ACCIDENTS STUDIES AND COLLISION CHARACTERISTICS

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1. ACCIDENT STUDIES

1.1. Definition of accident study

The investigation of accidents is the gathering, storing, adapting and analysing of accident data with the purpose to improve road safety. Accidents can happen to every kind of road-user but in this paper mainly car accident studies are mentioned, since car accidents, in most countries, are responsible for the greater part of the traffic casualties.
The human, vehicle and environmental elements of accidents are covering the complete area of all factors concerned in accidents. Results of accident studies are directly dependant on which element or combination of elements is studied.
A far more important and interesting distinction can be made in the sequence of facts during actual accidents (collisions) and therefore in the approach of accident studies, as mentioned in the next paragraph.

1.2. Pre crash versus crash studies

The sequence of what is happening in accidents, can be divided into three main phases: pre crash, crash and post crash phase.
In actual collisions these phases can be defined very accurately, for which we have to thank the former USA National Highway Safety Bureau, who invented the so called Program Matrix for Highway Safety Research (Figure 1).
In this cell matrix the important areas can be easily detected. The main distinction as far as accident studies are concerned lays between the pre crash and the crash phase.
In the pre crash phase one is concerned with accident avoidance or rather accident causation, since we are talking about real-accident studies.
In the crash phase one is concerned with injury prevention or rather injury causation.
In the post crash phase one is concerned with injury severity reduction, or rather with circumstances that have influence on injury severity.
In this paragraph only the main distinctions between pre crash accident studies and crash accident studies will be considered.

As already stated, in pre crash accident studies the investigators are looking for accident causation. This is a particularly tricky field since the definition of the accident cause is not a simple one, if there is any. And even then, the most important part of accident causation is contributed to the human element, so far most studies agree, but this element is the trickiest of all. Pre crash studies

have to deal with the most unpredictable factor in traffic: the human being and its behaviour. Even if those studies were concerned mainly with vehicles or environmental factors, the human influence can always spoil everything, unless robots are used for driving.
Besides, another very important factor in pre crash accident studies is the need of accurate exposure data. Those are by no means easy to gather, but are absolutely necessarily for comparing the accident population with the non accident population.

Crash accident studies are concerned with injury causation. Of course there is a human factor again in this area; in fact these studies are concerned mostly with the human element, but it is quite different from the pre crash human element. Human behaviour during the so called second collision (the crash phase in which the occupant moves relatively to the car interior and hits parts of it and becomes injured) is so predictable that already many mathematical (computer) models, describing behaviour, are existent.
For the study of injury causation, the accident investigator needs:
a description of the accident general;
a description of the exterior and interior damage to the cars;
a description of the injuries of occupants or other road users involved.
These fields are covered in the paragraphs 2.1 to 2.3 of this paper.

It might be strange for the study of human tolerance data, for which IRCOBI stands, crash accident studies cannot give conclusive data, since the missing factors in most crash studies are the exact decelerations and forces that actually caused the injuries or fatalities.
In paragraph 3 "Final remarks and recommendations" some possible solutions to this problem are mentioned.

However, crash accident studies do give answers to many important questions:

1. They give the injury pattern for the studied accident sample and this points straight to the areas of the human body that have to be protected. They also give the parts of the car (interior) that are responsible for the injuries and these parts also will form a pattern with main contributors (like steering column and windshield), that should be improved.
2. Crash accident studies will give effects of certain new features and improvements like energy absorbing steering columns, padding material and the use of seat belts.

Most of the studies mentioned in the following paragraphs will be crash accident studies. The authors acknowledge however, that future pre crash accident studies, if properly organised, might be more effective than crash studies, since the results are bound to take away the causes of accidents. But for the near future, crash accident studies are more effective, since they do not have to deal with the still unpredictable human behaviour. And even if human behaviour during the second collision is not quite uniform due to differences in age, sex, length, seat position etc., these data can be recorded easily and the influence can be analysed.

It is also true that, whatever (legal) measures will be taken in the near future, accidents will go on happening and therefore studies into injury reduction are necessarily.

