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The development of a method for traffic safety evaluation: The Swedish Traffic Conflicts Technique

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FOREWORD

Research on the Traffic Conflicts Technique has engaged a great number of people at the Department during the years.

It all began at the PLANFOR-group, headed by Olof Lövemark, in the early seventies.

All the efforts made since then have resulted in a working procedure that enables us, as well as others, to use the technique in traffic safety evaluation.

The findings presented in this report will hopefully contribute to a better understanding of the concept of conflicts, a concept that has started an "arousal" with many researchers, not only those directly involved in the area.

After more than 15 years in this area, I am still eagerly looking forward to the continued progression of work and the integrated discussions.

Financial support to this research is, during the last years, provided by the Swedish Transport Research Board.

I want to thank Gösta Lindhagen for his guidance and devoted work during the whole process that finally resulted in this report. Per Gårder, who is one of the old-timers, has also been heavily involved in reading, commenting and discussing the outcome. Per's wife Eva assisted me in correcting and improving my English. Karin Brundell-Freij has provided me with valuable guidance through tricky parts of the analysis and Arne Hansson also contributed a lot to the progression.

All my colleagues in the Traffic Safety Group at the Department have been heavily involved in all sorts of ways, from the first moment till the last.

Mia Sinclair, Inger Myhrén, Birgitta Åkerud and Anne-Marie Malmstedt have been doing all the typing. Majvi Magdeburg has made the drawings, except for the one on the front page which is made by Håkan Persson.

In addition to those mentioned there are quite a few other persons who have been involved in one way or the other. I want to thank everybody, mentioned or not, for invaluable assistance in this extensive research work.

Finally, I want to thank my dear family, from the youngest (Live) to the oldest (Ida-Marie). They have all supported me fully through the entire process.

Christer Hydén

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SUMMARY

This report is presented as an historical review of the developmental work that has been going on at the Department of Traffic Planning and Engineering at Lund University since 1974.

Motives for the need of intermediate measures in safety evaluation

To start with, I argue for the need for intermediate measures in safety evaluation. Evaluation of safety, based on accidents only, has a number of disadvantages:

- In many applications the accident numbers are so small that they easily lead to misinterpretations. In order to increase the numbers, one has to increase the number of applications or increase the analysis period. Both cases create problems - the first regarding the generalization of the results, the second regarding correction for accident trends over time.

  These problems make it very difficult to follow up the effects of a countermeasure that is introduced, for example. It is particularly difficult to analyze the development of the effects over time, which is quite important, as there are reasons to believe that short-term effects are often different from long-term ones.

- Regression to the mean is another problem linked to the use of accidents. Selection of entities for treatment, say intersections, is most often based on the accident history. This choice is also a natural one, but it creates problems because in most cases the "occurred number of accidents" is, due to the biased sampling higher than the "average expected number of accidents". In a before and after study it means that the safety effects will be overestimated. I have shown in the report how this problem can be treated theoretically but I also showed that it is much more difficult to apply these theories to a "real-life" situation.

- Diagnosis based on accidents is one of the main problems in safety evaluation. Highly qualified data that can be used for describing the pre-crash phase is only available through expensive in depth studies. This technique is, therefore, very rarely used for systematic data collection. The normally available accident information, through police records, gives very few indications, if any, on the causes of accidents.

The different problems involved in the use of accident data are illustrated with a case study: in order to obtain a larger data-base, the five Nordic countries together evaluated the safety effects of individual signalization of zebra-

crossings. All the problems mentioned earlier were still at hand and operational guidance to the implementors was almost non-existent.
The conclusion from this first part of the report is that accident data needs support to ensure a valid and useful evaluation of safety.

The introduction of indirect safety measures

Indirect safety measures are very logical examples of complements to accidents. Near-accidents are, for instance, used on a large scale in such different circumstances as in air transportation and work safety. These two, very different applications of near-accident studies, indicate clearly that the same concept should be able to be used in road transportation as well.

The strong need, expressed by local authorities, for a short-term evaluation of traffic management schemes, led to my involvement in the development of a Traffic Conflicts Technique (TCT).

Theory behind our Traffic Conflicts Technique

The basic idea behind our technique can be expressed as follows:

The interaction between road-users can be described through a number of elementary events. (figure S:1). These events occur with different probability and different degree of seriousness. One hypothesis is that serious conflicts are indicators of a break-down in the interaction between two road-users, i.e. the perceived accident-potential is so high that at least one of the road-users would not like to be involved in the creation of a similar event deliberately.

The basic hypothesis is:

THERE ARE ELEMENTARY EVENTS, DEFINED AS SERIOUS CONFLICTS, THAT CAN BE CHARACTERIZED AS BREAK-DOWNS IN THE INTERACTION. THE ACCIDENT POTENTIAL IS THEN WELL-DEFINED, I.E. THERE EXISTS A RELATIONSHIP BETWEEN THE NUMBER OF SERIOUS CONFLICTS AND ACCIDENTS.

Two important issues remained before this definition phase could be considered as finished:

1) Events, as described in figure S:1, had to be classified with regard to severity.

The threshold level between slight conflicts and serious conflicts had to be defined.

Among a number of candidate definitions of severity we selected a time based measure. We defined the Time to Accident (TA):

"TIME TO ACCIDENT" IS THE TIME THAT REMAINS TO AN ACCIDENT IN THE MOMENT WHEN EVASIVE ACTION HAS JUST BEEN STARTED, PRESUPPOSED THAT THE ROAD-USERS CONTINUED WITH UNCHANGED SPEEDS AND DIRECTIONS.

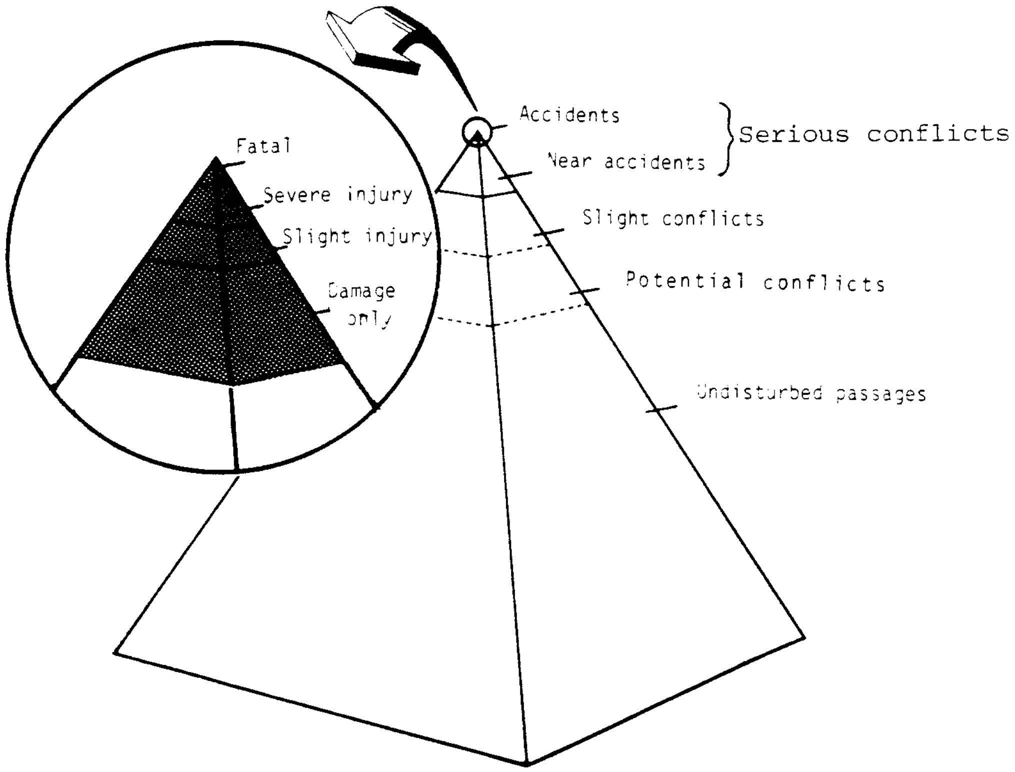


FIGURE S:1

Our opinion was that the time-margin as such was the best individual measure for the description of the closeness to an accident. We also considered the TA-value to be the best moment on the time-axis to use. This moment gives a "non-manipulated" indication of how close the road-users were to an accident before they detected the hazard. This would be particularly true for serious conflicts where no alternative, but a quick and harsh action, is at hand.

The threshold between slight conflicts and serious conflicts was derived from analyses of video-taped conflicts. Time to Accident values were evaluated and compared with the reaction and action by road-users. We came fairly quickly to the conclusion that there seemed to be a rather distinct time limit below which no road-user seemed to want to get involved in a conflict on purpose. This time limit was 1.5 seconds. We, therefore, selected the following general definition of a serious conflict:

A SERIOUS CONFLICT OCCURS WHEN THE TIME TO ACCIDENT IS EQUAL TO, OR LESS, THAN 1.5 SECONDS.

The definition was generally applicable to all kinds of conflicts involving at least one motor vehicle, occuring in urban areas with a speed-limit of 50 km/h or lower.

After some comparisons of video-based recording of conflicts with human observers in the field, the latter observation method was selected as being the most flexible and cost-effective one.

Two major topics remained in order to complete the development of the TCT:

1) The reliability of the technique, i.e. how accurate could human observers be in detecting and scoring conflicts with regard to the 1.5 seconds-criterion?

2) The validity of the technique, i.e. were these serious conflicts related to accidents in some way?

These two topics were dealt with for the first time in a project that ended in 1976.

<u>First generation of tests of observer reliability</u>

The reliability of observers was studied through tests where a number of observers were recording simultaneously, at the same location, with simultaneous video-taping. These video-tapes were evaluated afterwards by a number of experienced observers whose mean values formed the basis for a comparison with the groundlevel recording by human observers. Two tests (5+7 observers, 8+5 serious conflicts to be scored) produced very similar results. The main conclusions were:

- On the whole, there were very few missed serious conflicts, ranging from 10 % and 14 %

- Very few events were scored as serious conflicts without being so, on the whole only 4 out of 75 relevant scorings, corresponding to 5 %.

These results combined with others, where observer reliability was studied more indirectly, gave us the confidence to consider the observers "reliable enough" to allow large scale studies to start.

<u>First generation of validity studies</u>

The first approach to the validation problem was taken in the years 1974-76. We carried out a pure predict validation, i.e. we studied to what extent serious conflict numbers could predict accident numbers. The following strategy was used:

- Accident and conflict data were collected from altogether 115 intersections. Data about geometrical design, type of regulation, etc, were also collected.

- Data were grouped in three sub-sets; 50 intersections from the city of Malmö, 15 intersections from Malmö, and 50 intersections from Stockholm.

- To start with, the Malmö - 50 data was used for a multiple regression analysis where those variables were identified that accounted for a noticeable variation in the relationship between serious conflicts and accidents. The following variables were identified:

  * Category of road-user, (car-car, car-bicycle, car-pedestrian)

  * "Traffic class", (signal - or not signal controlled, low or high speed situations, in principle, defined by the average speeds in different flows. A high speed situation was at hand, for example when at least one of the cars involved belonged to a flow with a high average speed).

Variables such as "sight distance", "time of the day" and "islands" did not seem to influence the variation.

- Conversion factors (π*), i.e. ratios between number of accidents and number of conflicts, were estimated for four cells in each of the sub-sets. Confidence limits for each estimate were also calculated, based on the assumption that both accidents and conflicts were following Poisson-distributions.

The three sub-sets were then compared, cell by cell. The estimates were found to be similar enough to allow a combination of all three sub-sets. Figure S:2 presents the results from the final combination of Malmö and Stockholm data.

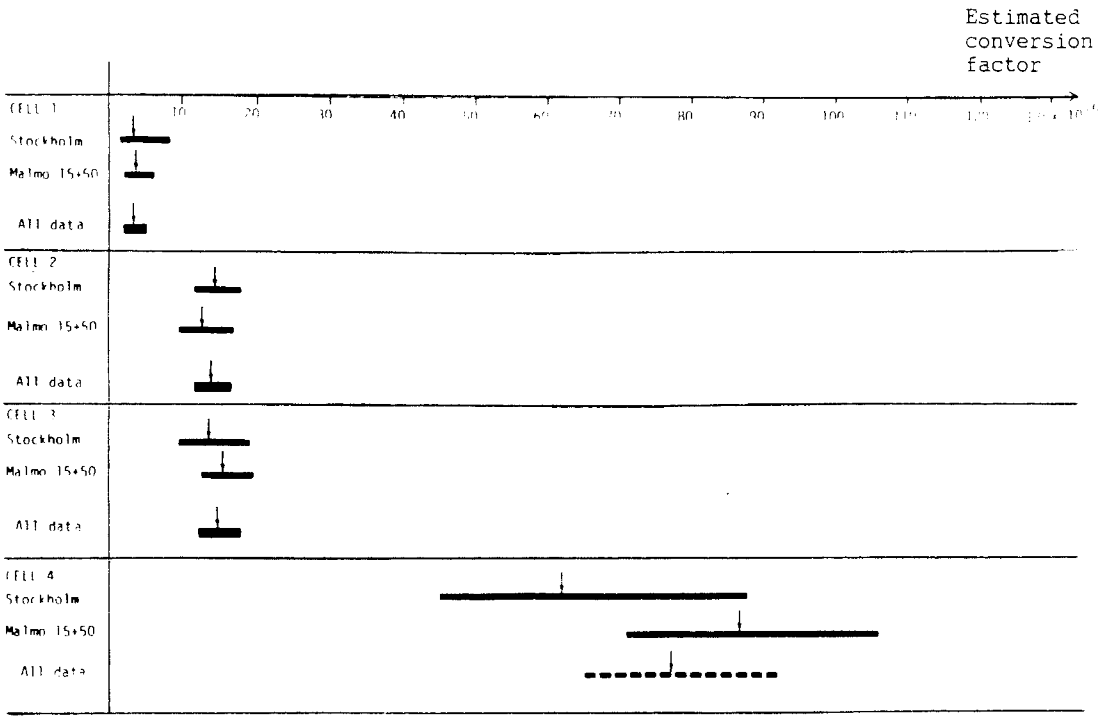


FIGURE S2: FINAL CONVERSION FACTORS FOR THE MALMÖ AND STOCKHOLM DATA COMBINED.

Evaluation of the original technique and modifications

These conversion factors have been used for almost ten years, in research as well as for practical applications. Their ability to predict accident numbers in new situations have been shown to be satisfactory, even though there seems to be a systematic overestimation. The usefulness has still been demonstrated, for instance, in before- and after-studies where safety effects have been possible to evaluate in the short-term, thanks to conflict studies. The usefulness of the technique for diagnostic purposes has also been demonstrated. There were, however, some drawbacks with the original technique:

New definition

The definition of a serious conflict had some obvious limitations. The simple 1.5 seconds criterion did, for instance, not take into account the speeds of the road-users. We did, come to the conclusion, fairly quickly that the threshold level between serious and non-serious conflicts should be speed-dependent, in addition to the TA-dependence. (The higher the speeds, the more severe were the conflicts, given the same TA-value). Five different alternative definitions of severity (and serious conflict) were selected for testing. The five definitions were different regarding their "degree of speed dependence". Based on the combined results from all tests (described later under the discussion about validation), the so called ALT.DEF 2 was found to be the most relevant definition (see figure S:3).

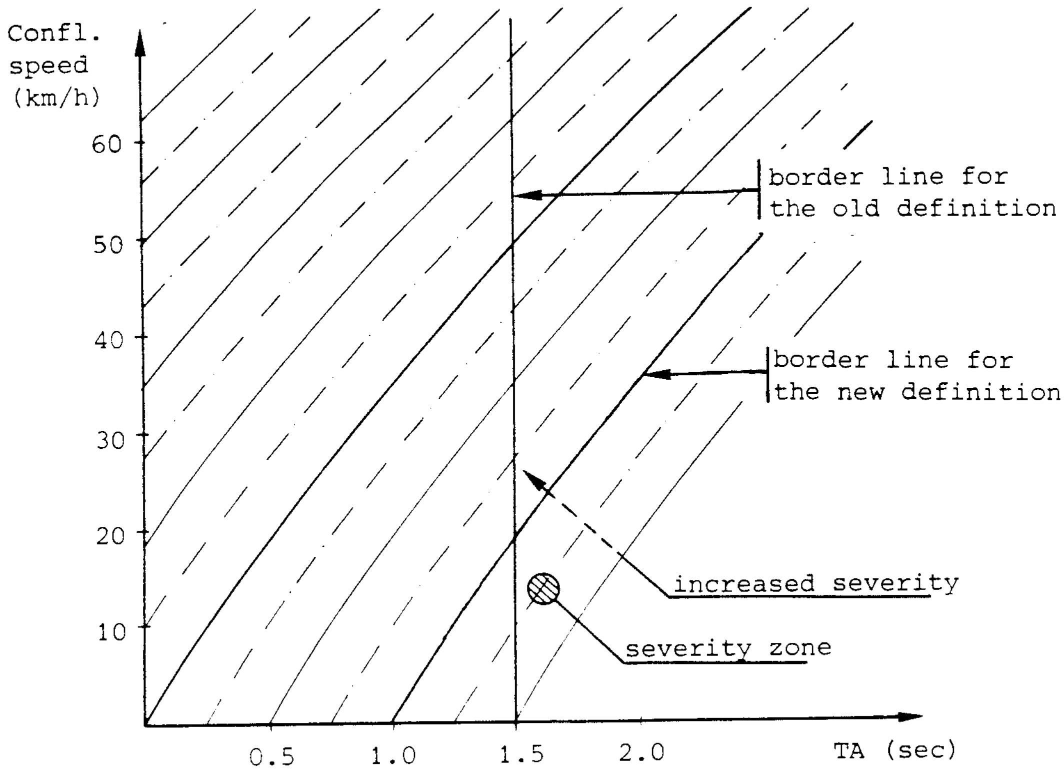


FIGURE S:3 THE OLD AND THE NEW DEFINITION OF A SERIOUS CONFLICT AND DEFINITION OF SEVERITY.

New generation of reliability studies

The old reliability studies were tentative, in the sense that there was no objective evaluation of conflicts from the observers' estimations. An international calibration study of different conflict techniques, in Malmö Sweden, 1983, gave an opportunity to compare estimates with objectively evaluated data. A semi-automatic, video-based, recording technique developed by IZF-TNO in the Netherlands was used to produce objective data. This has enabled me to compare speed and TA-estimations by our observers with the objective evaluation. The average TA-values for our observers showed a 0.05 seconds difference from the objective evaulation. In 50 % of the conflicts, the observer estimations were within the objectively evaluated value, ± 0.2 seconds. The speed estimations were on average, only 3.0 km/h lower than the objectively evaluated speeds.

This analysis also showed that our observers missed detecting 20 % - 25 % of the serious conflicts they were supposed to detect and write down.

These results are very encouraging and support the old studies. The conclusion is that human observers can detect and score (estimate TA and speed) without any problems for the use of the technique from this view-point.

Process validation: A new approach

An alternative to focusing on the predictive validity of serious conflicts, is to focus on the process validity, i.e. to compare the processes that lead to accidents and conflicts respectively. This has, however, created heavy problems because the information from accident-records about the pre-crash phase is normally very limited.

Still, I have, in the report, introduced a new approach to the validity problem by comparing the last phase of accidents and conflicts, from the moment when one of the road-users takes evasive action. This is the same moment as when the TA-value is determined. I collected information about accidents from the complete police-accident investigation files of injury-accidents. Data on conflicts were collected from the earlier mentioned, on-going, project on predictive validity.

The comparison of conflicts and accidents demonstrated similarities. Figure S:4 gives an example where the comparison is based on a TA-Conflicting Speed evaluation. (Conflicting Speed is the approach speed, in the moment evasive action starts of the road-user that stands for the TA-value.)

