity and casualty frequency. The first analysis stage was completed using data from a range of accident databases, including those which were nationally representative (STATS19, UK and STRADA, SE) and in-depth sources which provided more detailed parameters to characterise the accident scenarios (GIDAS, DE and OTS, UK). A common analysis method was developed in order to compare the data from these different sources, and while the data sets were not completely compatible, the majority of the data was aligned in such a way that allowed a useful comparison to be made. As the ASSESS project focuses on pre-crash sensing systems fitted to passenger cars, the data selected for the analysis was "injury accidents which involved at least one passenger car". The accident data analysis yielded the following ranked list of most relevant accident scenarios:

Rank	Accident scenario
1	Driving accident - single vehicle loss of control
2	Accidents in longitudinal traffic (same and opposite directions)
3	Accidents with turning vehicle(s) or crossing paths in junctions
4	Accidents involving pedestrians

The ranked list highlights the relatively large role played by 'accidents in longitudinal traffic', and 'accidents with turning vehicle(s) or crossing paths in junctions' (the second and third most prevalent accident scenarios, respectively). The pre-crash systems addressed in ASSESS propose to yield beneficial safety outcomes with specific regard to these accident scenarios. This indicates that the ASSESS project is highly relevant to the current casualty crash problem. In the second stage of the analysis a selection of these accident scenarios were analysed further to define the accident parameters at a more detailed level [7]. This paper describes the analysis approach and results from the first analysis stage.

INTRODUCTION

The ASSESS project [1] was developed as part of the European Commission's 7th Framework programme. The overall purpose of the ASSESS project is to develop a relevant and standardised set of test and assessment methods and associated tools for integrated vehicle safety systems, primarily focussing on currently available pre-crash sensing systems. The information and methodology developed by ASSESS can then be used for a wider range of integrated vehicle safety systems, encompassing assessment of driver behaviour, pre-crash performance and crash performance.

The first stage of the project was to define casualty relevant accident scenarios so that the test scenarios are developed based on accident types which currently result in the greatest injury outcome, measured by a combination of casualty severity and casualty frequency.

Therefore, the first task in Work Package 1 was to examine how relevant scenarios had been developed by previous projects (see [2] for further information) and to obtain and analyse European accident data to define most relevant accident scenarios. Furthermore, the study on relevant accident scenarios was followed by a more detailed analysis to provide necessary information on scenario parameters such as the pre-crash vehicle kinematics in terms of speed, for example.

METHODOLOGY

The task for the accident analysis in ASSESS was a two stage process. Firstly, the aim was to rank accident scenarios, aggregated on a general level, for the entire accident population. The principle of this accident analysis was that it considered the accidents and casualties independent of the safety system – so the real world accident problem. This was to ensure that the procedures developed for ASSESS are focussed on the priority casualty problems (system validation), not simply to develop assessment methodologies to demonstrate the system effectiveness in design conditions (system verification). The result of this first stage was a ranked list of most relevant accident scenarios. After this general level analysis, the project defined four main groups of appropriate preliminary test scenarios based on the system to be assessed. The corresponding specifications for these test scenarios needed further attention from the detailed analysis.

Ranking approach

The overall injury outcome of the relevant accidents was used to rank the accident scenarios. This is important, since by allocating greater weightings to more severe casualties this takes into account both the frequency of the accident and severity of the resulting casualties. This allows accident scenarios with a lower frequency of occurrence (but which result in casualties of a higher severity) to be balanced with accidents of greater frequency of occurrence, but with lower injury outcomes. Therefore, in terms of valuing the accident, it is the weighted casualty severity which is most important.

To use representative weighting factors for the casualties of different severities, casualty costs from the HEATCO [3] and eIMPACT project [4] were reviewed, which included casualty valuations from several European countries. In the study, large differences were noticed between the countries in all categories (fatal, serious, slight injuries). This was mainly due to different calculation techniques used in the different countries. There is a variety of calculation techniques available; the two most common methods are the willingness-to-pay (WTP) approach and the cost-of-damage (COD) approach.

In the ASSESS project, casualty costs were used for calculating overall accident scenario importance and for balancing high frequency scenarios with low casualty implications and low frequency scenarios with high casualty implications. Therefore, absolute cost values were not required, however information was required on the ratios between the different casualty valuation levels. In Table 1 a subset of the results from eIMPACT [4; Table 17] are presented for 10 out of 18 countries, as the full range of data was not available for the other countries for each category. Table 1 shows the resulting weighting factors per country by setting the costs for fatalities to “1.0” and calculating the relative weight of the other injury categories per country accordingly.