1.3. Classification of accident studies by quality/quantity ratio

The perfect accident study covers all accidents of a certain country in a certain time and gives complete indepth information on all of these accidents.
Both quantity (the amount of different cases or accidents) and quality (the amount of different data for each case and their degree of reliability) have to be 100% for the perfect accident study. Of course this is a non-existent situation, even in the smallest countries. Generally spoken quality and quantity are inversely proportional to each other. A study with the highest quantity (all accidents that happened during a certain time) will have the lowest quality. The studying of a nations accident statistics might be called such a high quantity/low quality study. In such a investigation the gathering of the data is not part of the accident study, since in most countries those data are gathered primarely for general purposes. In most real-accident studies these general accident statistics will form the reference material to which the study sample can be compared and adjusted.
An example of the other extreme is the indepth multi-disciplinairy study of a small number of specific accidents with teams going to the scene, using all technical means to gather all available data (like tape-recorders for interviewing and reporting, and camera's for the recording of car damage etc.), thus resulting in a low quantity/high quality study. Even the best teams, or better just the best teams, cannot gather much more than about 50 accident cases a year, as practice of many accident teams will have learned.

Now here we have the main problem related to high quality (indepth) studies: the sample is too small for any kind of statistical analysis. And since the main purpose of accident studies is to improve traffic safety by its results, it is imperative that these results are based on a statistically reliable analysis. Even though the data themselves might be very reliable, the sample will be nearly always too small for overall reliability and those who are responsible for legal or other traffic safety measures need reliable information.
Of course this is recognised by most accident investigators and sometimes increasing the sample by studying less indepth or be increasing the number of teams, which is a very expensive method, is considered. For statistical analysis a minimum sample of 1000 to 10.000 cases have to be investigated, dependant on how many data relations the analyser will consider simultaneously, and what level of reliability will be accepted for significant differences. Therefore the most valuable accident studies of the world have samples of over 10.000 cases.

However, the indepth study of accidents might be give answers to specific questions, resulting from larger accident studies. Especially when those studies are concerned with one make and model car, sometimes even with one production year and with specific defined collision types (frontal only, or rollovers only) they might be give the exact answers that the investigators (often manufacturers) are looking for, for instance an answer to the question wether their steering column is working properly in actual collisions or not.

The quality of big sample accident studies (10.000 cases or more) can vary, since it is dependent on the way the accident data are gathered and by whom. Data can be gathered by police, by other road patrols, by special teams even, or they can be supplied by drivers themselves as we will see in the examples. The more distance there is between analyser and accident in terms of different reporters, the less reliable the data might become. Quality can still be fairly high as compared to indepth information, especially if the organisation has been carefully planned and not more is asked for than can be gathered reliably.

1.4. Classification on accident investigators

The investigation and data reporting on one hand and the data analysing on the other can be done by people of different disciplines, as we will see in the examples (paragraph 1.5.). But of course those who finally analyse the data and draw their conclusions are the ones responsible for the study as a whole.
Obvious categories for accident investigating institutes are:
1. Scientific institutes, including hospitals and universities;
2. Manufacturers (mostly car manufacturers);
3. Police;
4. Governmental resorts, excluding police and universities;
5. Other institutes.

Another classification is possible as far as the disciplines of the investigators are concerned. Most current investigators can be devided into three main disciplines:
1. Technical (vehicle and traffic engineering);
2. Medical (surgery);
3. Psychological (also sociological).

In multidisciplinairy teams one will find at least investigators of discipline 1. and 2., no matter which category of institutes is concerned. Psychologists are needed for pre crash studies only.

1.5. Examples of important accident studies

The examples mentioned in this paragraph are chosen for different reasons. In the first place all of them were completed or nearly completed and reported. In the second place they all show some interesting characteristics both in their organisation and in their results. They have been chosen out of different countries; still the choice is limited, due to limited space for this paper.
Six different studies are described shortly in the next paragraphs.
In paragraph 2.4. some of their collision characteristics are compared.