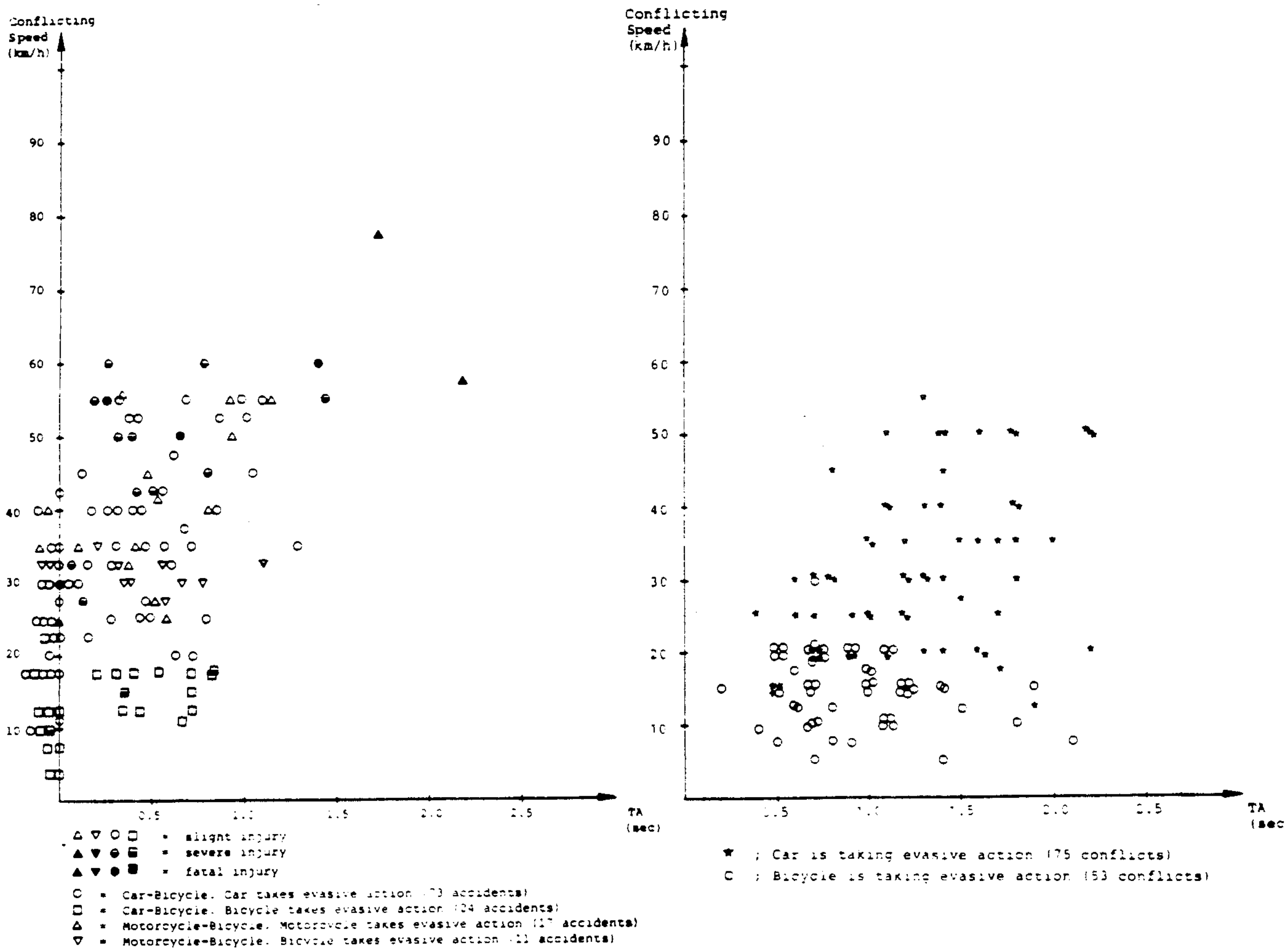


FIGURE S:4 TIME TO ACCIDENT AND CONFLICTING SPEED FOR ACCIDENTS AND CONFLICTS.
Car-bicycle.

We can see from figure S:4 that accidents and conflicts are very equally distributed with only a slight displacement of accidents towards lower TA-values and (partly) higher speeds.

Similar graphs as in figure S:4 are also made for "car-car" and "car-pedestrian". The three pairs of graphs were used to compare the five different alternative defintions of severity, by testing four criteria. The most important ones were:

- conflict severity, i.e. that severity increased with increasing severity zones. (See figure S:2). Conflict severity was defined as the accident-to-conflict ratio.
- accident severity, i.e. that severity of the accidents increased with increasing severity zones. Accident severity was defined as the weighed value of total costs for accidents of different severity.

The comparisons indicated very clearly that the ALT.DEF.2 was the most relevant definition, and it fulfilled all the four criteria in a quite satisfactory way. It produced severity distributions, both for conflicts and for accidents, that were logical and relevant: severity increased continously and logically.

In a second step of the process validation, evasive actions in conflicts and accidents were compared. "Braking only" was by far the most common action, both in conflicts and in accidents. (79 % and 68 % respectively, on the whole dataset). "Braking + swerving" was the second most common action (14 % and 20 % respectively), "swerving only" third (5 % and 10 % respectively). "Accelerating" was the least common action with 2 % among both conflicts and accidents.

The similarities between conflicts and accidents are big enough to draw the general conclusion that conflicts work satisfactorily as substitutes for accidents even from this point of view.

International comparisons

This report also presents the International Committee on Traffic Conflict Techniques (ICTCT) and its aims. One of its larger achievements was the execution of a calibration study in Malmö, Sweden, 1984. Eight teams were present, representing different TCT:s developed. Simultaneous recording on groundlevel was combined with video-taping continuously. A comparison between the eight teams was made, as well as a comparison between the scorings of the eight teams and some objective measures. It was found that a TA-related time measure (MTTC) was the most important factor in explaining the common severity. (MTTC = Minimum Time to Collision, at a continous measuring during the entire duration of the conflict. TTC is the projected time to collision presupposed unchanged speeds and directions). The second most important variable was found to be the "minimum distance between the two road-users." Thirdly, "conflict type", i.e. the type of road-user involved. Time to Accident was not included in this analysis.

It can be concluded from this calibration study that it seems as if the Swedish TCT includes all the three variables that were found to be important in explaining the common severity. The "time measure" and "conflict type" are included more directly than the "minimum distance". The latter is, however, indirectly included through the combined TA- and speed based definition of severity. (See figure S:2).

Road-users' perceived risk in conflicts

One of the basic hypotheses, namely that serious conflicts could be characterized as break-downs in the interaction between two road-users, have been tested through interviews with road-users that had been involved in conflicts. Road-users were stopped immediately after the occurrence of a conflict. Two questions relevant to the hypothesis mentioned above, were directed to the road-users. The first dealt with the recognition of the conflict, and the second with the road-users estimation of the likelihood that the conflict could have ended up as an injury-accident.

The results can be interpreted in the following way with regard to the hypothesis: both questions produced a very distinct difference between serious and non-serious conflicts. The first one showed that the proportion of road-users that could recognize the correct conflict without assistance was around 25 % for non-serious, while it was ranging from 55 % to 80 % for serious conflicts (the highest values for the most severe conflicts). The estimated likelihood that the conflict "easily could have ended up as an injury accident" was around 5 % for non-serious conflicts, while it was ranging from 15 % to 30 % for serious conflicts (highest value for the most serious conflicts).

The distinct difference between serious and non-serious conflicts gave a lot of support to the hypothesis of serious conflicts as indicators of break-downs in the interaction.

It was not possible, however, to detect a distinct threshold value between the two groups of conflicts. This indicated that the choice of borderline for serious conflicts exactly as we did, was not critical, from this point of view.

Conclusions

The major conclusions from this report can be summarized and commented on as follows:

- The definition of a serious conflict is improved, thanks to the introduction of the TA- and speed dependent threshold level between serious and non-serious conflicts. Further modifications are discussed in the report, some of them found to be interesting in the long run. As long as data volumes cannot be extensively bigger, however, a possible improvement due to the introduction of further modifications will hardly be possible to detect.

At present we,therefore, have a great confidence in the present definition.

- The reliability of the observers must be considered as fully acceptable. The bias introduced by them is very small, and it does not seem to create any problems in the use of the technique.

- The new process validity approach, that I have presented, is very promising because it has linked accidents and conflicts in a new and better way. The demonstrated similarities showed that accidents and conflicts (defined in our way) have very similar characteristics in their last phases. The results indicated clearly that conflict severity, the accident-to-conflict ratio, increased with increased severity zones and that accident severity also increased with increased zones. This opens up the possibility of new predict validity approaches based on a two-step design:

  1) The probability of a collision is determined, using information about, among other things, the conflict severity.
  2) The severity of the collision's outcome is determined using, among other things, the conflict's severity.

A validity study, for this purpose, should, however, be dealt with on a much larger scale than the earlier studies.

This, however, demands a new recording technique which can make recording of conflicts much more cost-beneficial than the present technique. (Video-based techniques for image-processing are mentioned in the report as one of the great potentials for future use).

More qualified accident information on a large enough scale is also highly warranted. This is particularly true for information about the pre-crash phase.

The usefulness of the TCT is discussed in the end of the report. It is obvious that the use today of the TCT on an operational basis is fairly limited. The main drawback of present techniques is most probably that data-collection is too time-consuming. The need for a more cost-effective recording technique is, therefore, coinciding with the need demonstrated for validation purposes.

The benefits of using the TCT on a routinebasis, in research or elsewhere, can, therefore, not be ascertained today to any greater extent. Research at out Department has, however, shown that the TCT can play an important role in identifying hazards (including their causes) and in testing new countermeasures in the field.

Finally, I want to stress the importance of seeing the TCT as one of many tools in the area of safety evaluation. A wide approach to this area demands the intergrated use of indirect and direct measures. It is in this context that the Traffic Conflicts Technique should be seen, and it is also from this stand-point that the TCT should be assessed.

NOTATIONS

ALT.DEF.1-5:	Alternative definitions of severity tested in section 7.3.
Collision course:	Two road-users are going to collide if they continue with unchanged speeds and directions.
Conflicting Speed:	Speed of the relevant road-user involved in a conflict, at the moment when TA is calculated.
Conflict type:	Type of road-users involved in conflicts. Section 7.4 (type of conflict is sometimes used synonymously to manoeuvre type).
Conversion factor (π):	Accident-to-conflict ratio.
Ground-level observers:	Human observers located on the ground, at the intersection studied.
MTTC:	Minimum Time To Collision.
Manouvre type:	A combination of the manoeuvres of the two road-users involved in a conflict or accident.
Potential conflict:	Elementary event in the interaction between two road-users.
Predict validition:	To establish the relationship between the (expected) number of accidents and the (expected) number of conflicts.
Process validation:	To establish the relationship between the processes leading to accidents and conflicts respectively.
Relevant road-user:	The road-user who defines the severity of a conflict.
Safety:	The expected number of accidents. (Used in connection with predict validation).
Serious conflict:	1) Elementary event in the interaction between two road-users. 2) Original definition: A serious conflict occurs when the Time to Accident is equal to or less than 1.5 seconds. 3) New definition: Conflicts that have a combined TA-Conflicting Speed value that fulfills the criterion of ALT.DEF.2, severity zone 2 or higher.

Severity:	A relation between TA and Conflicting Speed. (Increased severity is a result of either higher speed or lower TA or both).
Severity of accidents:	The indexed severity of (police-reported) injury accidents.
Severity of conflicts:	The accident-to-conflict ratio in different severity zones.
Severity (value) of a conflict	The lowest severity among the two road-users involved in the conflict.
Severity zone:	A zone in the TA-Conflicting Speed graphs with uniform severity.
Slight conflict:	Elementary event in the interaction between two road-users.
TA:	Time to Accident.
TMTC:	Same as TTC.
TTC:	Time To Collision, i.e. time that remains to a collision, presupposed unchanged speeds and directions (continuous over time).
Time to Accident:	Time to Accident, i.e. time from the moment when one of the road-users starts an evasive manoeuvre till the collision would have occurred, if speeds and directions were kept unchanged.
Type of conflict:	Synonym to manoeuvre type (N.B. Conflict type is used in a different context).
Undisturbed passage:	Elementary event in the interaction between two road-users.

1 INTRODUCTION

This report is presented as an historical review of the developmental work that has been going on at the Department of Traffic Planning and Engineering at Lund University since 1974.

I have chosen this form for several different reasons:

- It hopefully gives the reader, that is more or less unfamiliar with this area, an opportunity to understand the entire developmental process, from the need for indirect safety measures to validation problems and use of the technique.

- It hopefully gives readers who are familiar with the area an understanding of what lies behind different conclusions and considerations regarding this specific technique. It may, due to this, give guidance to other workers in the area.

- Personally, this was the best way of integrating old parts of the development, already published, with new parts not published before.

Chapter 2: "THE NEED FOR INTERMEDIATE MEASURES IN SAFETY EVALUATION", presents arguments for the use of accidents solely for safety evaluation. There is also a detailed evaluation of a case-study that illustrates the problems involved.

Chapter 3: "ALTERNATIVES TO ACCIDENTS IN SAFETY EVALUATION" gives the theoretical framework for conflicts, severity and serious conflicts. Our choices of original definitions are presented. The "first generation definition" of a serious conflict is particularly important.

In Chapter 4: "RECORDING OF SERIOUS CONFLICTS" different recording techniques are discussed as well as our choice of human observers for ground level observation. Training and testing procedure are presented as well as the results of the first reliability studies we made.

Chapter 5: "VALIDATION OF SERIOUS CONFLICTS AGAINST ACCIDENTS - FIRST GENERATION APPROACH" presents the original validation study based on the "the first generation of definitions". This validation study is only dealing with the prediction of accidents from conflicts.

After almost ten years of experience I made the synthesis presented in chapter 6: "EVALUATION OF THE ORIGINAL TECHNIQUE". I define the problems we had experienced with regard to the definition of a serious conflict, and more generally I try to identify all possible improvements of the definition. I review and comment on the reliability studies of observers and I discuss possible improvements of the test methods we used. Finally I review the validation study and discuss the theory behind and, again, possible improvements.

Chapter 7: "MODIFICATION OF THE ORIGINAL TECHNIQUE" is of great "ideological" importance to me. Based on the aforementioned evaluation I present five different ways of defining the severity of conflicts. I then compare these five definitions with a new approach:

- I define the last part of the processes leading to serious conflicts and accidents and compare these parts with a sample of conflicts and accidents.
- I formulate criteria that should define severity both for conflicts and accidents.
- Finally, I compare the given definitions and argue for the selection of one of these as being most relevant.

In a second step I compare evasive manoeuvres between serious conflicts and accidents. I try to find similarities and dissimilarities between accidents and conflicts.

My conclusion from this entire comparison of serious conflicts and accidents is that the similarities, in this last phase of the processes, are big enough to state that "serious conflict and accidents seem to be strongly related". The main difference has to do with the severity of the event.

Further on in chapter 7 I briefly present the on-going international cooperation on Traffic Conflicts Techniques (7.4). Specifically, I present the results of a major effort to calibrate conflict techniques developed in different countries. I also compare the conclusions drawn from this study regarding severity classification with my own findings regarding our technique.

In section 7.5 I use detailed results from the calibration study in order to compare recordings made in the field by Swedish observers with an objective evaluation. The comparison was of great interest as it was the first time we had the opportunity to compare our "subjective scorings" with an "objective evaluation". The results give a better insight into some of the reliability problems. The study, however, should have been bigger in order to make it possible to draw more definite conclusions.

Chapter 8 deals with the relation between conflicts of different severity and the reaction among road-users who get involved in such conflicts. I also relate the results to the "Risk homeostasis theory" presented by Gerald Wilde. Among other things I argue for a wider use of the concept of conflicts for research that is related to Wilde's theory.

Finally, in chapter 9, I conclude and comment on the whole report and give my arguments for the use of traffic conflicts in traffic safety evaluation, as one of many tools in order to improve the evaluation procedure.

2 THE NEED FOR INTERMEDIATE MEASURES IN SAFETY EVALUATION

2.1 Introduction

In order to gain knowledge about the causes of accidents one needs theories concerning the pre-crash phase. Such theories exist in quite a large number. The Insurance Road Safety Committee (TRK), (1978) has for instance presented a number of theories dealing with the information process that precedes an accident.

The main problem is however, also concluded by TRK (1978), that these theories are only to a small extent verified empirically. This is partly due to the inevitable fact that accidents are very rare events and, therefore, extremely difficult to observe on the scene.

Pre-crash accident studies, therefore, have to be based on historical data, i.e. data that is obtained some time after the accident has occurred. Besides, most data about the pre-crash phase has to be obtained through statements either of people directly involved in the accident or witnesses to the event. There are very few, if any, objective data, about the pre-crash phase, such as speeds, etc.

It is in this perspective a most natural thing to try and identify events that have a similar pattern but are much more numerous. If these kinds of events do exist, it will open up the possibility for external observers not only to observe the events as such, but also the chain of events leading up to the "accident-like" event. This in turn would lead to improved possibilities of studying different parts of the process leading to accidents.

2.2 Countermeasure evaluation based on accidents

2.2.1 Low numbers, long periods

Evaluation of safety, based on accidents only, has a number of disadvantages. For countermeasure evaluation accident frequencies are unstable even if the actual accident-risk keeps constant. When accident-frequencies are low, as often is the case when one deals with intersectional measures for instance, misinterpretation of the results may occur fairly easily. For instance, when a countermeasure has halfed the expected accident risk over a certain period of time from 8 accidents to 4, then there is still a 15% risk that the number of accidents in the after-period is higher or equal to the number in the before-period, just by chance (Van der Horst, Riemersma, 1981).

In order to increase the number of accidents observed the data collection has to run for many years. This has some obvious drawbacks.

To start with, long evaluation periods mean that changed conditions will appear there caused by factors other than those of immediate interest. Flows will change as the general behaviour. These factors may change accident risks quite considerably over a 5 to 10 year period, a time span which is not unusual at before and after studies.

It is therefore an extremely difficult task to discriminate the effect of the countermeasure itself from the effects of other factors. Control groups have to be used in order to be able to make this discrimination. The question then arises, however, how to form these control groups.

Is it possible to isolate a control group that only indicates the effects of flow changes and general changes of behaviour similar to the changes in the experimental groups? My answer to this question is that the general knowledge about relations between flows, "general behaviour" and accident risks is so poor today that a proper use of control groups, in order to isolate the "real" effect of a specific countermeasure, is very difficult. It then does not matter whether the countermeasure in question is a change of intersection design, change of intersection control, an information campaign, increased enforcement or whatever. The isolation of the "real" effects will always be difficult.

The problems are well illustrated by the example given in fig 2.1.

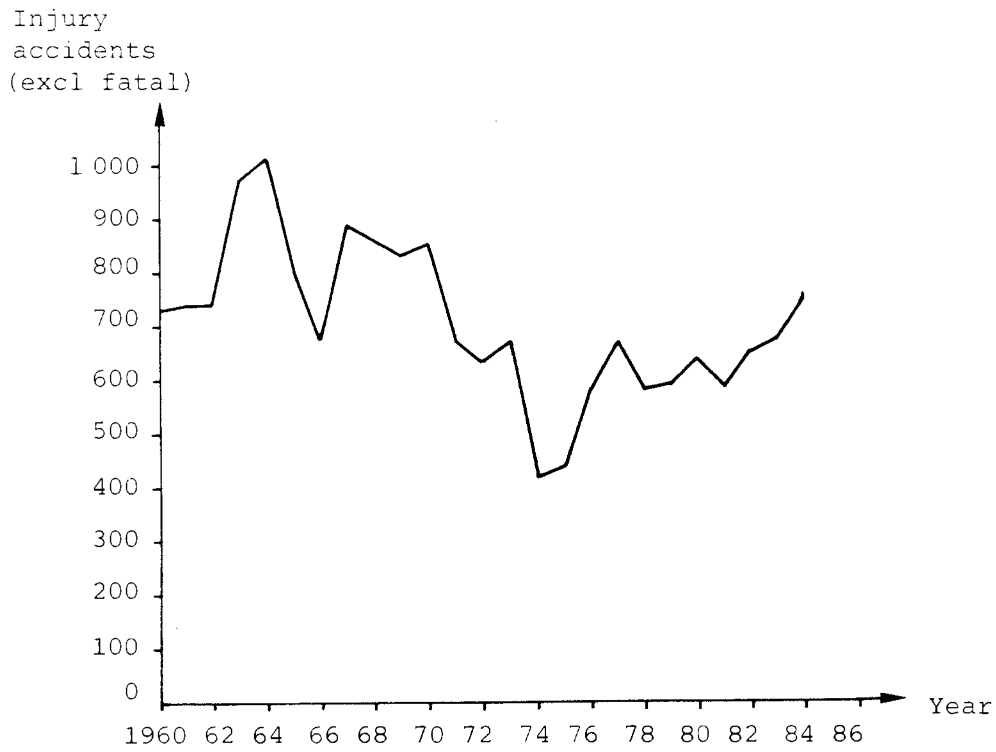


FIGURE 2.1 THE ANNUAL NUMBER OF POLICE-REPORTED INJURY ACCIDENTS IN MALMÖ 1960 - 1983 (EXCL FATAL ACCIDENTS).
From: Malmö Gatukontor, 1984.