Table 1. Costs per Accident Impact (Costs/Casualty) in EUR for 2005 in 10 EU countries [4; page 75] and resulting weighting factors per country by setting the costs for fatalities to "1.0" and calculating the relative weight of the other injury categories per country accordingly.

Region	Country	Population	Casualty Valuation [EUR]			Weighting Factors		
		[Mio]	Fatality	Serious Injury	Slight Injury	Fatality	Serious Injury	Slight Injury
North/West	Denmark	5.4	692,143	71,546	19,528	1	0.10	0.0282
	Finland	5.3	1,752,000	365,000	44,300	1	0.21	0.0253
	France	63.4	1,362,770	204,416	29,981	1	0.15	0.0220
	Germany	82.3	1,199,780	83,454	3,652	1	0.07	0.0030
	Sweden	9.0	1,364,503	243,430	13,637	1	0.18	0.0100
	UK	60.9	1,565,720	175,940	13,567	1	0.11	0.0087
East	Hungary	10.1	896,981	62,239	8,238	1	0.07	0.0092
	Latvia	2.3	709,636	16,149	191	1	0.02	0.0003
	Slovak Republic	5.4	221,530	39,344	704	1	0.18	0.0032
South	Portugal	10.6	355,483	16,663	1,111	1	0.05	0.0031
Average by population						1	0.1082	0.0106

With reference to the weighting factors presented in Table 1, still a large range can be observed. In order to have one common set of weighting factors applicable to all accident databases used for the scenario analysis, an average by country population was calculated. Table 2 show the average casualty cost weighting factors used for the analysis in ASSESS.

Table 2. Average casualty cost weighting factors

	Average weighting factor
Fatal	1
Serious injury	0.11
Slight injury	0.011

The rankings of the accident scenarios were calculated based on the casualties in the accident and the weighting factors for considering the injury costs with the following formula:

Number of slightly injured road users × 0.011 + Number of seriously injured road users × 0.11 + Number of fatalities × 1

Data sources and accident sample

In order to define accident scenarios at the required level of detail, in-depth accident data is required. For this purpose, in-depth data from the UK and Germany was used. In addition to these data, national accident data from Great Britain and Sweden were used to verify that the findings of the detailed data were sufficiently representative of larger populations.

National accident data

In Great Britain the STATS19 is the national accident recording system comprising details of accidents and casualties recorded by the police or local authorities and covering all road accidents in Great Britain which involve personal injury. Accidents are those which occur on public roads and which become known to the police within 30 days.

In Sweden the Swedish Traffic Accident Data Acquisition (STRADA) is an information system for road accidents with personal injuries. The system includes information from the police and the emergency hospitals. The police report road accidents involving at least one moving vehicle and a road user which sustained an injury.

In-depth accident data

In the German In-Depth Accident Study (GIDAS) road traffic accidents involving personal injury are investigated according to a statistical sampling process using the “on the scene” approach. The data collected in the study is compared to the official accident statistics and corrected by annually-calculated weighting factors. The detailed documentation of the accidents is performed by survey teams in the areas around Dresden and Hanover.

The UK On-The-Spot (OTS) database comprises in-depth accident and injury data collected by two teams in two sampling regions; in the South and in the Midlands of England. Investigating teams are deployed to the scene of an accident, generally within 20 minutes of the accident happening, for all road traffic accidents notified to police during the periods of operation. Therefore, this data source includes damage only accidents and accidents which may not result in an injury.

General level accident analysis

The ASSESS project focuses on longitudinal pre-crash sensing systems fitted to passenger cars. Therefore, the data selected for analysis were injury accidents which involved at least one passenger car and known injuries for all people involved in the accident. The purpose of the high level analysis was to rank the most frequent and severe accident scenarios. All injured people in all involved vehicles, plus vulnerable road users (e.g. pedestrians), were taken into account. For comparing the different data sets firstly the accident scenario frequency was assessed; secondly the accident scenarios were divided into the casualty groups (fatal, severe and slight) for all involved road users; and thirdly by applying the weighting factors for injury/fatality cost. Thus a ranking for the accident scenarios could be achieved.

Data sample

In the documentation of accidents, it is not always possible to record the injury severities for all people involved. For example, the injury severity of a road user who fails to stop after an accident cannot be determined. For the analysis of the casualty severity distribution, only people with known injuries were considered based on the assumption that the unknown injured road users have the same distribution as the road users with known injuries.