1.5.1. Volvo, Sweden

This well known study (ref.1) is not a current study anymore, although the results can be still very useful. Data were gathered in Sweden during 1965 and 1966. Only Volvo car accidents were considered and even more than 28.000 cases were examined. This Volvo study is an example of a crash study using completed questionaires of drivers as basic material and also using police and hospital reports for additional information. The sample was quite good for statistical analysis.

1.5.2. HUK Verband, Germany

The German Insurance Group, called HUK Verband, has studied accidents that occurred in 1969 and were reported to the German car insurance companies (ref.2).
A first sample of 10.271 accidents with occupant injuries were considered. Data were analysed by experts on car damage and injuries. Apart from data of insurance reports, data from police and hospitals were used. The reports yet published (I and II) can be considered as examples of a typical crash study. The material itself is also usable for pre crash analysing. No data about the amount of work needed for this study and the reliability have been published yet.

1.5.3. TRRL (Transport and Road Research Laboratory), Great Britain

This on the spot survey of accidents is the only typical pre crash accident investigation mentioned within this set of examples (ref. 3). It shows all the characteristics of such studies. The sample (gathered over a seven months period) is too small for statistical purposes but quite big for on the spot work with a team. This is the due to the fact that more than one team was available and that the working hours were 24 hours a day, and that not all accidents were studied completely indepth. The area was a mainly rural area around the laboratory.

1.5.4. ACIR, Cornell Aeronautical Laboratory, USA

This accident study of injury and noninjury crashes in rural Utah (ref. 4) is interesting because the effect of the use of seat belts could be analysed in relation to all crashes. The accidents happened from September 1966 through August 1967 and were reported by police on special forms to Cornell; photographs of vehicles and medical reports from medical and hospital authorities were included. ACIR developped a system of coding these data; the processing followed the general patterns already developped. The sample contains 7.125 car drivers.

1.5.5. Institute for Road Safety Research SWOV, the Netherlands

The results of this statistical research on the effects of safety belts and on injury causation have not been published yet. A final report is expected at the end of 1973.
During the end of 1968 and the years 1969 and 1970 accidents involving passenger cars were reported to SWOV by Dutch police and highway patrol officers. The area was selected to represent most parts of the country. Rural and urban accidents were reported. General accident data and general occupant data were gathered by means of forms sent to the drivers who completed and returned these. Overall response was more

than 50% and the working sample consists of 22.082 drivers. Medical data were collected after the accident by a co-operating medical institute. Car damage data were reported by special teams who visited the cars after the accident whenever this car could be found, which happened in 35% of all cases. In all 22.082 cases a damage report was made by the special teams from the general driver data, for which purpose the form was also developed. An analysis using multivariate analysis technics is carried out.

1.5.6. NATO - CCMS, Accident Investigation Study

The international study which is part of the big Road Safety Programme of the Committee on the Challenges of Modern Society of NATO is a pilot study, which means that the results are not directed towards improvement of road safety primarely, but towards improvements of accident investigations methods. The purpose in the study is the gathering of accident data (mainly crash data, but pre crash data can be examined voluntary) by means of on the spot examination with multidisciplinairy teams. About 9 countries are participating. Data are reported in a special collision form and the study is already on the point that final decisions about how to carry on in a follow up study can be made. The most important item of this study, apart from the international character is the collision analysis report form, which is similar for all participating teams.

1.5.7. Other studies

Worth mentioning are several current studies of the world.