There are some clear trends in the graph:

1) From 1964 to 1974-75 there was a more or less continuous decrease in accidents and during that ten years there was a 60% reduction in the total number.

2) Since 1974-75 the number has started growing again and by 1983 it has increased by 60%.

There are no big changes in any specific factors contributing to accidents in the period 1974-83 compared to 1964-74. The big change in the trend is, therefore, more or less impossible to explain. What is, for instance, the role played by different changes in the infrastructure, intersection design, etc? And what is the role played by police enforcement, information campaigns etc? It is most reasonable to assume that the positive trend is a "combined effect of all measures", but how does one explain that this "combined effect" does not work after 1975.

The example illustrates quite well how little we know about the reasons behind the different trends. It focuses on the problem of how to organize control groups that are relevant, i.e. that give all other effects excepting the effects of the countermeasure itself.

Another problem having to do with the long periods of evaluation is that the outcome of the analysis deals with mean values over long time periods <u>not</u> indicating at all the <u>process</u> of adaptation from a behavioural point of view and not indicating <u>the trends.</u>

The following theoretical example, however extreme, illustrates the problem quite well:

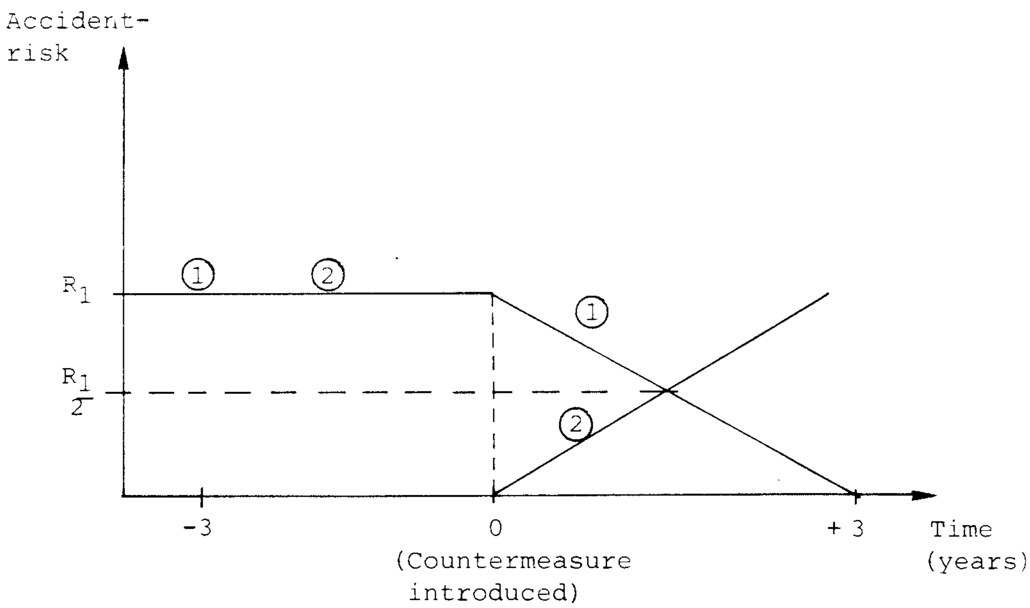


FIGURE 2.2 THE CHANGE OF ACCIDENT RISK CAUSED BY TWO DIFFERENT COUNTERMEASURES
A theoretical example

Two different locations are studied. Accident-risks are the same at both locations (R_1) before two different countermeasures are introduced at year 0. The effects of the two countermeasures develop in two completely different ways: At location 1 behaviours are changed gradually. There is no immediate reaction but the learning process introduces safer and safer behaviour the more acquainted the road-users become with the new countermeasure. After three years accident risks are close to zero.

The countermeasure at location 2 has a completely different kind of effect. There is a dramatic change of behaviour initially. Road-users are extremely careful and the risk drops to zero immediately. Gradually however, behaviours are modified and accident-risk becomes as high as it was before the countermeasure was introduced.

When evaluating the effects of the two countermeasures, we presume that three years have to pass before accident-statistics enable any proper predictions of the effect. Then, we find that both countermeasures show exactly the same effect (50% reduction) for the time-period included in the analysis. This information, however, is of very limited interest, especially as we know nothing about the trend. Normally, a countermeasure has a "lifetime" of much more than three years and when things develop the way they did in the example, the effect for the whole life-time is not possible to detect at all after three years.

Of course this example is too extreme. It is, however, fairly obvious that processes similar to these mentioned are at hand on most occasions. The initial changes may vary quite considerably due, for instance, to the changes in perceptual tasks. The development may also differ due, for instance, to the character of the perceptual tasks. One therefore has to count not only changes over time of behaviours and accident risks but also that trends may sometimes be positive and sometimes negative.

The main point of this example is, therefore, that an evaluation of effects over a couple of years may not only give wrong indications about the long-term effect but may also give no indications at all regarding the process of adaptation. The last point is very unfortunate in itself, as knowledge about the process of adaptation may be a very valuable entry to a better understanding of how countermeasures work.

A special case, linked to the same problem area as above, appears if a countermeasure has some kind of "defect" causing a completely new type of accident. As long as this "defect" does not produce a considerable amount of accidents it will be extremely difficult to find out, through a conventional evaluation based on accidents, that there is a "defect" that is reducing the potential effect of the countermeasure. Another evaluation technique, that not only could identify the effect of the "defect" but also could clarify the perceptual/ behavioural sides of it, could probably increase the safety effects of many countermeasures introduced.

One last point that has to do with long periods of evaluation, concerns administrative problems. If the effects of countermeasures become known over a couple of years time, there is a great risk that the knowledge about the effects has become less important and less interesting. Things may have changed, both administratively and politically which make the information much less up-to-date.

2.2.2 The regression to the mean

Regression to the mean, or bias by selection, is causing great problems in evaluation through accident statistics.

The regression to the mean effect should be interpreted as follows in our case:

Let us say one has a number of intersections. The number of accidents at these intersections is x during one year. Due to random fluctuation "the actual number of accidents", x_1, is rarely the same as "the expected number of accidents" at the same intersections during the same time, m_x. If $x_1 > m_x$ then there is a tendency that the actual number of accidents during next year, x_2, presupposed no changes, is smaller than x_1, i.e. $x_2 < x_1$. And vice versa, if $x_1 < m_x$, then there is a tendency that $x_2 > x_1$.

The use of x as an estimate of m_x, which is very common, most often leads to biases that creates problems, at for instance, effectiveness evaluation. When locations are treated on the basis of some accident-criterion, then the bias leads to an overestimation of the effectiveness.

The National Road and Traffic Research Institute (VTI) in Sweden carried out a general study on this subject. (Brüde, Larsson, 1982). The study serves as an excellent illustration.

Accident statistics were selected for a seven years period for all intersections on rural main roads in Sweden. No changes had been introduced during the seven years. The first four years were used as a before period and the last three as an after period.

The report shows that if all intersections with more than one police-reported accident for the first four years are selected then there is a regression to the mean effect ranging from 28% to 43% (depending on the number of accidents in the before-period), i.e. there is a reduction of accidents ranging from 28% to 43% and still there were no changes made at the intersections. If injury-producing accidents only are used for the selection, then the regression to the mean effects are ranging from 41% to 52% with the same preconditions as above.

Hauer, 1986, presents the problem somewhat differently. In table 2.1 accident counts are shown for 1142 intersections in San Fransisco for two consecutive years. All had stop signs on the two approaches carrying the lesser flows during both years.

TABLE 2.1 ACCIDENT COUNT AT 1142 INTERSECTIONS - 1974/1975.

1 Number of Intersections n(x)	2 Number of Accidents per Intersection in 1974 (x)	3 Average Number of Accidents per Intersection in 1975 (x_m)
553	0	0.54
296	1	0.97
144	2	1.53
65	3	1.97
31	4	2.10
21	5	3.24
9	6	5.67
13	7	4.69
5	8	3.80
2	9	6.50

(2 intersections had 13 accidents, one had 16)
From: Hauer 1986.

Hauer states that because the actual count of accidents of a certain type and severity (x) is subject to random variation, we define the safety of an entity (in this case an intersection) to be the expected number of accidents of a certain type and severity (m).

It follows that to measure safety, one has to obtain estimates of m.

It can then be concluded from table 2.1 that actual accident counts during one year produce bad estimates of the average number of accidents per intersection for the following year. (Hauer has also shown that the two years in table 2.1 were not unique. Similar results were obtained from data for 1975/76 and 1976/77).

Hauer draws the following conclusion:

a) **Were x a good estimate of m, entities which recorded x accidents in one period would record, on the average, x accidents in the next period of equal duration if their expected number of accidents remained unchanged. However, this is not born out by empirical facts.**

b) **We deduce therefore that x is not a good estimate of m.**

Later on in the paper Hauer continues:

...with one exception, our conclusion about x being a relatively poor estimate of m runs counter to common practise. The exception is that specific experimental design in which each "treated" entity which had x accidents in the "before" period is matched by one or more "control" entities which also had x accidents in that period and are left untreated. Inferences about treatment effectiveness are then based on the assump-

tion that were the treated entities left without treatment, they would have behaved just like the "control" entities, except for the effect of random variation ......

It follows that the experimental design which in safety work is commonly held to be superior to all others, implicitly abandons the notion that x is an estimate of m. This notion is replaced by the principle: "the m which would have prevailed during the after period had the entity not been treated is estimated by the average accident count on the matched control entities in the "after period". (Column 3 in table 2.1).

Hauer presents three alternative ways of estimating the expected value of m for an entity which had an accident count x. (See table 2.2). Thus these estimates are only based on the first years accident count. Hauer refers first to Robbins (1980) who presented the following estimate of m:

$$\hat{T} = (x + 1) \cdot n(x + 1)/n(x)$$

These estimates are presented in table 2.2, column 4. When compared with the average accident counts, column 3 in the same table, we can see that there are great similarities. The differences seem mainly to do with a wide fluctuation when the number of entities (n(x)) is small. This is true for both column 3 and 4.

To overcome this problem Hauer proposes two different ways of smoothing the estimates. These are shown in table 2.2, column 5 and 6.

TABLE 2.2 COMPARISON OF ESTIMATES OF THE EXPECTED NUMBER OF ACCIDENTS.

1	2	3	4	5	6
n(x)	(x) (From table 2.1)	(x_m)	$\hat{T}$	Estimates of m	
553	0	0.54	0.54	0.53	0.44
296	1	0.97	0.97	0.98	1.04
144	2	1.53	1.35	1.43	1.64
65	3	1.97	1.91	1.88	2.24
31	4	2.10	3.39	2.32	2.84
21	5	3.24	2.57	2.77	3.44
9	6	5.67	10.11	3.22	4.04
13	7	4.69	3.08	3.67	4.64
5	8	3.80	3.60	4.11	5.25
2	9	6.50	n.a.	4.56	5.85

From: Hauer, 1986.

Hauer's presentation is convincing; there is no doubt that the use of estimators of m is producing better results then using actual counts of accidents. The regression to the mean effect can thus be kept under control.

There are, however, some problems that complicate the use of these estimators:

a) All these estimators require the knowledge of accident numbers on a population of similar entities. The question is: What is a similar entity? If the study concerns for instance intersections what should the design criteria be then? What traffic volumes? If one wants to test the effectiveness of a particular countermeasure, what then defines the similar entities regarding the different criteria mentioned above?

b) Accident data and other intersectional data are often not very easily available and therefore not used. This is, of course primarily an administrative point of view but still, it plays an important role.

c) Quite often the number of locations to be treated is very small, as well as the number of accidents. The techniques presented by Hauer are then not working properly because there is a wide fluctuation in the accident numbers due to randomness.

d) The techniques presented by Hauer are not very well known, probably especially to practitioners who still are carrying out a considerable number of studies on the effectiveness of countermeasures.

My main point with this presentation is <u>not</u> to discourage the use of techniques to deal with the regression to the mean problem. They are of greatest importance in order to get rid of many of the exaggerated opinions about safety effects of countermeasures, that in turn may lead to wrong conclusions and a poor allocation of resources. <u>But</u>, as progress is slow, it is most appropriate to try and introduce alternatives such as intermediate measures. Using much more numerous, accident-like, events may solve problems linked to the regression to the mean problem and should therefore be considered as a worthy complement to accident analyses.

2.2.3 Diagnosis based on accidents

As was mentioned earlier, there is one fundamental problem when using accidents for diagnostic purposes: accidents can hardly be systematically observed in the field. Instead, one is bound to use <u>historical</u> data obtained in one way or the other:

1) The police authorities present a statistical report on each accident that comes to their attention.

2) The police authorities also carry out a special survey on each accident that may lead to charges against any of the road-users involved. This material is not official but may be used for research purposes.

3) Hospitals nowadays are providing statistics on persons brought to the hospital due to injuries caused by a traffic accident.

4) Insurance companies have statistics on all their relevant cases.

5) Special interviews with road-users that have been involved in accidents are sometimes carried out. For instance persons that have been brought to hospitals for medical care due to injuries obtained in a traffic accident have been interviewed afterwards. Children at schools have been interviewed about accident-involvement, etc.

6) Special accident investigation teams can be set up to visit accident locations as soon as possible after an accident has occurred. The car industry is utilizing this technique mainly in order to study the impact on the vehicles caused by collisions at different angles, speeds etc, injuries to car occupants, etc. Other than this there is only one pilot study carried out in Sweden, by the Insurance Road Safety Committee (TRK). The Committee decided in 1975 to commission a project aimed at evolving and testing a methodology of in depth investigation of road accidents (TRK, 1978).

The different sources mentioned above differ quite considerably with regard to the quality of the data for diagnostic purposes. Ordinary police-reports hardly give any indication of what the causes of accidents may be. Police surveys give some indication of causes through interviews with road-users involved or with witnesses to the accidents. For the purpose of finding the causes of accidents as a basis for finding remedial measures, this information has a limited value:

- The police authoritie's survey aims at finding causes from a legal point of view, which means that important knowledge about more complex relations may easily be overlooked.

- With regard to the aim of the police authoritie's survey, the road-users involved as well as witnesses may present a biased version of what actually occurred in order to "protect their own interests". Quite often, different versions of the event are in opposition to each other.

- From a psychological point of view, it is not simple for a road-user to reconfirm a series of events after being involved in a traumatic event that may even have been injury-producing and have left people with feelings of guilt.

Statistics from hospitals and insurance companies normally give very limited information on causes of accidents. Insurance companies certainly make surveys similar to the ones carried out by the police authorities, but the value of those is limited for the same reasons as mentioned above for police surveys.

Special interviews with road-users involved in accidents, designed specifically so as to give answers to questions of importance for the causual connections, have to be carried out close in time to the occurrence of the accident. Otherwise, too much of the important information is lost. Normally, however, interviews cannot be carried out in connection with the accident occurrence. Therefore, it is of importance to clarify the aim of the interviews and not pin too much hope to the possibility of finding useful know-how on complex relations between accidents and different causual factors.

The use of accident investigation teams visiting locations is the technique that, in my view, has by far the highest potential in regard to the aim of finding complex causual connections as the basis for remedial action. There are some obvious advantages compared with all other sources:

- Accident locations can be surveyed soon after the accident has occurred, before vehicles are moved, etc.

- Interviews with road-users involved, witnesses, etc, can be carried out on the accident-spot thus enabling straight references to local conditions (physical infrastructure as well as light and weather conditions, etc.)

The pilot study referred to earlier (TRK, 1978) included a literature review and problem identification. It says there that with regard to the whole accident process a differentiation can be made in three phases, each illuminating certain problem-areas:

Phase	Problem-areas
Pre-crash	Interaction between road-user - vehicle - road environment. Road-user's perception, decisions and actions.
Crash	External and internal environmental factors. Vehicle construction. Effect of protective systems.
Post-crash	First-aid, ambulance service. Care and rehabilitation.

The authors of the report state that, concerning completed or on-going projects, the main focus has been on crash-studies. One reason for this is said to be that the main interest has been in problem-areas that can be studied in the crash-phase. A reason for this, it is presumed, is that technicians and engineers have been initiators. Included is the car industry. They also conclude that it may be, or at least it seems to be, easier to work with damage/injury-prevention than accident-prevention.

The TRK-study was focused on studies of the interaction between human beings, vehicles, the road and traffic environment and especially the role played by the road-user. The main emphasis was, therefore, on events during the pre-crash phase.

The aims of the project were spelt out as follows:

"The overriding aim of this project has been to investigate actual road accidents with a view to elucidating accident processes and identifying the causes of accidents, and in doing so to help improve the state of knowledge in this sector and the factual documentation underlying road safety measures of various kinds.

In keeping with this aim, the experimental activities have been designed,

- **to evolve and test a methodology for the conduct of multidisciplinary investigations of road accidents.**
- **to try to identify the general course of the accidents investigated and their causes and the causes of injuries and material damage.**
- **in analysing the course of the accident, to devote particular attention to the course of events before the vehicle was involved in a collision, left the road, etc., points of inquiry here including the information available to the driver and the way in which the driver acted".**

A team of experts was set up, comprising a project leader, a vehicle inspector, a road engineer, a behavioural scientist and a medical doctor.

This group, or sometimes part of it, was cruising within a certain area in a specially equipped vehicle. Alarms were given via radio based on reports from the police.

At the accident locations data were collected by each member in the group according to special check lists. The study focused on the interaction of road-user, vehicle and road and traffic environment, especially during the pre-crash phase. Interviews of the road-users involved in the accidents were, therefore, very important.

Twenty-three accidents were investigated.

With regard to the pre-crash phase, the analysis of data led to a description of the course of the accident. Factors are defined which may have contributed to the occurrence and development of the accident. The final part of the conclusions are of interest as they stand:

> **"Properly used, investigations of this kind should be capable of providing a valuable supplement to conventional accident figures. Accident investigations conducted in the form of case studies - without purporting to yield representative findings - can then serve one or more of the following purposes, among others.**
>
> - **They can provide documentation leading to the discovery of "new" problems and/or the formulation of hypotheses which can then be tested experimentally or on other accident material.**
> - **They can supply detailed information concerning a phenomenon or a causual relationship which has previously been established with statistical material or as a result of laboratory experiments.**
> - **They can reveal obvious accident or injury factors of such a kind that the study of a single case is enough to show that action will have to be taken.**
> - **They can reveal the incorrect design of a detail of the road and traffic environment or of a vehicle - errors which are not conspicuous enough to be discovered by other methods.**
> - **They can furnish ideas and suggestions concerning measures of a general nature and indications of appropriate local measures.**
> - **Multidisciplinary accident investigation reports can supplement the experience which researchers and others take as their starting point when dealing with road safety problems of various kinds."**

All these conclusions from the pilot study are of major interest when searching for relevant know-how in the field of traffic safety. The special focus on the pre-crash phase makes this study particularly interesting from my point of view. The main problem is, however, that the finding of representative know-how, e.g. for a specific type of intersection or a specific manoeuvre type, demands very big resources.

This is where intermediate measures come into play. Observing many more numerous "accident - like" events on the scene may overcome the problems of representation. In order to improve knowledge, road-users involved in these "accident-like" events may also be stopped and interviewed right after such an event has occurred. (In chapter 8 studies are presented that show that such an interviewing technique is possible to use in practise).