Table 3. Data sample from national and in-depth data for general level accident analysis

Data source	Sample years	No of accidents	No of vehicles	Accidents involving at least one car	No of cars	Accidents involving at least one car and known injuries
STATS19	2005-2008	740,602	1,360,865	649,214	1,017,083	649,214
STRADA	2005-2008	74,974	131,914	61,814	87,555	49,033
GIDAS*	2001-2007	11,685	21,355	9,760	14,390	9,742
OTS	2000-06/2009	4,284	7,435	3,909	5,997	2,222

* weighted data

Accident scenario definitions

In order to compare the data, it was necessary to define a common classification which could be used to analyse and compare the different accident data sources. The accident scenarios selected were based on those defined by SafetyNet WP5 [5]. However, since the purpose of the analysis was to provide a condensed set of most relevant scenarios, only the first digit of the accident type was used to identify the type of conflict. This step was taken to find common categorisation criteria for all data sources. These accident or conflict type groups can be summarized as:

- Type 1a: Driving accident – single vehicle
- Type 1b: Driving accident – multiple vehicles
- Type 2&3: Accidents with turning vehicle(s) or crossing paths in junction
- Type 4: Accident involving pedestrian(s)
- Type 5: Accidents with parked vehicles
- Type 6a: Accidents in longitudinal traffic – same direction
- Type 6b: Accidents in longitudinal traffic – opposite direction
- Type 7a: Other accident type – single vehicle
- Type 7b: Other accident type – multiple vehicles

RESULTS

The accidents in OTS cannot be easily merged into the same accident type codes used in SafetyNet but OTS uses a similar system of "conflicts" which can be used to define the test scenarios. It also proved difficult to merge the SafetyNet accident types to the STATS19 accident types. Therefore, STATS19 results include accident types which are not presented in this paper. Interested readers should refer to [2] for discussions on STATS19 results.

Accident scenarios and accident severity distribution

The accident scenario frequency differed for each of the data sources shown in Table 4. In GIDAS and OTS the most common accident scenario is "accident with turning vehicle(s) or crossing paths in junction (type 2&3)". STRADA also shows high numbers for this scenario however the scenario "driving accidents – single vehicle (type 1)" has the highest frequency. More than a fifth of all accidents with injuries involving at least one car are "accidents in longitudinal traffic – same direction" for all data sources. For pedestrian accidents the data sources show similar results from all sources.

Table 4. Accident scenario distribution of accidents involving at least one passenger car in injury accidents.

Accident scenario	GIDAS n=9,760	OTS* n=1,940	STRADA n=61,814
Type 1a: Driving accident - single vehicle	13%	24%	34%
Type 1b: Driving accident - multiple vehicles	5%	-	-
Type 2&3: Accidents with turning vehicle(s) or crossing paths in junction	38%	31%	27%
Type 4: Accidents involving pedestrians	7%	9%	6%
Type 5: Accidents with parked vehicles	3%	2%	1%
Type 6a: Accidents in longitudinal traffic - same direction	21%	10%	18%
Type 6b: Accidents in longitudinal traffic - opposite direction	3%	21%	6%
Type 7a: Other accident - single vehicle	4%	3%	8%
Type 7b: Other accident - multiple vehicles	6%	-	-

* Injured road users in passenger cars

For accident severity the data sets show similar distributions (see Table 5). In GIDAS and OTS the frequency of severe accidents are slightly higher. The lower distribution of severe accidents for STRADA and STATS19 could be explained by the fact that the injury severity is coded by the police at the scene and this might therefore be underestimated.

Table 5. Accident severity of accidents involving at least one passenger car in injury accident.

Accidents everity	GIDAS n=9,760	OTS n=2,222	STRADA n=49,033	STATS19 n=649,214
Fatal	1%	4%	2%	1%
Severe	20%	18%	16%	12%
Slight	79%	78%	82%	87%

When comparing the accident scenario distribution based on all involved road users in the accident the numbers show that most casualties are caused in accidents at junctions (Type2&3) and accidents in longitudinal traffic (Type 6) for all data sets (see Table 6). This is expected due to the fact that these accidents include more vehicles and therefore more road users are involved in these types of accidents.

Table 6. Accident scenario distribution based on involved road users in injury accidents involving at least one car.