1. There is in the USA a nation wide tri-level study, in which three types, each with a different quality/quantity relation, are combined all the advantages of each seperate study. Since in 1966 the Highway Safety Act and the Traffic and Motor Vehicle Safety Act became operational, many valuable accident investigation programmes have been started in the USA, and this tri-level programme is one of them. Reports on its indepth multidisciplinairy team studies are currently available all over the world; most of the reports are dealing with pre crash, crash and post crash factors simultaneously.
2. Another interesting "multidisciplinairy" study is formed by the combined efforts of Wayne State University, USA (Prof. Patrick) and Volvo Sweden. From this investigation is not much information available. Purpose of this study is the determination of human tolerance data by the combined methods of actual accident investigation and tests in the laboratory.
3. NATO - CCMS, already mentioned, is carrying more projects in which many countries of the world (including Japan and Sweden, being no NATO countries) are participating. Worth mentioning is the Experimental Safety Vehicle (ESV) programme, in which many accident studies were carried out by manufacturers or others.
4. Many other institutes, all over the world, are working on their own accident investigation programme and it is one of the aims of this paper that more co-operation will be reached, since it is proved that it can be done. (See the NATO - CCMS example).

2. COLLISION CHARACTERISTICS

In the first three paragraphs of this chapter, data needed for accident investigation are discussed. In paragraph 2.4 some of the actual collision characteristics of the 6 main examples, mentioned in 1.5, will be compared, or at least put next to each other.

2.1. Data classification

Data needed for accident investigation can easily be divided into three main categories:

1. General accident and occupant data;
2. Car (damage) data;
3. Injury data.

For crash accident studies all three categories of data are needed; for pre crash studies detailed data are needed of category 1, including a description of the maintenance condition of the car before the accident. In the next two paragraphs, data needed for crash accident studies are dealt with.

2.2. Review of important data and the ways of obtaining them

2.2.1. Important data

General accident data
date and location of accident
overall collision type (frontal, side, etc.)
collision sequence description (configuration)
collision speed and/or
driving speed before the accident.

General occupant data (for each occupant)
seat position
age
sex
description of available restraint system
use of restraint system.

Car (damage) data
general car characteristics (make, model, etc.)
car damage (every part of the car separately, interior and exterior)
damage causation.

Injury data
type and severity of every single injury to each occupant.

2.2.2. Obtaining of data

The ways to obtain all these data are various and dependent on how the study is organised.
Most general accident and occupant data are easy to record. Police reports can be used and also driver reports (such as insurance reports or special enquiry forms).

The greatest problem is the speed determination of which the collision speed is the most important. Once this factor is known, there is a reliable parameter for the accident severity. Many methods of reconstructing collision speed have been created, using skid marks and other physical evidence.
Driving speed can be determinated more easy, (for instance by driver, by witnesses) but gives less information about the resulting collision severity and the information might be biased.

Obtaining damage data of the case car(s) is mostly work for specialists, though there are some indirect ways that can be quite useful. For instance, since in many actual accident cases the specialists are not available, or will come too late on the scene, it can be necessarily that the damage data are recorded by others (for instance police officers, towing service people) by means of photographing. The responsible accident investigators and analysers may use these photographs or slides to determinate the damage of the car. Even if specialists did see the car(s), in many cases slides and photographs proved to be very useful.
In Figure 3 a comparison is made for the mentioned study examples as far as the obtaining and description of the important accident data are concerned (see also paragraph 2.3). In some studies damage data were provided completely or partly by drivers (or in case of fatalities) by police-officers.
It also might be useful, if driver enquiries are being used, to ask questions about the parts in the interior that were hit and relate the answers to the same data from reports of damage specialists.

Accurate injury data can easily be obtained, assuming that a physician or surgeon made a report on the injuries. Co-operation of medical authorities proved to be rather well in most studies yet reported.
Since in most countries various legal problems arise if someone is killed in an accident, the autopsy reports (if available) and injury descriptions might be very difficult to obtain, thus causing a big lack of information for those cases. Hospital teams, organising accident studies, have an advantage there, since they will start their cases on detailed injury descriptions even of fatal injured occupants.
The only source for injury description of minor injured occupants, are the occupants themselves. This information and also the knowledge that certain occupants were not injured at all, are important data in every crash accident study, because this information might help to answer the questions about threshold values for injury causation, concerning interior structures and human tolerance data.