2.3 Case - study

2.3.1 Introduction

In this section, one example will be presented on the use of accident analysis for the evaluation of countermeasures. The example is not meant to be representative of the use of accident-statistics for this purpose in general. It, however, reflects some of the fundamental problems mentioned earlier concerning the use of accidents for evaluation purposes. The example is also a good one because large investments in safety action are made.

2.3.2 An accident study on the safety effects of signalization of zebra-crossings

In the Nordic countries, as elsewhere, signalization of only zebra-crossings have been used for quite a few years as a safety-measure on different types of roads. The crossings are either located mid-block or close to a non-signalized intersection. Different strategies have been tried. The most common ones in Sweden are ALL-RED, RETURN TO GREEN FOR CARS and FLASHING YELLOW. The main differences between them are:

ALL-RED:	When there are no road-users detected all signals show red.
RETURN TO GREEN FOR CARS:	When there are no road-users detected the vehicle-signal shows green.
FLASHING YELLOW:	When there are no pedestrians detected the vehicle-signal shows flashing yellow. The pedestrian signal is then switched off. A detection of a pedestrian means that the vehicle-signal turns to red via steady yellow. The pedestrian signal turns to green via some seconds of red.

In Iceland, a modified strategy of the RETURN TO GREEN is used. It is the British invention of PELICAN CROSSING. The main difference is that red for vehicles is just shown for a couple of seconds. It then turns to flashing yellow which means that vehicles may pass if no pedestrian has started to cross. Pedestrians are shown flashing green in this special phase.

A joint Nordic study on the effects of signalized pedestrian crossings have been carried out in the frame-work of a Nordic traffic safety project called EMMA (Evaluation of the traffic safety effects of minor road improvements). (Vejdatalaboratoriet, 1982). The overall results of the study are as follows from table 2.3.

TABLE 2.3 THE TOTAL NUMBER OF INJURY ACCIDENTS BEFORE AND AFTER SIGNALIZATION OF PEDESTRIAN CROSSINGS IN THE NORDIC COUNTRIES

	Before[1)]	After	χ^2	Significant
Denmark	18.0	12	1.40	
Finland	7.0	6	0.07	
Iceland	33.8	21	3.36	*
Norway	30.6	23	1.19	
Sweden	29.6	33	0.25	
Total	118.9	95	3.14	*

1) Corrections are made due to the length of the after-period compared with the before-period and due to the accident-trend.
From: Vejdatalaboratoriet, 1982.

Altogether, in the Nordic countries the corrected number of accidents before signalization was 119 while the number after was 95. This represents a significant decrease which is around 20%.

For the Swedish locations though, the corrected number before is about 30 accidents while it is 33 after. Thus there is an <u>increase</u> of the total number of injury accidents, though not significant.

While there was a 20% reduction in the total number of injury-accidents and a 35% reduction in pedestrian accidents, there was only a very small reduction of non-pedestrian accidents. (See table 2.4).

TABLE 2.4 THE EFFECT OF SIGNALIZATION OF ZEBRA-CROSSINGS ON PEDESTRIAN AND NON-PEDESTRIAN ACCIDENTS

	Before[1)]	After	χ^2	Significant
Pedestrian accidents	55.0	36	4.44	**
Non-pedestrian acc.	63.9	59	0.24	
Total	118.9	95	3.14	*

1) Corrections are made due to the length of the after-period compared with the before-period and due to the accident-trend.
From: Vejdatalaboratoriet 1982.

The report unfortunately does not present these data with a break-down on the different countries.

It can be seen from table 2.4 that pedestrian accidents stand for less than half of the injury accidents at the studied locations, both before and after introduction of the signal.

The report presents the number of road-users of different types involved in the accidents. It does not state, however, what kind of accidents (manoeuvre type, etc.) this majority of the accidents represents.

A number of parameters were analysed:

- Category of road
- Function of road
- Distance to nearest intersection
- Type of signal strategy
- Equipment (detectors, etc.)
- Coordination with other signals
- Distance between the accident-location and the zebra-crossing
- Light conditions
- The severity of the accident
- Type of road-user involved
- Speed limit
- Median refugees
- The length of the crossing
- Traffic volumes
- Time of the day
- Time of the year

One of the points made in the report was that "there was an 80% reduction in the number of fatally injured road-users, from 10 to 2".

Another finding was that the distance between the accident location and the zebra-crossing was of importance. Table 2.5 presents the accidents with a break-down on distance to the zebra crossing.

TABLE 2.5 THE LOCATION OF ACCIDENTS RELATED TO DISTANCE FROM THE ZEBRA CROSSING, BEFORE AND AFTER SIGNALIZATION.

	Car - Car		Car - Pedestrian	
	Before[1)]	After	Before[1)]	After
On the crossing	22.11	23	20.35	18
< 10 m	40.40	38	11.23	5
11-50 m	32.20	34	15.45	7 *
51-100 m	25.90	13 *	13.21	6 *
> 100 m	5.91	3	4.46	1
Total	126.5	109	64.7	47

1) Corrections are made due to the length of the after-period compared with the before-period and due to the accident-trend.
From: Vejdatalaboratoriet, 1982.

Table 2.5 shows that there does not seem to be any reduction at all on crossing itself, neither for cars nor for pedestrians. For the latter, the distance has to be between 11 and 100 meter to find a significant reduction in the number of observed accidents. It is stated in the report that the reason for the observed differences in distance cannot be explained from the data available. For instance, it cannot be clarified whether there are differences in exposure before and after the installing of signals.

Regarding many of the parameters studied, there is an obvious covariance between them. Wide roads, for instance, most often carry heavy vehicle-volumes and they often have islands, etc. The interesting thing is that the largest part of the total reduction in accidents, 18 out of 24 "saved" injury accidents, occurred in 10 out of the 112 crossings included in the study. These locations had a number of parameter-values in common:

- They are situated in big cities
- Vehicle volumes are big (13000-23000 ADT)
- The zebra-crossing has a length of more than 15 meter
- There is a median island
- The distance to the nearest signal is at the most 550 m (9 out of 10 have a distance of less than 300 m).

2.3.3 Comments on the different problems with the accident study

A. LOW NUMBERS, LONG PERIODS

For the 31 locations in Sweden that are included, the average accident rate is a bit more than half an accident per year, both before and after signalization. This means between 15 and 20 accidents per year in total, out of which 5 to 10 are pedestrian accidents.

A reduction in pedestrian accidents of 35%, which was the reduction in pedestrian accidents totally in the study, will be quite difficult to trace based on the Swedish part of the study. A study duration of 3-5 years, both in the before and after study, is needed in this case just in order to find a significant change in the number of accidents. If then there are a lot of parameters - as in this case - of potential interest to relate to accident risk, then the number of accidents in the study should have been considerably higher than was the case.

In this project, one solution to the problem was to create a joint nordic project. The question, however, is if the locations selected from the different countries can be said to be selected from one sample of locations. It is doubtful for instance if the Swedish sites (with a 10% increase in recorded accidents) should be mixed with the Norwegian sites (with a 20% reduction in recorded accidents). It seems as if variables other than those controlled create differences in the effect of these signalizations.

Besides, in spite of the increased data-base, it was not possible to draw any important conclusions because:

- The effect of different signal strategies is not clarified, except for the positive effect of pelican crossings.These, however, only exist in Iceland. The positive effect, therefore, cannot automatically be generalized as to the other countries.

  In Sweden there are, as mentioned earlier, at least three different strategies applied quite frequently. Still, the study does not even give indications as to what strategy to prefer, if any. Besides, <u>if</u> the effect of different strategies varies with regard to other variables, the study would have had to be extremely enlarged so as to give any operational answers.

  The only operational answer given in the report, was that the reduction of accidents could be referred to 10 locations fulfilling criteria like "heavy traffic", "wide road", "big city". The question is of course "what about all other potential locations". In total, there is a <u>very small</u> proportion of the road network that fulfills the criteria mentioned. There is no indication of the strategy for the other part of the road network. Finally, is there any use of installing signals if the effect is dubious?

To conclude on this point, the study under scrutiny could not produce any important answers and left the practitioner completely without operational guidance. The small number of accidents was one key factor. Still, data from five different countries were aggregated in order to increase the numbers. This aggregation was dubious as it seemed as if the effect of signalization varied from country to country.

B. REGRESSION TO THE MEAN EFFECT

This problem is only partly dealt with in this Nordic report.

To start with, 16 locations (5 from Sweden and 11 from Denmark) were omitted because there were no accidents reported either before or after. It is admitted in the report that this omittance will lead to a biased sample and the effect of the signalizations will therefore be overestimated.

The data available does not give any opportunity to estimate the possible problem of biased selection of the locations in general. A complete file of accident data for all relevant locations would be needed in order to be able to estimate the regression to the mean effect in line with what is proposed by Hauer (1986) (see section 2.2). To produce this information is time-consuming and not considered feasible in this project. Even if this had been done, however, a major problem remained - namely to define what locations were relevant.

In principle it is easy; all locations that have a potential for treatment with signalization. In practise we find, however, that the criteria used for choice of locations to be treated varies considerably, from occasion to occasion and from one local organisation to another. It is therefore almost impossible to select a proper population of relevant locations. The estimates, as proposed by Hauer (1986) can consequently not be done.

Facts in this case, however, indicate that the regression to the mean effect may be considerable. The earlier mentioned reduction of fatal accidents with 80%, from 10 accidents to 2, is one such indication. To start with, there were 10 fatal accidents in 255.33 accident years before signalization. This produces an average of one fatal accident per 25 accident years. This seems to be an extremely high frequency, and most likely much higher than the average on relevant locations. Secondly, an effect of 80% is much higher than the average effect on injury accidents. There is very little to support the idea that fatal accidents should be more influenced than less serious ones. Thirdly, it is most likely that the fact that there had been a fatal accident in the before-situation played a role in the local decision to install a signal.

From the selection of sites one may conclude that some kind of consideration is given to the regression to the mean problem. Thus, some of the locations selected have no accidents in the before-period. (At these locations there is a regression to the mean effect, the other way around). From the Swedish data, however, there are only 6 out of 31 locations that have no accidents before. This seems to be much less than would be the case at all potential locations for treatment. This is based on the following assumptions:

- In Ezra Hauer's data from San Fransisco, referred to in section 2.2, the average number of accidents per location was 1253/1142 = 1.1. The number of locations with zero accidents were then 553, corresponding to 48%. In this Nordic study there are 30 accidents from Sweden on 31 locations, before signalization. This corresponds to 0.97 accidents per location, thus in the same order as the San Fransisco data. Still, the number of locations with zero accidents is only 19% (6/31) in this case. It is reasonable to believe that the distribution of accidents over locations would be similar among the Swedish locations as among the San Fransisco locations. If so, the number of locations with zero accidents seems to be severely underrepresented and consequently, the number of locations with one or more accidents seems to be overrepresented. It is therefore most likely that there is a considerable regression to the mean effect present. This implies that the reported increase in accidents, regarding Swedish data, might well have been an even bigger increase in accidents, presupposed that a proper technique to treat the regression to the mean problem had been used.

  There is a similar underrepresentation of locations with zero accidents in the whole Nordic study, as in the

Swedish part. This means that the reported reduction of accidents might well have been smaller and it might even have turned to an increase in accidents instead.

This is the first, and very important, conclusion drawn with regard to the regression to the mean problem.

The second conclusion bear much more of general interest: In this case it seems extremely difficult to be able to produce relevant accident distributions and consequently, to produce proper estimates of the actual effect of these signalizations.

C. CONTROL GROUPS/AREAS

The Swedish control group consists of "Injury accidents including pedestrians on roads in the jurisdiction of the national authorities". This road system mainly consists of roads with a speed limit of 70 km/h and above. The signalized locations in the study, however, are to 95% situated on roads with a speed limit of 50 km/h and only to 5% on roads with a speed limit of 70 km/h.

In order to study the effects of this, the accident trends for pedestrian accidents in built - up areas and non-built up areas in Sweden are compared. (See table 2.6).

TABLE 2.6 THE NUMBER OF INJURY ACCIDENTS INVOLVING PEDESTRIANS IN BUILT-UP AND NON BUILT-UP AREAS Swedish, police-reported accidents.

		Before			Implementation[1]			After		
		1972	1973	1974	1975	1976	1977	1978	1979	1980
Built-up areas	Number	1786	1728	1817	1761	1763	1660	1627	1661	1549
	Index	100	97	102	99	99	93	91	93	87
	Mean Index		99			97			90	
Non Built-up areas	Number	279	287	304	289	251	251	229	268	194
	Index	100	103	109	104	90	90	82	96	70
	Mean Index		104			95			83	

1) All signals were installed during one of these three years.

The results indicate differences in the trend. The average reduction in built-up areas, when three years before are compared with three years after implementation, is 9% while the reduction is 20% in non built-up areas. The control group used - pedestrian accidents in the road network under governmental jurisdiction, mainly in rural areas but also in urban areas, gives a trend that is a mixture of the two rather different trends. It is probable that a more relevant trend would have been produced if the above-mentioned figures from built-up areas were used.

Whatever trend was chosen, it would indicate a reduction of accidents. In the report there is a 4% increase reported from before to after in the Swedish control data. This means that if the trend in the control data is negative, instead of positive, then we have one more indication that the effectiveness of the Swedish signals might even be more negative than indicated in the report.

The main conclusion is, however, that the use of control-data is complicated. The following main problems may be mentioned:

- It is not clear what would form the most relevant control group. Different sampling obviously leads to different trends and thus leads to different interpretations of the results.

- It is also unclear as to which type of trend should be used. Should the same trend be used for all locations or is the trend going to be decided on individually, due to the number of accident-years in the before and after period respectively. Table 2.6 shows the change in accident numbers from year to year. It indicates some rather big "jumps" for consecutive years. The consequence of this is that, if only one or two years are used for the before or after period, the trend may change quite considerably in regard to which years were chosen. The question is whether this gives a more relevant control group, or if it would be better to use more years so as to get a more stable trend.

  In the report it seems as if the latter technique is used. It seems as if more than three years in the before and after period are used to produce the trend. This gives a trend that is positive instead of negative, as was implied in my example. Obviously the choice of trend can be argued about.

To conclude: The interpretation of the results of the study is sharply influenced by the choice of control group, time period, etc. At the same time it is extremely difficult to find out what the relevant choices are.

D. DIAGNOSIS

The study is specifically designed to test the statistical difference between accidents before and after signalization, in relation to a number of parameters describing geometrical design, volumes, etc.

The problem is that there are no basic hypotheses at all regarding how the signals are supposed to work or not work from a behavioural point of view.

This leaves a lot of important questions unanswered:

- How does the introduction of a signalized crossing influence the route choice of pedestrians? Does the signalized crossing attract, for instance, more pedestrians or not? There was a clear indication in the report that pedestrian accidents did not drop on the crossing but 11-100 m away. It is very unfortunate that this cannot be explained at all. The reader of the report is left completely without any operational advice regarding this result.

- There are different signal strategies represented in the study. Of the Swedish locations there are appr. 75% with RETURN TO GREEN FOR CARS, 22% have FLASHING-YELLOW and 2% have ALL-RED (see section 2.2) All these three strategies are common in Sweden today. ALL-RED has become more and more popular and today the majority of new installations have this strategy.

It is from this point of view very unfortunate that there are no indications whatsoever as to which one of the three strategies is preferable from a safety stand point. The accident-data base available was not large enough to allow any comparisons of that kind.

Again, the diagnostic part of the evaluation is missing completely. There are no hypotheses on how the different strategies work with regard to behavioural risks. This is particularly unfortunate in view of the fact that other Swedish studies have shown that different signal strategies seem to create quite different behaviour. (See for instance Statens Vägverk (1985), HB SÄKTRA (1983)).

2.3.4 Conclusions

The study is an excellent example of the problems created by a "normal" accident-study. The problems are not primarily due to misses in the implementation of the study, but much more due to the general difficulties in designing a "good" study with only accidents as the basis for all analytical work.

The main conclusions are:

- In spite of 15-20 years of experience with this kind of measure the answers on important questions with regard to safety effects were either extremely tentative or totally lacking.

- No precedent guidance in operation of this kind of signal was set. The most obvious question is why there are almost as many pedestrian accidents, or more, after signalization when there in theory should be no such accidents. Was this due to incompliance of car drivers or pedestrians? The answer, although of great importance, is not indicated.

- The use of accident statistics does not seem to create, as mentioned earlier in the report, an interest for explanation of the process leading to accidents. This is a fundamental problem. In case of the described study it is fairly obvious that a process evaluation based on theories about the relation between driver/pedestrian behaviour and accident-risks, would have led to operational answers to many questions at a much earlier stage.

- In Sweden there are appr. 900 signals of this kind. The investment costs exceeds 70 million SEK. The total resources spent on evaluating the effect of these signals, however, corresponds to just a very small part of the investment costs. This seems to be a poor allocation of money; a greater part on evaluation would most probably have led to a better return on the invested money.

- There is a desperate need for establishing evaluation techniques that are relevant enough to ensure a proper handling of even more complex relations.

- As a consequence:
  ACCIDENT DATA NEED SUPPORT, not only to ensure a proper use, but to establish complementary measures to accidents, for which there is a strong need.

3 ALTERNATIVES TO ACCIDENTS IN SAFETY EVALUATION

3.1 Our introduction of indirect measures in traffic safety evaluation

In our own research the need for indirect accident-measures became obvious already in the beginning of the seventies. The two cities Lund and Uppsala were both planning the implementation of area-wide traffic management schemes in their city centres. An evaluation of "all" the effects of these schemes was strongly encouraged by the local authoroties. A safety evaluation was looked upon as important, particularly with regard to the extensive rerouting of car traffic and introduction of new solutions, e.g. one-way roads for cars combined with two-way bicycle traffic, roads allowed for buses only, etc. When evaluation was discussed, it became clear that one needed a short-term evaluation of the safety effects so that corrections could be made before any unexpected problems had been documented in a severe accident problem.

This situation called for the use of indirect accident measures. The first tentative "conflict technique" was developed and used in before and after studies in both cities (PLANFOR, 1972. PLANFOR, 1973). The technique was based on a purely subjective definition of events that were classified as having "a certain severity". The reliability of the measure was ensured by having one trainer who did all the training of human observers for ground level observation.

The projects in the two cities produced quite a few operational answers with regard to how different countermeasures worked and, partly, why they worked as they did. The answers were, however, difficult to interpret in terms of changes in actual accident risks. This was due to the fact that the defined events were not validated against accidents.

Our main conclusion from the two projects was that there seemed to be a great potential for a technique for indirect measuring of accident risks. We realized, however, that we had to start more or less from scratch and we also realized that we faced a huge effort in order to develop a technique that could fulfill all possible criteria for implementation in research or elsewhere.

Based on our experience, our primary interest at that time was to produce a technique that had a predictive value, i.e. a technique where the indirect measures could replace accidents in the prediction of "expected number of accidents". The diagnostic part, i.e. to use the technique for safety diagnoses of problems at for instance intersections, was still looked upon as a secondary aim.

3.2 The use of indirect safety measures in other fields than road transportation

Problems associated with the use of accidents are not confined to road transportation. In air transportation, for instance, the number of accidents is so small that all possible additional information has to be collected. Thus, all pilots of air crafts have to report all incidents/near-misses they are involved in. A miss in the physical separation of two air crafts that leads to a near-miss, however defined, demands a big and thorough investigation to find the causes of the near-miss and to find relevant remedial measures.

Industry often works with reporting of near-accidents. A pamphlet concerning techniques for reporting on near-accidents in industry was recently provided by the National Board of Occupational Safety and Health in Sweden. It says in the pamphlet that "reporting of near-accidents is a way of utilizing information on accident-like events at work".

Concerning the reporting of near-accidents, it says that it:

- can be carried out in different ways.
- can increase information on accident-risks at work
- can increase the possibilities to systematize and analyze this information.
- can increase the willingness to report the accident-risks at work, even after a period of reporting is finalized.