Accident scenario	GIDAS n=26,248	OTS n=10,459	STRADA n=106,397
Type 1a: Driving accident - single vehicle	8%	21%	23%
Type 1b: Driving accident - multiple vehicles	5%	-	-
Type 2&3: Accidents with turning vehicle(s) or crossing paths in junction	38%	28%	30%
Type 4: Accidents involving pedestrians	6%	5%	6%
Type 5: Accidents with parked vehicles	2%	3%	1%
Type 6a: Accidents in longitudinal traffic - same direction	28%	31%	24%
Type 6b: Accidents in longitudinal traffic - opposite direction	3%	8%	8%
Type 7a: Other accident - single vehicle	3%	3%	8%
Type 7b: Other accident - multiple vehicles	6%	-	-

Ranking of accident scenarios

The accident scenarios were ranked according to their frequency and to the severity of injuries suffered by all involved road users. This ranking (see Table 7) is based on the accident scenario distribution weighted by the injury costs. It can be concluded that the most frequent accident scenario is “single vehicle accident” which shows a high percentage in all databases. OTS shows the same percentages for Type 1 and Type 6 accidents; however the decimal (not shown due to rounding) assigns Type 6 the highest ranking. The accidents in longitudinal traffic which occurred both in the same and opposite directions were merged because in the analysis of OTS and STRADA it was more difficult to distinguish between these subgroups. For comparing single vehicle accidents in GIDAS, Type 1a and Type 7a were merged (23% and 5%).

Table 7. Distribution and ranking of the accident scenarios weighted based on involved road users by injury costs for injury accidents (ranking with merged Type 6 group). Weighted average is calculated by using the population size for included countries.

Accident scenario	GIDAS n=26,248		OTS n=10,459		STRADA n=106,397		Weighted average	
	freq	rank	freq	rank	freq	rank	freq	rank
Type 1a: Driving accident - single vehicle	28%	1	31%	2	34%	1	30%	1
Type 1b: Driving accident - multiple vehicles	10%	4	-	-	-	-	-	-
Type 2&3: Accidents with turning vehicle(s) or crossing paths in junction	27%	2	22%	3	22%	3	25%	3
Type 4: Accidents involving pedestrians	8%	5	13%	4	7%	4	10%	4
Type 5: Accidents with parked vehicles	1%	7	1%	6	1%	6	1%	5
Type 6: Accidents in longitudinal traffic, same/opposite direction	21%	3	31%	1	30%	2	26%	2
Type 7a: Other accident - single vehicle	-	-	2%	5	6%	5	-	-
Type 7b: Other accident - multiple vehicles	4%	6	-	-	-	-	-	-

The weighted average ranking (see Table 7) shows that the second ranked accident scenario is “accidents in longitudinal traffic”. In OTS this accident scenario is ranked first, and Type 1 is ranked second. In STRADA accidents of Type 6 are ranked second, only in GIDAS they are ranked third. Accidents at junctions appear third in the overall ranking. The final ranking of accident scenarios is shown in Table 8.

The ranking of the accident scenarios (see Table 8) considers all databases by using the mean value of the rank order. The ranking includes accidents with opponents travelling in both same and opposite direction in the Type 6 group.

Table 8. Final ranking of accident scenarios for the three databases, GIDAS, OTS and STRADA.

Rank	Accident scenario
1	Type 1a: Driving accident - single vehicle
2	Type 6: Accidents in longitudinal traffic, same/opposite direction
3	Type 2&3: Accidents with turning vehicle(s) or crossing paths in junction
4	Type 4: Accidents involving pedestrians

Preliminary test scenarios

Four main groups of preliminary test scenarios were developed in the project [6] considering accident scenarios which can be addressed by longitudinal pre-crash sensing systems. From the ranking above important accidents scenarios to be considered are Type 6 and Type 2&3. Pedestrian accidents are not included in the scope of the project. From these two types of accident scenarios the rear end, junction, on-coming traffic and cut-in scenarios were developed (see Figure 1- Figure 4)

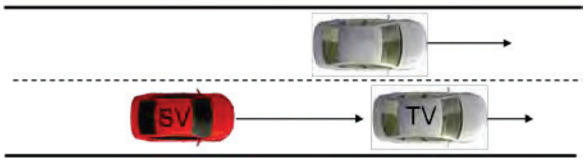

Figure 1. Rear end test scenario, the subject vehicle (SV) impacts either a slower, decelerating or stopped target vehicle (TV).

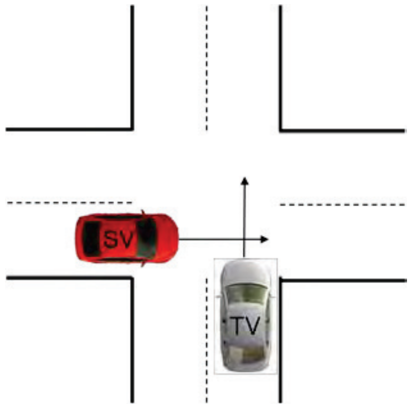

Figure 2. Junction test scenario, turning vehicles to the right or to the left and vehicles on crossing paths.