2.3. Data description in accident forms

2.3.1. General

In every accident study some kind of accident form is used for the uniform recording and storage of accident data. Since for the studies with bigger samples almost always (digital) computer analysis or at least computer counting is applied, the forms will show already signs for that purpose. This means that numerical codes have to be used and code lists have to be available, either on the form itself, or on separate lists, for every separate variable.

Simple data like sex (male, female, unknown) are easy to describe numerical, for they need only one computer card column. In cases with more than 9 or 10 possibilities within one variable it is possible to use two or more columns (digits), as with "speed" or "age" or "year".

2.3.2. Severity scales

In most studies codes have been created for severity ratings both of the car damage and the injuries to each occupant. These severity ratings can be very important for simplifying the analysis and for comparing accidents.
A well known car damage severity index is the Vehicle Deformation Index (VDI), created in the USA. This index is among others described in the SAE draft Recommendation Practice, nr J 224a, 1971. Apart from a classification for the damage severity this index gives a description of the main collision events and the damaged parts of the car (using a total of 7 digits).
This index has been used in the NATO-CCMS study but until now, on its interpretation no final agreement has been reached.

Simple, but very useful severity ratings for car damage classify the damage into 5 or 6 categories, ranging from "0" = no damage to "5" or "6" = complete destruction of car compartment.
To avoid misinterpretation it is important that a severity scale is simple enough. But at the same time, to allow the analyser to determinate the important differences between categories, it has to be detailed enough.

Another important severity scale is the injury severity scale,of which many different kinds are in existance today. A well known American one is the Abbreviated Injury Scale (AIS), also been used in the NATO-CCMS study. All these scales give in more or less categories the overall severity of the injuries to an occupant, ranging from not injured to fatal injured. The simplest way is a three category scale: not injured, injured, dead. A more sophisticated one is: not injured, slightly injured, severe injured, fatal injured.
Of course all depends on the proper description of the different categories, but practice proved that less difference between analysers existed in interpretation of injury severity than in interpretation of car damage severity. Both the damage severity and the injury severity need support of detailed damage and injury descriptions for detailed analysis.

2.4. Examples of characteristics of accident studies

In this paragraph some of the most interesting characteristics of the before mentioned studies will be compared, as far as comparison is possible and allowed.
Important characteristics of accident studies are:
distributions of collision types;
distributions of collision speeds;
distributions of injuries to body regions;
distributions of injury severity;
effects of use of seat belts.
In Figure 4 these characteristics are given.

In some studies no collision speeds had been determinated but driving speeds by means of driver reports.
The effect of the use of seat belts can be described in terms of the number (or percentage) of people that would have been saved from fatalities or injuries with regard to the number of people actually killed or injured, if they had been using their belts.

3. FINAL REMARKS AND RECOMMENDATIONS

Crash accident studies have proved to be adequate means of improving traffic safety by applying their results in terms of improving exterior and interior parts of cars (especially by applying restraint systems) and environment.
Pre crash studies have to deal with the almost inpredictable human behaviour factors and their results might therefore be difficult to apply; although recommendations for improvement of cars and roads, as far as accident prevention is concerned, seems to be necessary.

Human tolerance data, the determation of which is part of the IRCOBI programme, cannot be gathered only from crash accident studies. Supplementary information is needed on the forces and decelerations that caused actual injuries or fatalities.
Two important ways existing today are:
1. The use of laboratory (sled) test in which dummies or human cadavers are being used and in which the collision conditions can be accurately measured. By combining these results with those of actual accident information on injuries, it is possible to determinate threshold values for injury causation. Many different projects in this area are carried out all over the world at this moment (one being mentioned in paragraph 1.5.7., item 2).
2. By providing a big sample of cars (preferably of one owner) with so called crash recorders, in which the decelerations of the car during the accident are recorded, the accident investigator has got much actual information about the accident severity; but even then he will miss the forces and decelerations to the occupants themselves.
Again in the USA a promising project had been started, involving cars of fleet owners. But this project seems to be abandonned due to lack of money.