There are more than a 100.000 work-related accidents annually in Sweden. The number of minor accidents is higher, it says, and the number of near-accidents is even higher than that.

To use near-accidents creates possibilities of acting preventively <u>before</u> accidents have occurred. It also says in the pamphlet that "accident-rate and the rate of severe accidents had dropped after two years of reporting of near-accidents at our big wood-industries".

The two examples represent two quite different situations and pre-conditions. In air transportation there are very few accidents, most often with severe outcome. In industry there are many accidents, often with rather slight outcome. In spite of the different preconditions, reporting of near-accidents are used in both cases for similar reasons. The potential in <u>preventing accidents</u> by analysis of near-accidents, is also strongly emphasized in both cases.

It is not surprising that near-accidents have a potential for use in road transportation as well. Problems and motives to use near-accidents are very much the same in this area as in the other areas.

It also becomes clear from the two examples that if alternatives/complements to accidents are discussed, then the concept of near-accidents is a strong candidate.

3.3 Basic hypothesis

3.3.1 Types of elementary events

The interaction between road-users can be described through a number of elementary events. These events occur with different probability and different degree of seriousness. Simplified, the relations can be visualized as indicated in figure 3.1.

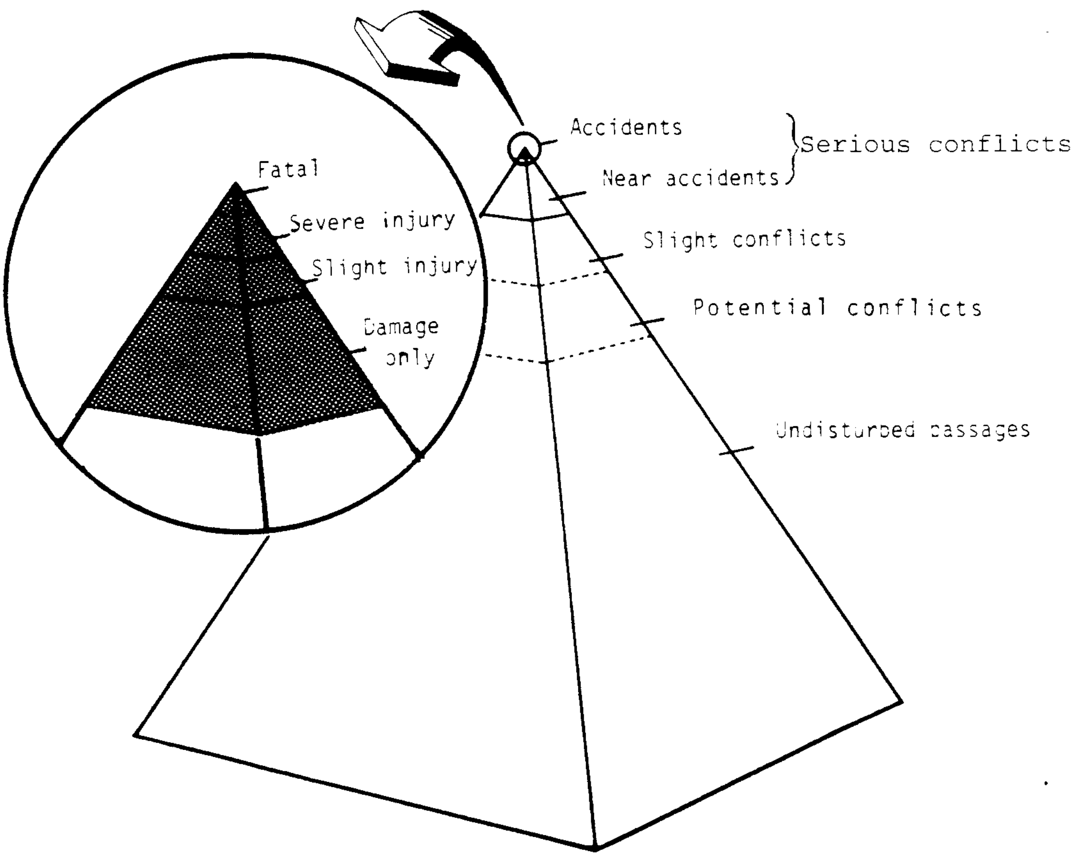


FIGURE 3.1 THE GENERAL RELATION BETWEEN DIFFERENT TYPES OF ELEMENTARY EVENTS FOR THE ILLUSTRATION OF INTERACTION BETWEEN ROAD-USERS.

It is to be noted that the figure does not necessarily illustrate any actual relation between <u>numbers</u> of different types of events.

Verbally the sub-groups can be expressed as follows:

UNDISTURBED PASSAGE

One road-user is passing the intersecting point without being at all influenced by the presence of any other road-user.

POTENTIAL CONFLICT

Two road-users are approaching each other in such a manner that the occurrence of a conflict is imminent unless avoidance action is undertaken by either of the road-users involved. Ample time is at hand for action, thus offering margins to compensate for a mistake.

SLIGHT CONFLICT

Two road-users are approaching each other in such a manner that the risk of a serious conflict is obvious. Time margins are fairly small thus demanding a rather precise and alert action to avoid an accident.

SERIOUS CONFLICT

Two road-users appear in a situation that demands sudden and harsh action to avoid an accident.

A small number of serious conflicts leads to accidents because the available margins were not big enough, for one reason or another. Thus the outcome of a serious conflict may be a near-accident <u>or</u> an accident with various degrees of severity.

One hypothesis is that serious conflicts are indicators of break-downs in the interaction between two road-users. (The description so far has presupposed two road-users involved. In theory however the same description goes for single vehicle situations as well).

A break-down in the interaction is defined as a situation where the perceived accident-potential is so high, that at least one of the road-users would not like to be involved in the creation of a similar event deliberately.

The basic hypothesis can now be formulated:

THERE ARE ELEMENTARY EVENTS, DEFINED AS SERIOUS CONFLICTS THAT CAN BE CHARACTERIZED AS BREAK-DOWNS IN THE INTERACTION. THE ACCIDENT-POTENTIAL IS THEN WELL-DEFINED, I.E. THERE EXISTS A RELATIONSHIP BETWEEN THE NUMBER OF SERIOUS CONFLICTS AND ACCIDENTS.

3.3.2 Relation between elementary elements

The relationship between elementary events of different types is influenced by many factors. The following ones may be mentioned as being the most important:

- Type of road lay-out
- Type of intersection control
- Road-user category involved
- Manoeuvre type
- Vehicle speeds
- Road-user volumes and composition
- Age, sex, etc. of the involved.

The more severe events the fewer factors will influence the relation between two sub-groups of elementary events. The extremes are good examples:

- In the relation between undisturbed passages and accidents, it is obvious that most of the factors mentioned above play an important role. The most obvious examples are volumes, intersection control and road lay-out (e.g. number of lanes).

- The outcome of the most severe near-accidents, e.g. where a vehicle-driver managed to stop his vehicle just a couple of centimeters away from another road-user, is primarily due to randomization. Obviously, traffic volumes, intersection control,etc. play a very minor role in settling the probability that a severe near-accident leads to an accident.

  Thus, the more severe conflicts, the less factors influence the probability that the conflict leads to an accident.

The above mentioned example leads to two contradictions in the optimal definition of an event that is going to be related to accidents:

1) The more severe the included conflicts are the fewer factors will influence the relation to accidents. The fewer factors involved, the easier it will be to generalize results from one situation to another.

2) The more severe the conflicts are, the fewer conflicts there are per time unit. The fewer conflicts per time unit the more difficult it will be to estimate the expected number of conflicts.

   The optimal definition of a conflict, i.e. the definition that will lead to the best estimates of the expected number of accidents, will have to be based on a balancing of the two factors mentioned against each other.

Two points appeared when the question of what kind of conflicts to include in relation to accidents came up:

a) The classification of different types of conflicts, as described above, implies that only serious conflicts represent a direct link to accidents. This is because serious conflicts occur as the result of a break-down in the interaction between two road-users. It was, therefore, not logical to include other types of conflicts that were the result of a controlled interactive behaviour. Our definite opinion was that the conflicts that we included should represent a concept in itself, i.e. that they were easily recognizable as "hazardous" events. They should not represent "any type of common event".

b) The Road Research Laboratory (RRL), later on The Transport and Road Research Laboratory (TRRL) in England presented a Traffic Conflicts Technique in the early seventies. They were at that time using a scale of danger to classify conflicts. (See table 3.1). Their operational definitions of serious and slight conflicts seemed to coincide fairly well with our semantic definitions. In their early work on the relation between conflicts and accidents they concluded that serious conflicts and accidents were related but not all conflicts and accidents. (Spicer, 1971, Spicer, 1972, Spicer, 1973).

TABLE 3.1 CONFLICT SEVERITY DESCRIPTION USED BY ROAD RESEARCH LABORATORY IN ENGLAND IN THE EARLY SEVENTIES

Description	Classification
Precautionary braking or lane changing; collision very unlikely	Slight conflict
Controlled braking or lane changing to avoid collision but with ample time for manoeuvre	Slight conflict
Rapid deceleration or lane change to avoid collision resulting in "near miss" situation	Serious conflict
Very near miss or minor collision occurred	Serious conflict
Serious collision	Serious conflict

From: Spicer, 1971

Due to the aforementioned arguments, it was fairly easy for us to decide that we were going to use serious conflicts only when trying to establish relationships between conflicts and accidents.

Two important issues now remained before the "definition-phase" could be considered as finished:

1) Events, as described in figure 3.1 had to be classified with regard to severity

2) Threshold level between slight conflicts and serious conflicts had to be defined.

3.4 Severity of conflicts

3.4.1 General

In order to find the optimal definition of a serious conflict, one has to define the degree of severity in an event to start with. The definition should in some way reflect the closeness to a collision.

There are some basic ways of defining the degree of severity objectively:

- Distance in space between the road-users

- Distance in time

- Deceleration power needed to avoid an accident.

These factors are the primary indicators of the degree of severity. There are other, "background factors" that also play a role in deciding on the closeness to a collision. The following ones may be mentioned among those:

- Type of road-user
- Speeds of the road-users
- Manoeuvre type

A distance-measure is intuitively the logical thing to use. The closer in distance the closer to a collision. When distance is approaching zero the probability of a collision is approaching one.

Time to collision is another measure that can be used. This time-measure can be the projection of the time-vector to the accident point based on actual speeds and distances to the collision point at each given moment.

The various elementary events, as described in section 3.3.1 can be visualized graphically through this time-measure, from now on called the Time To Collision (TTC). The principle outlook of a TTC-graph is shown in figure 3.2.

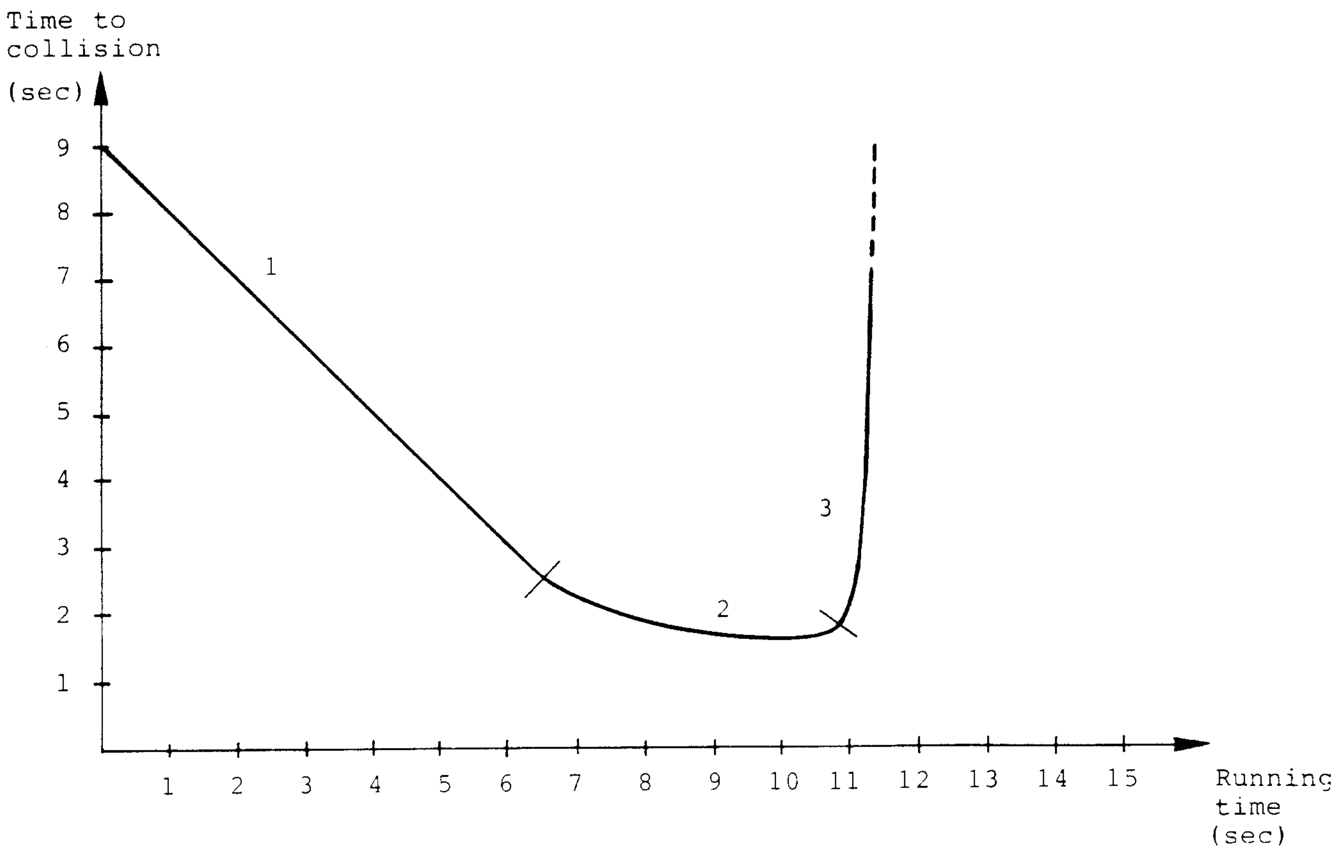


FIGURE 3.2 THE PRINCIPLE OUTLOOK OF THE RELATION BETWEEN TIME TO COLLISION AND RUNNING TIME.

Each road-user involved in some kind of interaction with another road-user has an individual TTC-graph.

There are three typical sections in a typical TTC-graph (see figure 3.2):

1) Two road-users are on a collision course i.e. they are going to collide if momental speeds and directions are kept unchanged. The road-user that is illustrated in figure 3.2 is approaching the collision point with constant speed and unchanged direction.
The TTC-value and running time are changing simultaneously.

2) The road-user is taking evasive action, in this case by braking. The TTC value is decreasing less and less quickly. At a certain point there is a minimum and TTC starts increasing again.

3) The interaction with the other road-user is about to end, either because one of the road-users is stopping or because the collision course is disappearing. In the latter case the curve forms a vertical line from the moment the collision course is passed.

Thanks to the TTC-graphs it is now possible to elaborate on the elementary events describing the interaction between two road-users. (See figure 3.3).

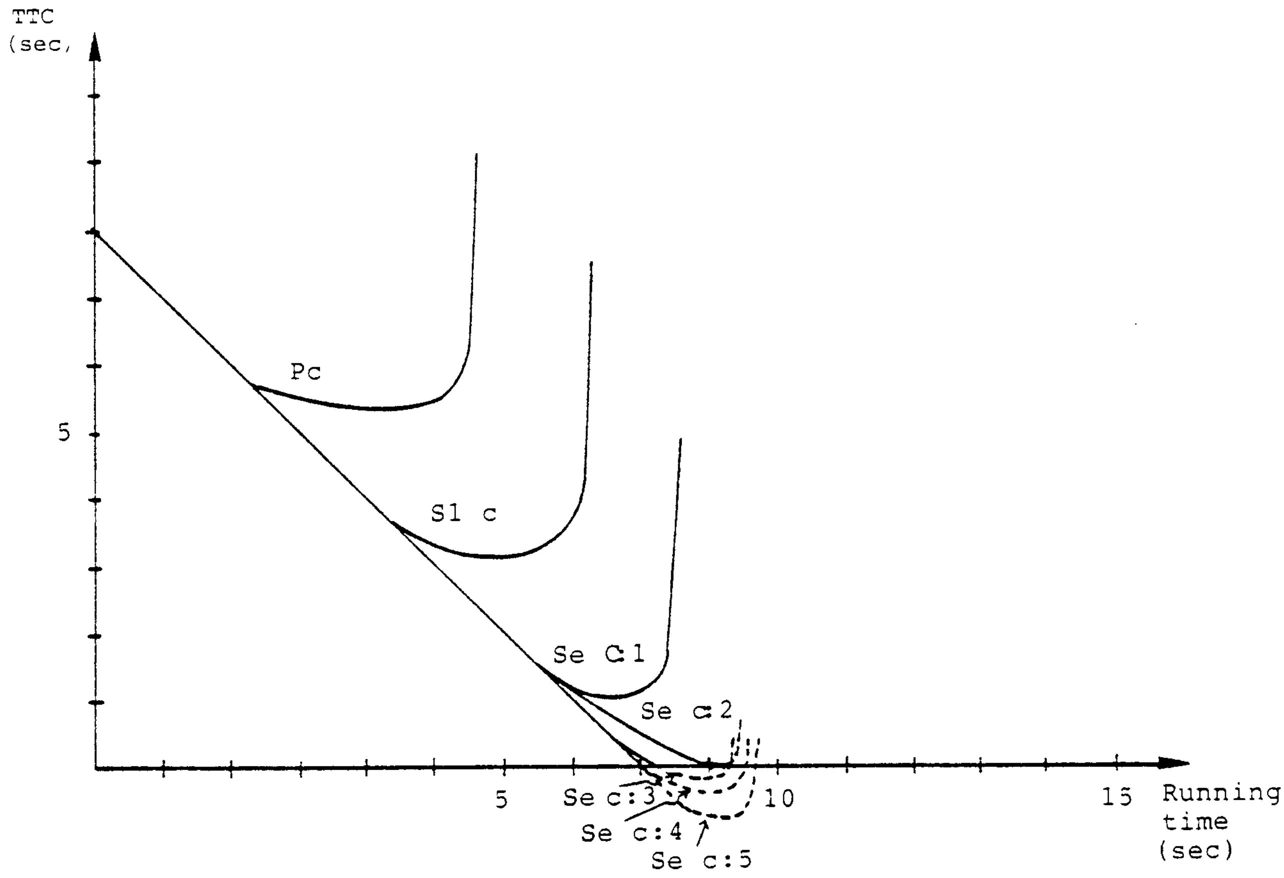


FIGURE 3.3 ELEMENTARY EVENTS IN THE INTERACTION BETWEEN ROAD-USERS AS A FUNCTION OF TIME TO COLLISION (TTC)

The different elementary events may now be described verbally as follows below. The avoidance behaviour is braking in all examples. Each event presupposes two road-users involved. If the two road-users act differently corresponding to two different types of elementary events, only the least severe is taken into account.

Undisturbed Passage (UP)

None of the road-users involved is influenced in behaviour due to the other road-user's presence. TTC has a high value. (More than a couple of seconds).

Potential Conflict (PC)

Two road-users are approaching each other in such a way that there is a potential risk of a conflict if they continue. (At least) one of the road-users changes speed or direction in very ample time, thus avoiding a conflict. The TTC-curve is turning in very ample time and does not get close to zero. This type of event is the most common one when both road-users are fully aware of each others manoeuvres.

Slight conflict (Sl C)

Two road-users are approaching each other in such a way that there is a potential risk of a serious conflict if they continue. At least one of the road-users takes evasive action in ample time, thus avoiding a serious conflict. This type of event accounts for a large portion of those events where one of the road-users is accepting a fairly small gap, thus forcing the other to brake. It also includes events where one of the road-users "takes a chance" and starts crossing a path without complete control of all possible intersecting road-users.