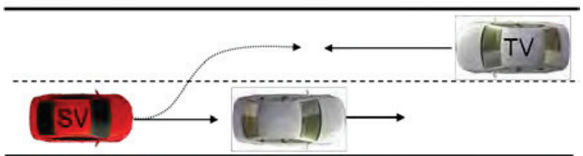

Figure 3. On-coming traffic test scenario, the subject vehicle (SV) is entering and collides with an on-coming target vehicle (TV).

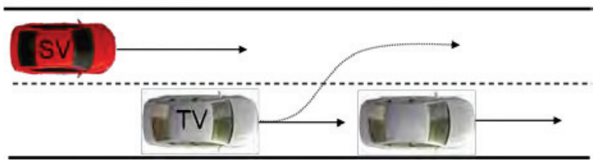

Figure 4. Cut-in test scenario, the target vehicle (TV) cuts in front of the subject vehicle (SV).

For the test programme these four main categories include 20 related manoeuvres with estimated specifications, (see Deliverable 4.1 [6] for further information). Further analysis is underway to identify the relevant accident parameters (defining the corresponding test setup definitions) at a more detailed level. The results will be presented in deliverable 1.2 [7] of the ASSESS project.

DISCUSSION

Firstly, it should be considered that in the high level analysis, nationally representative databases with police reported accidents (STATS19 and STRADA) have been compared with in-depth databases where professional accident investigators have coded the accidents (GIDAS and OTS).

When comparing accident scenarios between the data sets, it is important to remember that the proposed accident scenarios based on SafetyNet [5] refer to the conflict situation rather than the configuration of the accident. The SafetyNet code originates from the same source which is also used in GIDAS. Type 1 accidents are often considered as single vehicle accidents and this is why this group should be comparable with single vehicle accidents from other data sets. Type 2&3 accidents were merged because it made it easier to compare with other data sets; where accidents happened in or close to junctions. Type 4 accidents involved pedestrians (occurring in all accident conflict types). For Type 6 accidents, a distinction between same and opposite directions was made. This distinction is expected to be the largest source of difference between results from each data set and it was therefore decided to examine this group as a whole group as well as the subgroups.

Throughout the analysis the three main groups identified as accident and injury producing accident scenarios are Type 1 “single vehicle accident”, Type 2&3 “accidents with turning vehicle(s) or crossing paths in junction” and Type 6 “accidents in longitudinal traffic”. The results show that for Type 6 accidents, those which occur in longitudinal traffic (same direction) are more frequent, but that when the casualty weighting are applied, those which occur between vehicles travelling in opposite directions predominate.

Not all test scenarios defined in ASSESS can be handled by currently available systems and therefore a “technology readiness factor” will be considered when implementing these scenarios into a test program for assessing a system. However, the ASSESS project will explore possibilities to generate the scenarios in a test environment to be prepared for future systems assessment.

CONCLUSION

The overall purpose of the ASSESS project is to develop a relevant and standardised set of test and assessment methods and associated tools for integrated vehicle safety systems, primarily focussing on currently available pre-crash sensing systems. Casualty relevant accident scenarios were identified so that the test scenarios will be developed based on accident scenarios which currently result in the greatest injury outcome.

The initial analysis was completed for a range of accident databases, including those which were nationally representative (STATS19, UK and STRADA, SE) and in-depth sources which provided more detailed parameters necessary to characterise the accident scenario at a more detailed level (GIDAS, DE and OTS, UK). A common analysis method was developed in order to compare the data from these different sources. After a comparison between the data sources, the ranking of the most relevant accident scenarios from the analysis were:

Rank	Accident scenario
1	Driving accident - single vehicle loss of control
2	Accidents in longitudinal traffic (same and opposite directions)
3	Accidents with turning vehicle(s) or crossing paths in junctions
4	Accidents involving pedestrians

The ranked list highlights the relatively large role played by ‘accidents in longitudinal traffic’, and ‘accidents with turning vehicle(s) or crossing paths in junctions’ (rank 2 and 3). The pre-crash systems addressed in ASSESS propose to yield beneficial safety outcomes with specific regard to these accident scenarios. This indicates that the ASSESS project is highly relevant to the current casualty crash problem. Further analysis is underway to define the accident parameters (and therefore test setup definitions) at a more detailed level.

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