It has been stated that there is need for big sample accident studies. Since gathering indepth information (often on scene studies) means small samples, there are two ways left:
1. Organising large statistical accident studies as given in some of the examples, in which qualitatively fair information was gathered without visiting the scene of the accident. A preliminary study of the differences between on-scene and off-scene information as far as quality concerned (carried out by SWOV) did not show that off scene information was necessarily worse than on scene information.
2. The combining of indepth studies. If organisers of indepth crash studies use the same accident report forms, and if the ways of gathering the data are the same, it is possible to compare and/or to combine results, provided that differences in specific local factors can be eliminated.Up tillnow it proved to be almost impossible to compare results of different accident studies. The examples of Figure 4 will prove this.

The NATO-CCMS Accident Investigation Program seems to be one of the first in which these facts are acknowledged, and we hope that all parties concerned will agree upon ways to go on with this kind of combined investigation.

No crash accident studies have yet been mentioned concerning improvement of the environment (the third factor in the accident area of Figure 1). However, many studies are existing and it has been proved that studies on roadside obstacles and guard rails are important contributors to road safety.

REFERENCES

1. N.I. Bohlin. A statistical analysis of 28000 accident cases with emphasis on occupant restraint value. AB VOLVO, Gothenburg, Sweden

2. Innere Sicherheit im Auto. Eine Untersuchung des HUK-Verbandes über PKW-Unfälle mit Insassenverletzung. Bericht über 10.271 Fälle, nr I und II HUK-Verband, Hamburg, Germany, 1972.

3. R.N. Kemp. I.D. Neilson, G.C. Staughton and H.A. Wilkins. A preliminary report on a on the spot survey of accidents. TRRL report LR 434. TRRL, Crowthorne, Berkshire, U.K., 1972.

4. Jaako K. Kihlberg. Efficacy of seat belts in injury and noninjury crashes, in rural Utah. ACIR-CAL report VJ-2721-R3. C.A.L., Buffalo N.Y., USA, 1969.

	pre crash	crash	post crash
human	1	2	3
vehicle	4	5	6
environment	7	8	9

Figure 1. Programme Matrix for Highway Safety Research

	VOLVO	HUK	TRRL	ACIR	SWOV	NATO-CCMS
	1	2	3	4	5	6
sample year	1965/66	1969	1968/69	1966/67	1969/70	1970/71
number of cases	28780 drivers	10271 drivers	247 drivers	7125 drivers	22082 drivers	500 drivers
quantity/ quality	high/ fair	high/ fair	low/ high	fair/ fair	high/ fair	low/ high
data analysed by	VOLVO, Sweden	HUK, Germany	TRRL, U.K.	CORNELL, USA.	SWOV, Netherlands	SOUTH WESTERN RESEARCH INST. USA.
institute code (see 1.4.)	2	5	1	1	1	1
area	rural mostly	unknown	rural mostly	rural	rural and urban	different for different teams
types of cars	Volvo's only	all	all	all	all	different for different teams
types of accident	all	only drivers who were "quilty" only injury producing accidents	all	injury producing and non injury producing accidents	all	different for different teams

Figure 2. Characteristics of 6 different accident studies.

Reporting of	VOLVO	HUK	TRRL	ACIR	SWOV	NATO-CCMS
general data by	drivers	drivers	team	police	drivers + police	different for different teams
car damage data by	drivers	damage group	team	police	special teams	see above
injury data by	drivers	doctors and hospitals	team + hospitals	police + hospitals	special physician + driver information	see above
damage severity scale used	own system repair costs and estimated collision speed	own system 5 categories non lineair	own system 5 point scale + lineair	own system estimated impact speed into 4 categories	own system 5 categories non lineair	VDI
damage reporting	not detailed	detailed	not detailed	not detailed	detailed	very detailed
injury severity scale used	own system 3 and 4 categories	USA system 7 categories	STATS system 4 categories	police system 5 categories	own system 7 categories	AIS
injury reporting	groups of injuries coded	detailed code system for severity, type and body region	none	none	detailed code system ("N code") for severity, type and body region	detailed code system for severity, type and body region
amount of data or computer cards for one	at least 80 different data	about 200 different data	unknown	about 80 different data	about 280 different data (average of 4 computer cards)	about 3000 different data (average of 50 computer cards)