Serious Conflict, type 1, (SeC:1)

Two road-users are approaching each other in such a way that there is a potential risk of a collision. There is still a small margin left-TTC is not getting close to the absolute vicinity of zero. This is by far the most common type of serious conflict. Even though the interaction has broken down, i.e. at least one of the road-users becomes highly surprised and is forced to take immediate action, a collision is avoided in most of the cases.

Serious Conflict, type 2, (SeC:2)

(At least) one of the road-users involved is either acting so late or performing so poorly that the TTC-graph in both cases is "touching" zero. There is a slight touch between the two road-users.

Serious conflict, type 3, (SeC:3)

(At least) one of the road-users involved is acting so late that he is just able to start on an evasive action. The road-user is hitting the other one with almost the "approach" speed.

Serious conflict, type 4, (SeC:4)

(At least) one of the road-users is detecting the danger so late that he is just about to start taking evasive action when the collision occurs. The road-user is hitting the other one with the "approach" speed.

Serious conflict, type 5, (SeC:5)

None of the road-users involved detects the danger until the collision is a fact. The road-users are colliding with the "approach" speed. Besides, the road-users are not at all prepared when they collide.

3.4.2 Severity rating through Time Measured To Collision (TMTC)

At an early stage of the development of traffic conflict techniques there was an interesting approach of rating conflicts with regard to severity in the U.S. (Hayward, 1972). A scale of danger for near-misses based on a time-measure was introduced by Hayward. He proposed the use of the unit Time Measured To Collision (TMTC), defined as the time required for two vehicles to collide if they continue at their present speeds and on the same path.(Thus the same as Time to Collision (TTC)). The situations were filmed and analysed through a sophisticated automatic technique. This made it possible to calculate TMTC at each frame point in the analyzed sequence, so that TMTC is continous with time.

Hayward claims that the theoretical shape of a simple near miss curve of TMTC-values versus time should be concaved upward, reflecting the increasing and then subsiding danger as a near-miss passes. (See figure 3.4).

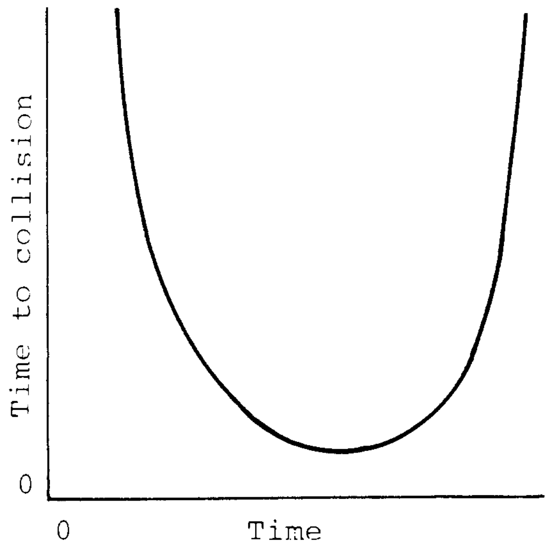


FIGURE 3.4 THEORETICAL TMTC CURVE ACCORDING TO HAYWARD

(From: Hayward, 1972)

The minimum value of the TMTC measure for a near miss, Hayward continues, would be the driver's perception time plus reaction time. This time is the time required for the driver to perceive the imminent danger of collision and to decide a course of action and implement it plus the time needed for the vehicle to respond to the drivers command in order to avoid a collision. If the TMTC value drops below this level, Hayward states, a crash will occur because there is not enough time for avoidance. A numerical value of the minimum TMTC measure would be approximately 0.5 seconds, Hayward supposes in referring to data of braking reaction time given elsewhere.

Unfortunately Hayward was only able to carry out one small field study. One intersection was studied during 9 hours. 90 sequences were filmed, but only 43 were possible to analyze. 38 sequences were producing curves with minimum TMTC-values. These values are shown in table 3.2.

TABLE 3.2 MINIMUM TMTC VALUES IN HAYWARD'S STUDY

Conflict nu	TMTC (Minimum) sec	Type	Conflict nu	TMTC (Minimum) sec	Type
1	0.20	Rear-end	20	1.30	Lane-change
2	0.30	Lane-change	21	1.35	Cut off
3	0.35	Right-of-way	22	1.40	Lane-change
4	0.40	Lane-change	23	1.45	Lane-change
5	0.45	Lane-change	24	1.50	Right-of-way
6	0.55	Lane-change	25	1.75	Cut off
7	0.60	Lane-change	26	1.80	Cut off
8	0.65	Lane-change	27	2.00	Lane-change
9	0.70	Cut off	28	2.00	Rear-end
10	0.80	Rear-end	29	2.15	Rear-end
11	0.80	Cut off	30	2.25	Lane-change
12	0.80	Rear-end	31	2.25	Broadside
13	0.90	Cut off	32	2.35	Lane-change
14	0.90	Rear-end	33	2.40	Lane-change
15	0.95	Lane-change	34	2.55	Right-of-way
16	1.15	Cut off	35	2.55	Rear-end
17	1.15	Rear-end	36	2.80	Lane-change
18	1.20	Cut off	37	3.40	Lane-change
19	1.25	Cut off	38	3.95	Cut off

From: Hayward, 1972

In the following graph (figure 3.5) a typical TMTC curve from Hayward's results is presented.

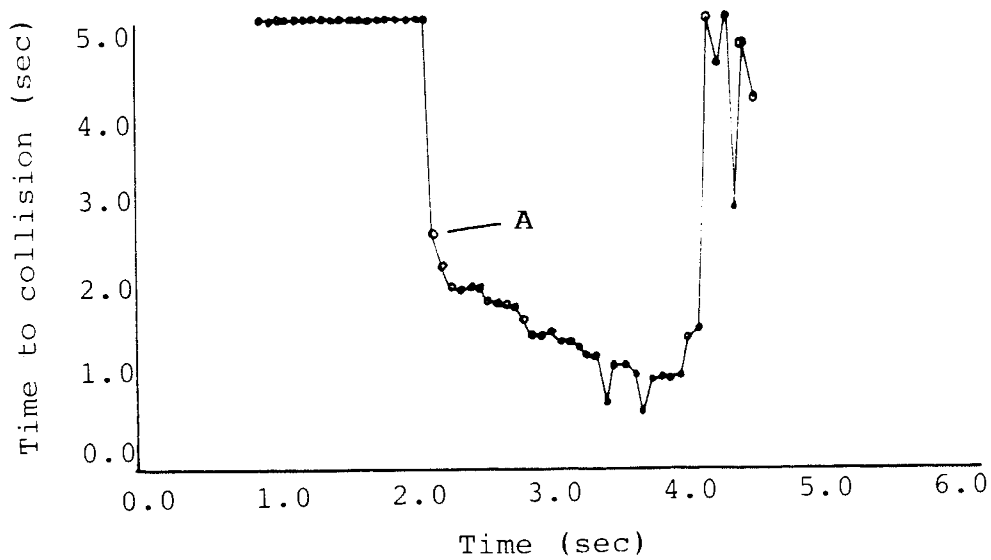


FIGURE 3.5 TYPICAL EMPIRICAL TMTC CURVE IN HAYWARD'S STUDY
From: Hayward, 1972

In the graph in figure 3.5 the moment when avoiding action by one of the road-users starts is point A. Thus braking reaction is undertaken before this point. From point A on, the curve is becoming concave. The shape of this curve will depend on the type of manoeuvre and the intensity of the manoeuvre.

It is strange that Hayward includes reaction time in the minimum TMTC that is required to avoid a collision. As long as TMTC is > 0 then there is no collision. Thus the only requirement is that min TMTC>0.

Hayward's choice of a minimum value of 0.5 seconds is not clear, especially as he presents empirical values of 0.2 seconds.

I will present a theoretical example that illustrates the problem:

A vehicle is approaching another one which is standing still. The speed is 54 km/h corresponding to 15 meters/second. The driver starts braking at a distance of 16.5 meters from the other car. His deceleration is constantly 6.9 m/s^2. (Corresponds to braking with locked wheels with a friction coefficient of 0.7 between tyres and road surface).

TMTC is then calculated as follows:

$$TMTC = \frac{d_o - v_o \cdot t + \frac{a \cdot t^2}{2}}{v_o - a \cdot t}$$

a = acceleration
d_o = distance to the collision point when evasive action starts
v_o = approaching speed, i.e. just before " "
t = running time, t = o when evasive action starts

In this case:

$$TMTC = \frac{16{,}5 - 15t + \frac{6{,}9 \cdot t^2}{2}}{15 - 6.9\ t}$$

t	0	0.5	1.0	1.5	1.75	2.0	2.1
TMTC	1.1	0.85	0.61	0.37	0.26	0.18	0.24

The graph is shown in figure 3.6.

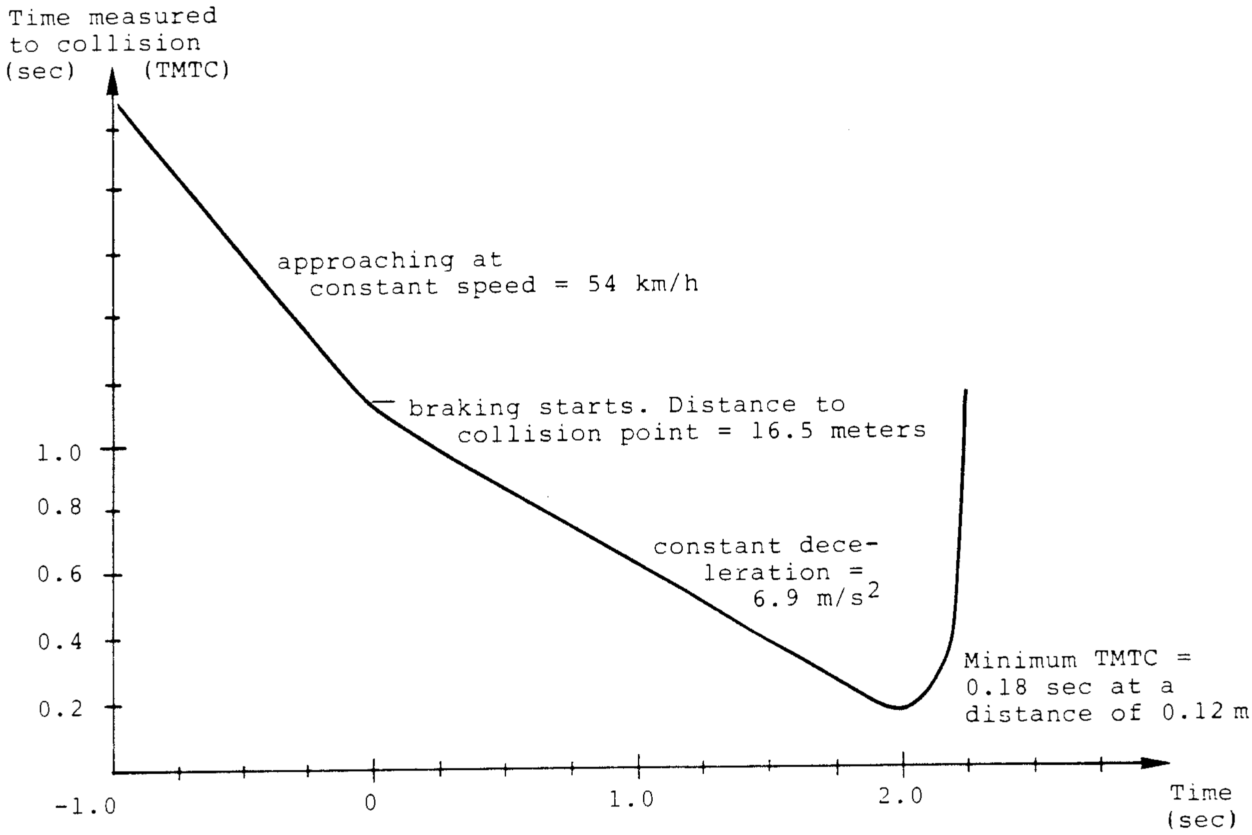


FIGURE 3.6 THEORETICAL EXAMPLE ILLUSTRATING A CONFLICT WITH A MINIMUM TMTC OF 0.18 SECONDS.

In the example, the minimum TMTC is 0.18 seconds at a remaining distance to the collision point of 0.12 meters. Thus it is now obvious that the minimum TMTC may very well go towards zero when the minimum distance to the collision point is going towards zero. It is therefore obvious that it does not exist a minimum TMTC dependent on the braking reaction time as Hayward claims. This is however, of minor importance, the major thing is that Hayward presented an approach to severity scaling and a technique that produced results which gave a lot of insight into the whole area of traffic conflicts.

3.5 Definition of a serious conflict

In section 3.4 the two main issues to consider, when developing a definition of a serious conflict, were phrased. They are as follows:

1) A method for severity rating has to be defined

2) Threshold level between slight conflicts and serious conflicts has to be defined

3.5.1 Method for severity rating

Three main ways of rating the severity are mentioned before:

- Distance in space, to collision point
- Distance in time, to collision point
- Deceleration power needed to avoid an accident.

Various problems of both theoretical and practical nature were experienced,when the method were to be defined:

Distance in space creates problems for some various reasons:

- A small distance may be linked to a low speed thus creating a very low accident-potential.
- A hazardous situation could be solved with still rather ample distance between the road-users. It could then be continued by the road-users passing each other on very small distance when leaving "the scene". The question then is what distance measure should be used and how should different measures be interpreted? (Longitudinal versus lateral distance, for example).

  One example illustrates the problems:

  Let us assume that there are two conflicts, both involving two cars on perpendicular courses. In both conflicts the minimum distance is two meters. In the first of the two conflicts a car driver is emergency braking in front of a car that is standing still. The car comes to a complete stop two meters from the other car. In the other conflict two cars on a perpendicular course are passing each other on a smallest distance of two meters. The two conflicts are, even though the minimum distance is two meters in both cases, completely different in nature.

Deceleration also creates problems:

- A certain deceleration power could be linked with any distance (in space or time). The accident potential could therefore not be easily defined unless the deceleration is related to speed or distance.

- A conflict where swerving is the only evasive manoeuvre can not be defined at all with regard to the degree of deceleration.

Thus none of the two measures seem to be very useful individually as indicators of the degree of severity. They have to be linked with other variables. Then, however, recording complexity increases. Besides, recording of deceleration power is complex as such and needs sophisticated hardware to be properly recorded.

Distance in time partly reflects both distance in space, speed of the road-user and deceleration power, or swerving capability, needed to avoid an accident. A low time value either indicates a short distance to the collision point or high speed, or both. Although a small distance in time can be linked to a low speed, thus creating a low accident-potential, this type of situation seemed to be rather rare and easy to discriminate from other events holding a low time-value.

We decided at an early stage that we wanted to use one single measure, not to make recording and interpretation of the results too complex. One reason for this was that we hoped that the developed technique could fulfill a purpose not only for researchers but also for practitioners. In the latter case the demand for simplicity in the application of the technique was considered very important.

In the choice between individual measures we were convinced that the time measure was the most general one and that it would produce the most relevant severity ratings for the most events compared to the other measures.

Once the time measure was selected, the next step was to decide which time measure to use. Hayward's approach, Time Measured To Collision, continously calculated from the approach till the conflict was solved, was quite interesting.

There was, however, hesitation with regard to this approach for some reasons:

- The recording technique was, even though challenging, too complicated to allow any kind of general use of the technique. This implied high costs for implementation and still, the reliability of the recording technique was not clear. Neither was the validity, which means that it was difficult to judge whether this expensive technique produced more valuable results than a less complex one.

- It was not clear from Hayward's results in what way the whole TMTC-graph was of interest. Hayward himself primarily used one value, namely the minimum TMTC. In that case one might ask if this value could not be obtained in some other way, for instance by judgments from trained observers in the field. It is a pity that Hayward did not elaborate more on the potential use of the TMTC-graphs. The graphs contained more information than was used by him. To start with, the shape of the curve preceding the minimum value could be combined with the minimum value. It would then reveal the character of the evasive manoeuvre that preceded the specific minimum value. Was for instance the manoeuvre sudden and/or hard? It seems obvious that this extended knowledge about the conflict would increase the possibility of estimating its accident potential. Even though we did not consider the use of such a sophisticated technique as Hayward's it was a pity that he did not elaborate his technique more. Such work might well have given indications of the potential of alternative approaches.

There is, however, another approach that raised our interest. From Hayward's graphs it is possible to find out at what TMTC-value the road-user started to take evasive action. Based on the fact that serious conflicts would reflect break-downs in the interaction between two road-users, we concluded that the TMTC-value mentioned above represents the time margin to a collision when a road-user has detected the danger and started on an evasive manoeuvre as quickly as possible. This time value would represent a "true" value which could not be manipulated by the road-user: If for instance the detection had occurred at an earlier stage the road-user would not deliberately increase the danger by postponing the evasive action till it would be classified as a serious conflict.

This specific TMTC-value consequently represented the (best) available time margin to avoid a collision. Thus the smaller the margin was, the more difficult it would be to avoid a collision and the higher the accident potential. This would at least be true as long as the events were homogenized, for instance with regard to what kind of evasive manoeuvre he performed and what speed was prior to the manoeuvre.

Based on the above mentioned arguments we felt that the TMTC-value, in the moment evasive action is just started, represented an excellent way of classifying conflicts with regard to their severity. Besides we believed that, due to the character of serious conflicts, the moment when evasive action is started would be easily recognizable.

This specific TMTC-value, or Time To Collision value as I will call it from now on, was, therefore, selected as our first approach to the severity rating of conflicts. It was from that point on defined as the "Time to Accident"-value (TA).

DEFINITION OF CONFLICT-SEVERITY (FIRST APPROACH):

THE SEVERITY OF A CONFLICT IS DEFINED BY ITS TIME TO ACCIDENT (TA)-VALUE. THE TA-VALUE IS THE TIME THAT REMAINS TO AN ACCIDENT IN THE MOMENT WHEN EVASIVE ACTION HAS JUST STARTED, PRESUPPOSED THAT THE ROAD-USERS CONTINUED WITH UNCHANGED SPEEDS AND DIRECTIONS.

It was presupposed at that time that if both road-users took evasive action, the TA-value of the road-user that produced the highest TA-value defined the severity.

It is to be observed that this definition presupposes a collision course, i.e. that the two road-users would have collided if their speeds and directions had been kept unchanged. It was, for instance, not considered necessary at that time to include near-misses, i.e. events where no collision course was present. Later on near-misses were brought up by other researchers as a potential measure for severity rating of conflicts. It was then considered even by us. Comments on this are found in various statements later on in the report.

3.5.2 Choice of threshold level between slight conflicts and serious conflicts

Once the technique of measuring the degree of severity through the TA-value was settled, the next step was to decide what degree of seriousness did define the threshold level between slight conflicts and serious conflicts.

In a first phase, video-tapings were carried out at urban intersections. The aim was to study the interaction between road-users generally, and to try and estimate the Time to Accident in conflicts. This was made through estimation of speeds and distances from video-taped situations.

The non-systematic observing through video produced the following main comments:

1) Normally there was a very distinct relation between the action observed and the TA-value. The lower the TA-value was, the more sudden and harsh was the action.

2) Some road-users, most often professional drivers, sometimes tended not to take any evasive action until "the very last moment". A typical situation of that kind was a driver approaching a pedestrian. Instead of braking once he had detected the conflict he went on with the anticipated wish that instead the pedestrian would perform the evasive action. If the pedestrian did not do so, there was still enough time for him, to start braking. One obvious reason behind these driver's way of behaving is, of course, to keep up speed and to reduce the delay as much as possible.

There seemed to be a lower limit for when action at "the last moment" took place. This limit seemed to be around 1.5 seconds in the sequences observed.

It was obvious at the same time, however, that this lower limit was speed dependent. This is clearly indicated in figure 3.7 where two conflicts with different initial speeds, but the same TA-value, produce very different final time margins.

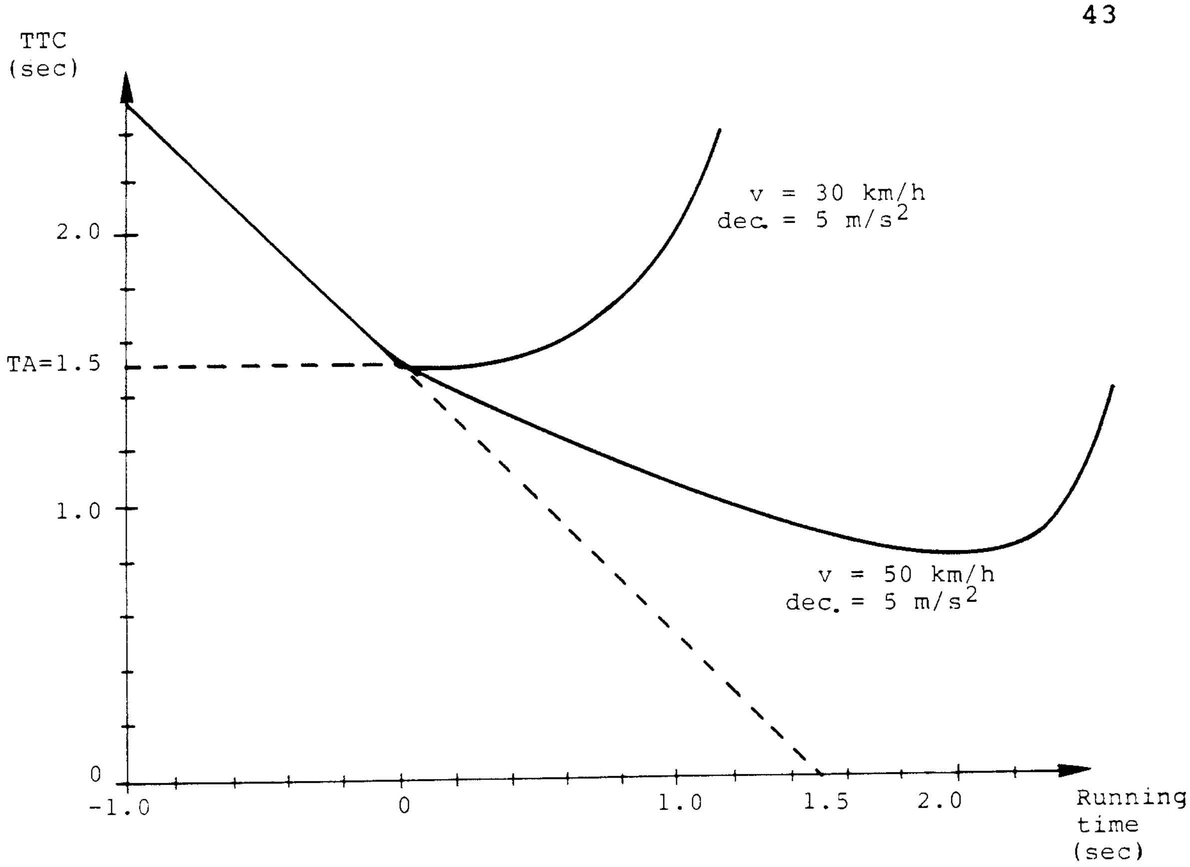


FIGURE 3.7 TTC-GRAPHS FOR TWO DIFFERENT VALUES ON INITIAL SPEED WITH TIME TO ACCIDENT = 1.5 SECONDS.

In spite of the speed dependent time margins, it was considered at this stage that the speeds observed at urban intersections were homogeneous enough to allow the choice of one single value on the lower time-limit.

3) Conflicts with TA-values above approximately 3 seconds became very hard to detect as they became part of the common interacting pattern at the intersection.

4) The vast majority of events that involved an abnormal increase in danger, as subjectively experienced by the observer, were events where a collision course was at hand. Thus, if the road-users speeds and directions had been kept unchanged there would have been a collision. Very rarely, an abnormal increase of the experienced risk was due to other types of events, like "close shaves" or whatever they may be called.

From this view-point it, therefore, seemed to be relevant to include only events where a collision course was at hand. In-depth studies of accidents would reveal whether accidents were preceded by evasive action or not, and consequently if a conflict definition based on the presence of a collision course was relevant or not.

3.5.3 Choice of first generation definition of a serious conflict

Based on the aforementioned studies and mementos it was decided that:

- One single severity class with regard to TA would do for urban conditions, as long as speed variation was not too great. This condition seemed to be fulfilled for the types of junctions studied in the pilot phase.

- No special differentiation with regard to vehicle speeds was considered necessary, with reference to what is said above. It was, however,also clear that different speeds do create different risks of producing injury and severe damage. Thus if conflicts were going to reflect the seriousness of the accident as well, then speed of the vehicles involved would probably be even more important. There are, however, other factors that will influence the severity of the outcome of an accident as well. The most important ones are type of road-user involved, type of vehicle, angle of collision and passive safety systems like safety belt, helmet etc. It was quite clear that these factors could not be included in the definition of the conflict. Rather the influence of these factors had to be taken into account in a second step. The serious conflicts, therefore, must be looked on primarily as indicators of the risk of a collision.

Considering all arguments presented so far in the report, a great confidence was felt for the introduction of, from a theoretical point of view, a very simple definition of a serious conflict:

A SERIOUS CONFLICT OCCURS WHEN THE TIME TO ACCIDENT (TA) IS EQUAL TO OR LESS THEN 1.5 SECONDS.

TA is calculated for both road-users involved and the calculation starts at the moment they begin acting to avoid the accident. The highest TA-value is selected as bearer of the greatest time margin, as the relevant TA-value for the conflict in question.

Each conflict directly involves <u>two</u> road-users - neither more nor less. Single vehicle/road-user conflicts were neglected at this stage, even though they could be treated in a similar way as the conflicts involving two road-users. Conflicts involving more than two road-users were treated as a number of different conflicts involving two road-users each. If an accident occurs that involves more than two road-users this can also be split into a number of accidents involving two road-users only. (A completely different thing is that the "second" accident may be caused by the "first" one.)

The definition is general in the sense that it can be used for any type of interaction between road-users, no matter

what type of road-users were involved or what manoeuvres were preceding the conflict.
One exception from the generalization was made, however:

- Due to the expected infrequency of certain road-user combinations it was decided that one of the road-users involved had to be a motor-vehicle.

4 RECORDING OF SERIOUS CONFLICTS

4.1 Choice of recording technique

There were two main ways of collecting data:

A. Indoor recording by human observers, from film or video.

To start with, a comparison between film and video was, from our point of view, completely to the favour of video. As films could not be reused, we considered that filming continously, looking for a few conflicts per hour, (that was what we anticipated after our pilot-studies) would not be possible financially. Even though the quality of filmed sequences was higher than with video, we still thought that the quality of video-taping was suitable for our purposes.

The early video-tapings that were made in the pilot-phase when we looked for potential definitions of serious conflicts, gave us a lot of experience in the use of video. To start with, we found some obvious advantages in using video compared to the use of human observers on the ground:

- The play-back facility made it possible to review conflicts until all information of interest was collected. Sometimes this was very advantageous, especially when the complexity was high or when the sequence had a very short duration.

- Video makes it possible for many persons to watch the same sequences under the same conditions together, thus enabling discussions to take place. Besides, conditions are more agreeable than what is normally the case outdoors. Video could also be used for documentary purposes, discussion of safety problems, etc.

- We felt that there was a great potential in video due to a foreseen development of semi- and fully automatic systems for detection of movements, incl. conflicts. Such systems might contribute both to more cost-effective collecting and analyzing of data and to higher reliability.

The use of video however, also had some disadvantages:

- The camera has to be mounted high and at some distance from the observation area so that an overview is given and so that the view is obscured as little as possible. This fact makes the use of video fairly complicated: Camera positions have to be planned in advance, permission to get access to localities is needed (often flats or offices), all equipment has to be transported, the camera has to be mounted in queer positions, electricity has to be provided etc. All this makes video-tapings non-flexible and adds costs.

- The area covered by one camera is normally limited. For instance only parts of an intersection can normally be covered. The use of two or more cameras increases the complexity quite a lot and it increases costs for the recording quite considerably.

- Video-tapings are static by nature. Thus the camera can not be moved instantaneously if sight is obscured i.e. by a big lorry etc.

- Video-tapings can only partly reflect "real life". Audible transmittance is (still) very different from real life and road-user reactions, etc. can not be detected from a video. Besides, perspectives are differently transformed on the screen, etc.

- Personnel is required both for the taping and for the analysis carried out afterwards. (Due to Swedish law a video-taping has to be supervised by a person close to the camera).

B. Outdoor recording by human observers on ground-level

The use of human observers for ground level observation was practised in the earlier mentioned studies in the cities of Lund and Uppsala. (PLANFOR 1972, 1973). Based on this experience we felt that this technique had the following <u>advantages</u>:

- The technique can be simple in use with relatively low costs, as long as recordings can be made by one or two observers per location and as long as the observers can use data-sheets for written records.

- The technique is flexible from many view-points. For instance, the organisation of studies is easy to carry out and to change, as the observer demands very short time for preparation. Changes in the format of written records can also be easily adopted.

- Observations made in the field, "close to the scene" give excellent opportunities to experience "the reality of conflicts". Cues, such as audible indications and communication between road-users can be included in the evaluation of events. Due to the simple technique, the observer can always move around so that he has the best overview depending on actual traffic volumes, light conditions, etc.

The use of human observers had the following <u>disadvantages</u>, we felt:

- The reliability of the records is crucial. To record conflicts demands a high degree of alertness combined with the skill to record data from complex events retrospectively.

- The observer(s) might be too conspicuous at certain locations/occasions. This might influence the behaviour of road-users.

- Bad weather conditions might have a negative influence on the observer's abilities. It might even limit the possible use of the technique.
- Air and noise pollution might create health problems for the observers.
- Low frequency situations might be too expensive to cover with regard to the outcome. (It would, however, be due to the aims of the study).

I mentioned earlier that we wanted to develop a technique that could be widely used, not only in research but also in practical applications. Criteria such as low-costs, flexibility, simplicity were then considered important.

In this perspective video-tapings were ruled out for use on a routine basis. The conclusion was, therefore, that a technique for recording by human observers in the field had to be developed. The disadvantages with such a technique had to be minimized so that the reliability of the technique could be acceptable.

While video was omitted for making regular recordings, we felt that it had many more benefits for the training of human observers. We decided therefore to apply video for this purpose.

4.2 Development of a data-sheet for ground-level observers

The data-sheet for recording of conflicts in the field had to be simple to fill in so that time-consumption was minimized. It also had to be logical in its structure for the same reason. In addition, it had to be logical so that the risk of misinterpretations was minimized.

A simple data-sheet was also essential from the point of view of observer's conspicuousness. The less conspicuous the observer, the smaller the risk that the behaviour of road-users would be influenced.

Figure 4.1 shows the original data-sheet that was developed on the grounds mentioned above.

Location No: 6
Date: 750512
Time: 1600–1830

Location: DJÄKNEGATAN / BALTZARGATAN, N ↓

Climate: CLOUDY, RAIN WET ROAD

confl. sit. no.	Description of the conflict situation
1 TIME: 1605 SPEED: 35	CLASS: 2 PRIMARY INVOLVED: C-C SHORT DESCRIPTION OF COURSE OF EVENTS: AGE: 1 SWUNG OUT BEHIND 3 WHICH BLOCKED THE VIEW OF 2. BOTH CARS BRAKED AT A SHORT DISTANCE
2 TIME: 1615 SPEED: 30	CLASS: 1 PRIMARY INVOLVED: C-C SHORT DESCRIPTION OF COURSE OF EVENTS: AGE: 1 BRAKES TO ALLOW PEDESTRIANS TO CROSS. CONFLICT BETWEEN 1 AND 2. 2 BRAKED LATE.
3 TIME: 1641 SPEED: 30	CLASS: 2 PRIMARY INVOLVED: C-C SHORT DESCRIPTION OF COURSE OF EVENTS: AGE: 1, A TRUCK REACHES THE INTERSECTION FASTER THAN 2 HAD EXPECTED.
4 TIME: 1651 SPEED: 20	CLASS: 1 PRIMARY INVOLVED: C-P SHORT DESCRIPTION OF COURSE OF EVENTS: AGE: 3 LETS 2 CROSS. 1 WHO COMES AROUND THE CORNER DOESN'T SEE 2 BEFORE HE COMES INTO VIEW FROM BEHIND 3 2 AND 1 BRAKE QUICKLY
5 TIME: 1704 SPEED: 25	CLASS: 2 PRIMARY INVOLVED: C-C SHORT DESCRIPTION OF COURSE OF EVENTS: AGE: U-TURNING CAR 1 FAILS TO COMPLETE THE TURN AND STOPS AT AN ANGLE OVER R-LANE. 2 THEN COMES AROUND THE CORNER AND IS FORCED TO STOP BY THE UNEXPECTED OBSTRUCTION.

Sketch of the involved

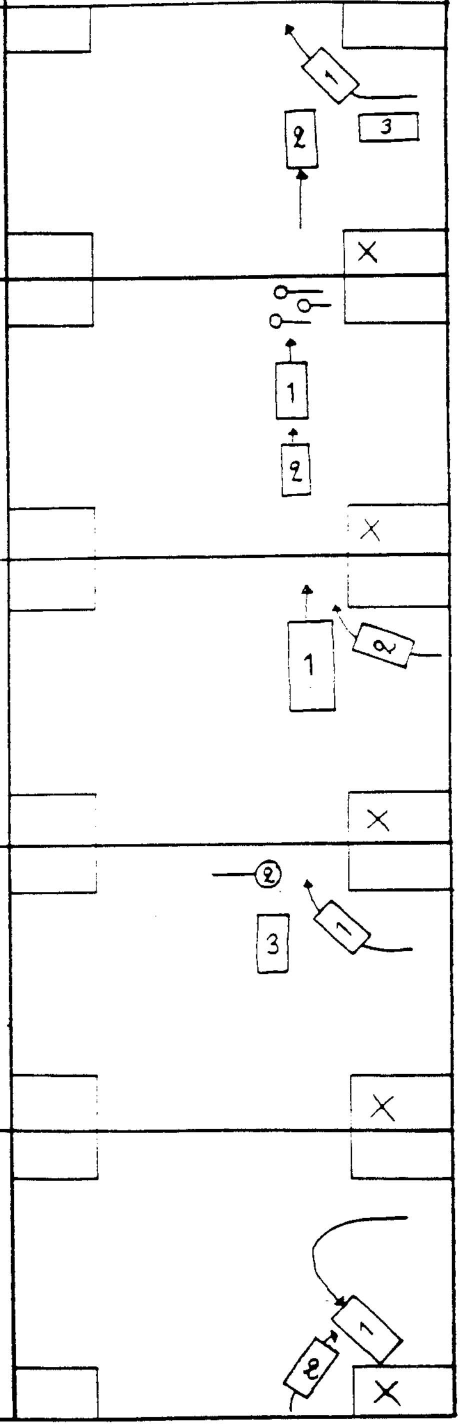


FIGURE 4.1 ORIGINAL DATA SHEET FOR THE RECORDING OF SERIOUS CONFLICTS.

Some comments and explanations have to be made regarding the data sheet:

Class: As it was made clear already at this stage that both the Time to Accident (TA) value and the initial speed of the road-users were linked to the severity of a conflict, it was decided that a four class scale based on TA and speed should be introduced so as to make more detailed analysis possible. The initial speed and TA-values that are filled in are those of the road-user who has the highest TA-value. As the relationship between conflict severity, "speed" and "TA" was not known, the ranking of the four classes with regard to severity had to be tentative. This was especially true for the ranking of class 2 and class 3.

Class 1:	Speed	< 35 km/h,	1.0 ≤	TA ≤ 1.5 sec
Class 2:	"	< 35 km/h,		TA < 1.0 sec
Class 3:	"	≥ 35 km/h,	1.0 ≤	TA ≤ 1.5 sec
Class 4:	"	≥ 35 km/h,		TA < 1.0 sec

Speed: Initial speed of the motor-vehicle with the highest speed.

Age: Estimated age of unprotected road-users

Primarily involved: Always two road-users; those two that would have collided if they had continued without change of speed or direction. Any other road-user that would have been involved, for instance by being the initiator of the conflict,is called a secondarily involved road-user. This is referred to in the description of the event.

Short description of course of events:

Here, any information should be added that cannot be read out by the sketch, and which could add something to the understanding of what did happen and why. Hypotheses on the causes of events are accepted, as long as there is information as to what the hypotheses are based on. (Example; Driver 1 did not see the pedestrian in time because he was looking at an oncoming car from the right).

The data sheet was found to fulfill all important criteria while in use during the first years. The demands for further information on each conflict, however, increased gradually and the original data-sheet was changed to another one where each conflict was recorded on a separate data-sheet. One of the things that was made possible, thanks to this, was the introduction of a scale-proof sketch of the actual intersection studied. This soon began to be demanded from observers as geometry varied quite a lot between intersections and it was not satisfactory to use a standardized graph of one intersection on all occasions.

4.3 The development of a training procedure for human observers

4.3.1 Principles for training.

Training was, from the very beginning, based on the assumption that estimation of time margins is made continously by all road-users, thus making it part of a normal driving or walking procedure. Road-users make all the adjustments of speed and direction of travel due to these estimations of time margins. The smaller the time margin is, the more sudden and harsh the action has to be. Of course there is a variation with regard to individual attitudes and capabilities, but the closer to an accident the more homogeneous the action will be, especially in the initial stage of the avoiding action, which is the part of the action we have selected for our definition.

Our definition of a serious conflict is based on the assumption that "the last moment of safe action"is passed when Time to Accident is equal to or less than 1.5 seconds. This implies that it should be easy to discriminate a serious conflict from slight conflicts, as the road-user in the first case has to make a sudden and very distinct manoeuvre.

The above mentioned arguments were used to formulate the following hypothesis:

TRAINING OF OBSERVERS IN ESTIMATING "TIME TO ACCIDENT" CAN BE BASED ON ESTIMATIONS OF THE SUDDENESS AND HARSHNESS IN THE OBSERVED ACTIONS.

4.3.2 Original training procedure

In the initial stage of training, the potential observers watch video-taped conflicts with varying TA-values, above and below the border-line of 1.5 seconds. Conflicts involving different types of road-users and different types of intersections are included in this first section. The main aim is to link a certain "Time to Accident" to a certain level of suddenness and harshness and, especially, to distinguish between serious and non-serious conflicts. In conflicts that are close to the border line, the observers are trained first to make the ordinary judgment of "Time to Accident" and then in a second step to estimate speeds and distances and in that way obtain a second estimate of the "Time to Accident" through calculations. The amount of agreement will determine whether the conflict will be considered serious or not.

A training-period is five days long and has the following structure:

Day 1	Before noon	Introduction, theory including examples from edited video-tapes.
	Afternoon	Training from video, test from video.
Day 2	Before noon	Outdoor training 1) Instructions with regard to positioning, scanning technique, written record making, etc. 2) Common training session where conflicts are discussed and the records are immediately compared.
	Afternoon	Individual observation outdoors. Simultaneous video taping.
Day 3	Before noon	Comparison of results indoors. Each conflict detected by any (potential) observer is checked on the video and also scored from the video by an experienced observer. Results are summarized and conclusions are drawn according to each individual's present reliability.
Day 4	Before noon	Comparison of results indoors (As Day 3 - Before noon). "Refreshment" by going through the written records of conflicts one more time.
	Afternoon	Reliability test, outdoors. Simultaneous video-taping. (Individual records on a routine basis).
Day 5	Before noon	Results of the reliability test. Indoor session where individual results are compared to results from video. Each observer's result is summed up and conclusions are drawn with regard to the status of each.
	Afternoon	Closing session. Enquete to all participants. Discussions.

The optimal number of trainees is 8-10 persons. The sessions could then be run by two persons, one mainly responsible for the video sessions (taping and play-backs including scoring from video) and one person responsible for everything else.

4.4 Tests of observer reliability

4.4.1 Original tests

Two studies were originally carried out in order to study the external reliability of observers. The external reliability concerns the ability of observers to discriminate serious conflicts from other events in the same way among themselves and in accordance with the objective criteria (TA $\leq$ 1.5 sec).