Figure 3. Comparison of the ways data were reported and described in 6 accident studies

	VOLVO	HUK	TRRL	ACIR	SWOV	NATO-CCMS
number of drivers and passengers	28780 drivers 8731 front seat 5302 rear seat 42813 occupants	10271 drivers 5175 front seat 1909 rear seat 17355 occupants	not reported	7125 drivers 4163 front seat 2564 rear seat 409 unknown 14261 occupants	22082 drivers 9088 front seat 5347 rear seat 1490 other + unkn 38207 occupants	not yet reported
distribution of collision types	frontal 35,7 side 33,5 off road 17,2 roll over 4,9 rear and other 8,7 100% 28780 cases	frontal 30,2 side 41,3 rear 28,5 100% 10271 cases	not reported	frontal 40,6 side 11,3 rear 15,3 roll over 8,6 unknown 24,2 100% 14261 cases	frontal 41,5 side 25,5 rear 13,6 roll over 4,0 underride 0,2 rear+front 7,3 other 4,0 unknown 3,9 100% 22082 cases	see above
distribution of speeds	not available	only available for seperate collision types	not reported	highest impact speed (mph) < 20 23,7 20-39 35,2 40-59 22,6 ≥ 60 7,8 unknown 10,7 100% 14261 cases	driving speed (km/h) 0 13,5 1-25 19,2 26-50 34,4 51-75 14,7 76-100 12,2 101-125 2,2 > 125 0,8 unknown 3,0 100%	see above
distribution of damage severity	not available	only cat to car collision (8226 cases) light 5,9 medium 31,3 heavy 46,6 very heavy 13,0 total destruction 3,2 100%	0- 8,9 $\frac{1}{4}$-17,0 $\frac{1}{2}$-38,5 $\frac{3}{4}$-22,3 1- 8,9 $1\frac{1}{4}$- 2,8 over $1\frac{1}{4}$- 1,6	not available	minor 63,3 moderate 14,0 severe 11,3 considerable compartment damage 3,3 complete compartment destruction 0,9 unknown 7,2 100%	see above

Figure 4. Part 1

	VOLVO	HUK	TRRL	ACIR	SWOV	NATO-CCMS
distribution of injury severities (drivers only)	not available for all 28780 cases	no injuries 22,8 light 60,2 moderate 12,3 severe 3,0 dangerous/ life threatening 0,6 fatal 0,9 unknown 0,2 100%	not reported	not available	no injuries 63,7 light 20,4 moderate 8,7 severe 3,6 dangerous/ life threatening 0,6 fatal 1,4 unknown 0,2 100%	not yet reported
distribution of injuries to body regions (drivers only)	not available	head 39,6 thorax 17,2 abdomen 5,6 neck 19,5 spine (lower) 3,0 arms 32,4 legs 39,3 10271 = 100% (number of drivers)	not reported	not available	brain 14,1 head 14,5 neck 6,8 thorax 7,7 abdomen 1,2 back 2,8 pelvis 0,3 arms 21,3 legs 31,2 16046 = 100% (number of injuries)	see above
effectiveness of seatbelts	3-point belts: 40-90% injury reduction dependent on speed no fatalities below 60 mph accident speed	considerable effectiveness	not reported	lap belts, all occupants: 50% reduction; any injury: 40% more risk if seat belt not used	50-80% reduction of fatalities for all seat belt types together	see above

Figure 4. Comparison of some characteristics of 6 accident studies. Part 2

Summary

This paper gives a review of real-accident studies in general, the required efforts, the problems and the benefits.
Examples of specific studies from different countries of the world are mentioned and some of their characteristics are compared, both in terms of organisation and of results.
Though much of the data used in this paper are based on various literature, only in specific cases references are given.
Emphasis will be laid on so called crash accident studies, of which a definition will be given.