The studies were designed in the following way:

- The trainees were making conflict-studies at the same location - at the same time but independently of each other. Simultaneously video tapings that covered the same observation area were carried out for the whole session.
- The video tapes were evaluated and serious conflicts were discerned by an experienced observer.
- Each event scored by an observer or from the video was included. Comparison of scores was made.

In order to assure that the comparisons were relevant, i.e. that each event was given the same unique identity by each observer and the video evaluation, two steps were taken:

1) The exact time of each event was recorded by the observer and on the video.

2) The observers recorded the type of road-users involved and their direction of travel.

The first study of the external reliability of observers was carried out in the city of Malmö in May 1974. Five observers were tested. Detailed results are found in appendix 4.1.

The results are summarized in table 4.1.

TABLE 4.1 SUMMARY OF THE FIRST RELIABILITY TEST

Observer	A	E	H	J	M	Total
Number of serious conflicts to be scored	8	8	8	8	8	40
Number of serious conflicts actually scored as serious	7	7	8	8	6	36 (90%)
Number of non-serious conflicts actually scored as serious	0	2	0	0	0	2

A second test was carried out in May 1975. Seven observers were then involved, trained on three different occasions.

The detailed results are shown in appendix 4.2 and summarized in table 4.2.

TABLE 4.2 SUMMARY OF THE SECOND RELIABILITY TEST

Observer	L	H	M	T	P	J	R	Total
Number of serious conflicts to be scored	5	5	5	5	5	5	5	35
Number of serious conflicts actually scored as serious	5	3	3	4	5	5	5	30 (86%)
Number of non-serious conflicts actually scored as serious	0	1	1	0	0	0	0	2

The two tests produced very similar results. The primary conclusions were:

- On the whole there were very few missed serious conflicts. Only between 10% and 14% of the scores that should be made were missed.
- Very few events were scored as serious conflicts without being so. Only 4 'extra'-scorings were made compared to 75 relevant conflict-scorings (5%). Besides, the "extra" scorings made the number of serious conflicts scored by the observers closer to the real number. Thus, if 'the extra' scorings represent similar conflicts as those that were missed, then they could (partly) compensate for the missed conflicts. Due to small numbers, however, the possible compensation effect can not be studied.

The main conclusion regarding 'the extra' scorings is that it is a very small number and they can therefore not create any noteworthy turbulence in the results, even if they cannot compensate for any missed conflicts.

The four-class scale for an internal classifying of serious conflicts with regard to the degree of seriousness introduced at the training of observers, (see section 4.2), was not used in the following validation studies. The test results with regard to this were therefore not considered as important. Still, it can be seen from Appendices 4.1 and 4.2 that only 11 out of 66 scores, corresponding to 17%, were given the wrong degree of severity. Even this result must be considered as encouraging. It emphasized the impression that observers may well estimate both "TA" and "Speed".

4.4.2 Indirect tests of the variance in day-to-day counts of serious conflicts

On quite a few occasions studies have been carried out at the same locations during two or more days. This enables the calculation of the variance in day-to-day conflict counts. It makes it also possible to discuss the reliability of observers. If we presuppose, namely, that conflicts are rare events that occur at random, then the number of conflicts at a specific location is Poisson-distributed. If we also presuppose that traffic volumes, light conditions, etc were approx the same during different days at the same location then the number of conflicts during different days at the same location also follows a Poisson-distribution. It then follows that the variance in day-to-day counts should be equal to the mean.

In table 4.3 the results from a number of conflict studies are presented. They all fulfill the above mentioned criteria regarding (approx.) similar conditions during the different counting days. Besides, different observers were counting on different days, not informed of the result of any other observer at the same location.

In figure 4.2 the individual means and variances are plotted and in figure 4.3 are two days of conflict counts compared.

TABLE 4.3 THE NUMBER OF SERIOUS CONFLICTS DURING DIFFERENT DAYS AT THE SAME LOCATION.

Type of location, study, reference	Number of conflicts Day 1	Day 2	Day 3	Day 4	Day 5	Mean	Variance	Var / Mean
Urban intersections, Malmö Similar days during two consecutive years (1974), 1975), (Hydén, 1976)	1	2				1.5	0.5	
	3	0				1.5	4.5	
	2	3				2.5	0.5	
	4	2				3.0	2.0	
	6	7				6.5	0.5	
	4	6				5.0	2.0	
	4	6				5.0	2.0	
	2	0				1.0	2.0	
	3	4				3.5	0.5	
	5	4				4.5	0.5	
	0	1				0.5	0.5	
	1	3				2.0	2.0	
	2	4				3.0	2.0	
	3	2				2.5	0.5	
	5	4				4.5	0.5	
	5	5				5.0	0	
	9	6				7.5	4.5	
	12	18				15.0	18.0	
	9	10				9.5	0.5	
	5	4				4.5	0.5	
	12	12				12.0	0	
	4	4				4.0	0	
	6	13				9.5	24.5	
	10	13				11.5	4.5	
Σ						123.6	59.2	0.48
Urban signalized intersection before all-green for pedestrians was introduced. Eslöv (Gårder, Hydén, 1978)	7	6	7	8	7	7.0	0.5	
Ditto, after	3	3	6	2	4	3.6	2.3	
Ditto, before, Stockholm I	16	10	14			13.3	9.4	
Ditto, after, Stockholm I	7	5	10	7		7.2	3.7	
Ditto, before, Stockholm II	6	6	11	10		8.2	6.9	
Σ						39.3	22.8	0.58
ΣΣ						162.9	82.0	0.50
Intersections between local streets and arterials Eindhoven and Rijswijk, the Netherlands (Traffic Safety Group, 1983)	2	2	1			1.7	0.34	
	1	0	1			0.7	0.34	
	0	1	0			0.3	0.34	
	4	1	2			2.3	2.34	
	0	0	0			0	0	
	0	0	2			0.7	1.34	
	0	0	0			0	0	
	2	4	0			2.0	4.0	
	5	2	5			4.0	3.0	
	4	5	3			4.0	1.0	
	4	1	3			2.7	2.34	
	1	2	4			2.3	2.34	
	2	1	3			2.0	1.0	
	0	1	1			0.7	0.34	
	2	0	1			1.0	1.0	
	3	5	2			3.0	2.34	
	0	0	3			1.0	3.0	
	2	2	2			2.0	0	
	0	1	4			1.7	4.34	
	3	4	2			3.0	1.0	
	0	2	5			2.3	6.34	
	0	2	6			2.7	9.34	
	3	1	7			3.7	9.34	
	18	16	15			16.3	2.34	
	7	6	2			5.0	7.0	
	3	3	1			2.3	1.34	
	3	2	2			2.3	0.34	
	0	0	2			0.7	1.34	
	0	2	2			1.3	1.34	
	3	1	1			1.7	1.34	
Σ						73.7	58.3	0.79
ΣΣ						236.6	140.3	0.59

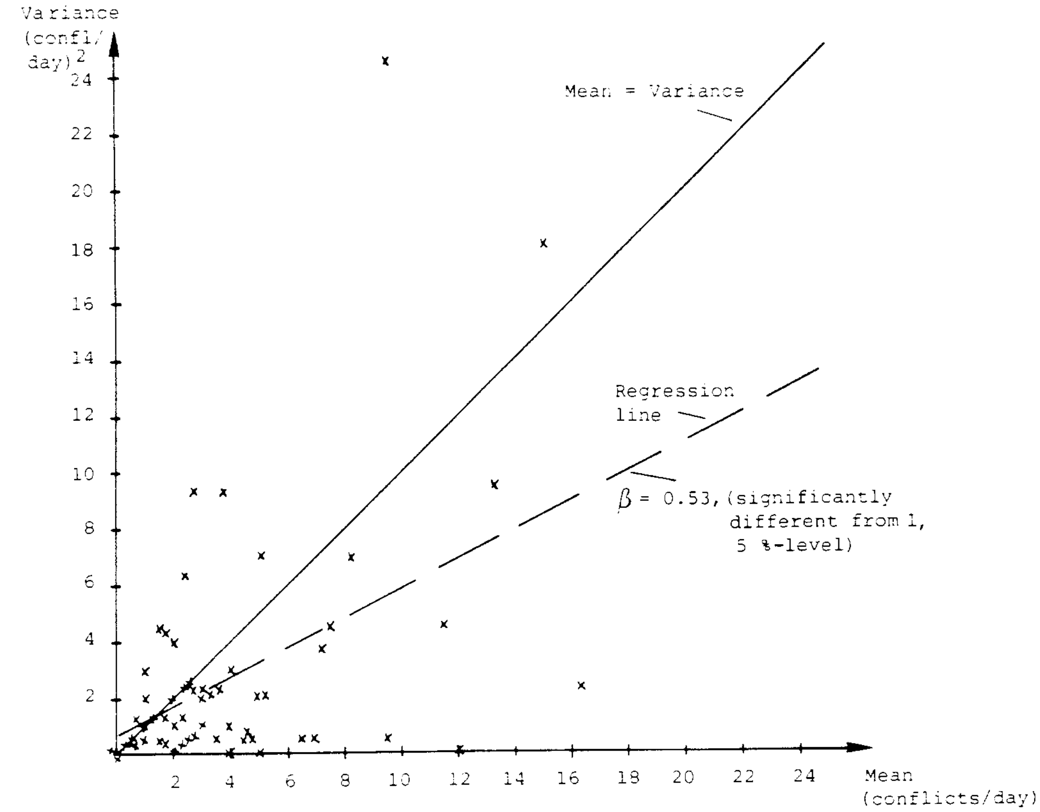


FIGURE 4.2 MEAN AND VARIANCE FOR DAY-TO-DAY COUNTS OF CONFLICTS.

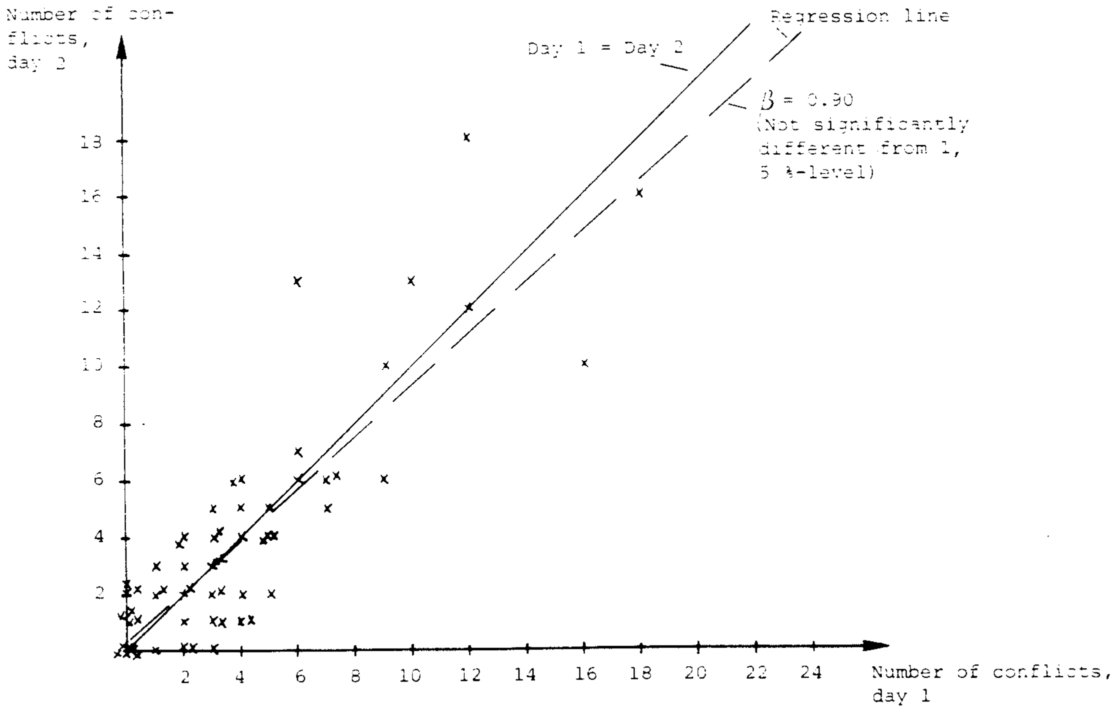


FIGURE 4.3 COMPARISON OF TWO DAYS OF CONFLICT COUNTS.

One important result from table 4.3 and figure 4.2 is that our variance-to-mean ratio is lower than 1.0, which should be the value if the assumption of Poisson-distribution of the daily conflict numbers were true. Our value of appr. 0.6 indicates that the distribution of daily conflicts at one site is more regular than indicated by the Poisson-distribution.

Hauer, 1978 has compared results from various countries. He found that **"the day-to-day variability in conflict counts is larger than that implied by the Poisson distribution. This may be attributed to changes in the expected conflict rate from day-to-day and to the subjectivity of conflict identification by observers."**

In view of Hauer's conclusion it is somewhat difficult to explain our low variability in day-to-day counts. In this connection it should be noted again that the various observers involved in our studies at the same location were not informed of the result of other observers at the same location.

In spite of Hauer's conclusion the first conclusion from these results has to be that our day-to-day counts produce a variance-to-mean ratio that is lower than 1.0, and the value of 0.6 should therefore be used from henceforth on to describe the variance in our day-to-day counts.

The second conclusion has to do with observer reliability. It seems obvious from the results that very little variability is introduced through the subjective scorings by the observers. The comparison of means and variances clearly indicate this. The comparison of two days of conflict counts illustrates the same thing in a good way: The number of conflicts scored one day was on average very similar to the number scored the second day. Figure 4.3 shows that the regression analysis gives a regression line which is very close to the line for equal numbers. These results confirms the earlier results about a high level of observer reliability.

5 VALIDATION OF SERIOUS CONFLICTS AGAINST ACCIDENTS - FIRST GENERATION APPROACH

5.1 Introduction

Validation of the serious conflicts against accidents is a critical issue in order to be able to state if and how accidents and serious conflicts are related. The term validity may be understood in different ways:

- Process validity, i.e. to what extent conflicts may be used for defining the 'process' that leads to accidents. Process can for instance be understood as the chain of events/behaviours that precedes accidents. A validation in this case must be based on some sort of theory that defines the aforementioned process.

- Predict validity, i.e. to what extent the number of conflicts can be used to forecast number of accidents. Hauer and Gårder (1986), have treated this problem. They state to start with that **"some will regard the TCT as valid if it proves successful in predicting accidents; others will judge validity by the statistical significance or the magnitude of the correlation between conflicts and accidents"**. There is a **"semantic and conceptual confusion"** as they phrase it.

  In order to overcome this they state that they **"define safety of an entity to be the expected number of accidents (by severity) occurring on the entity per unit of time"**. Entity is defined as some part of the transportation system, say an intersection. They continue: **"Thus when the validity of the TCT is questioned, one is in fact asking whether the estimate of the aforementioned expected value is in some sense 'valid'"**.

  It should be clear they say **"that the performance of the TCT cannot and should not be judged by its success in predicting future accidents. The number of accidents to occur in the future can no more be predicted than the roll of a die. The proper question to ask is: how good is the TCT in estimating the expected number of accidents?**

  Safety can be estimated either directly, making use of recorded accidents, or indirectly using, for instance, conflict studies. The technique to prefer is then generally the one that produces the smallest variance.

This leads Hauer and Gårder to the following operational definition of what 'validity' means in their paper:

"A technique (method, device) for the estimation of safety is 'valid' if it produces unbiased estimates the variance of which is deemed to be satisfactory".

This first approach to the validation problem presented in this chapter, was presented a bit more than ten years ago (Hydén, 1976), thus long before Hauer and Gårder presented their paper on predict validity. In principle, however, we used a similar operational definition of 'validity' as Hauer and Gårder presented in their paper: We estimated accident-to-conflict ratios for different 'entities' and we checked whether these ratios were 'stable' and 'similar' by comparing the estimates and their confidence intervals between subsets of data.

Some of the assumptions that were made were not in line with those made by Hauer and Gårder. This is one of the things that will be commented on in chapter 6 where the whole original technique is evaluated.

The work on validity presented up to that point had dealt with predict validity. In chapter 7 I present a new approach to the validity problem, which can be characterized as a process validity study.

The presentation in this chapter of the original validation work, section 5.2 - 5.9, is a reporting from the original presentation (Hydén, 1976). The statistical design, partly mentioned above, was made by a consultant.

5.2 Basic hypothesis and strategy

Our general strategy was to collect accident data and conflict data from a number of intersections. Our primary aim was to analyze data with regard to what variables accounted for the variation in the relationship between serious conflicts and accidents. Data were then grouped with regard to these variables. The basic hypothesis was then that: **THERE IS ONE REAL VALUE IN THE RELATIONSHIP BETWEEN SERIOUS CONFLICTS AND ACCIDENTS FOR EACH GROUP.**

The hypothesis was tested through a comparison of three subsets of data. This split of data into three subsets was considered feasible with regard to the size of each subset. It was also strategic to split data in this way. The following is the operational description of the validation work:

Study Ia — 50 intersections in Malmö were studied in 1974 to differentiate which variables were important for the relation between serious conflicts and accidents. A first model was selected for this relationship.

Study Ib — The same intersections were studied again in 1975. The purpose was partly to study the stability of the conflict frequency and partly to increase the amount of data. A final model for the relation between serious conflicts and accidents was selected.

Study II — 15 new intersections in Malmö were studied in 1976 to clarify the stability of the model within the same urban area.

Study III — 50 intersections in Stockholm were studied in 1976 to study whether the stability of the model was kept when the characteristics and size of the urban area were different.

5.3 Data collection, principles and procedures

5.3.1 Recording of conflicts

Taking into consideration the varying traffic intensities during the day, studies were made in four separate periods on weekdays (excl Saturdays) as follows:

Period	Time
1	09.00 - 11.30
2	11.30 - 13.00
3	13.00 - 16.00 (15.45 at some intersections)
4	16.00 (15.45) - 18.30 (18.15)

Each conflict study included all, or parts, of a time period. Considering the relatively constant traffic intensity within each period, a study during part of a period was considered representative for the intensity of conflicts during the entire time period.

All of the conflict studies have taken place sometime during the period of april 15 - june 15 in order to keep conditions as similar as possible so that comparisons were justified without any doubt.

Table 5.1 shows the months and periods of the various studies.

TABLE 5.1 OBSERVATION PERIODS FOR CONFLICT STUDIES.

		Studied part of period			
		Period 1 09.30-11.30	Period 2 11.30-13.00	Period 3 13.00-16.00	Period 4 16.00-18.30
Ia	Malmö, 50 intersections, May 1974	0,2	0,7	0,2	0,7
	May 1975	0,5	0,4	0,5	1,0
II.	Malmö, 15 intersections, May 1976	1,0	0,9	1,0	1,0
III.	Stockholm, 50 intersections, May, June 1976	0,6	1,0 [1)]	0,5	1,0 [1)]

1) 1,0 designates studies that lasted the entire period

The observation area in each intersection is designated by an imaginary line 5 meters outside the marked pedestrian crossing, or, by a corresponding area where the pedestrian crossing is not marked.

During periods 1, 2 and 3 one observer was used, except in certain intersections in Stockholm where two observers were considered necessary because of the traffic intensity. During period 4 two observers were used, except in the first studies during May 1974, where only one observer was used.

5.3.2 Traffic volume counts

In connection with the conflict studies, flow counts were done in accordance with a procedure for determining the probability of how many encounters may occur in different situations. All car, bicycle/moped and pedestrian flows were counted. One person carried out each series of counts. As one person is not able to count all directions of flow at the same time, the following method was used:

"The counter" divided the total number of flows into two or three sections and counted each for five minutes. The minimum requirement is that each flow must be counted twice during each half hour - the counting should cover at least one third of the total time. This procedure gives an error which is small enough to be acceptable for this application. All the traffic counts were carried out with special personnel. These "counters" worked independently from the conflict observers. The traffic counts covered the same time periods as the conflict recording. In certain situations the goal of counting each flow one third of the total time could not be met. This was due to lack of sufficient resources and the fact that the conflict studies held higher priority than the traffic counts. With regard to the fact that these counts were aggregated in the analysis the reduced counts played a very minor role in adding uncertainty.

5.3.3 Accident selection

To start with one must conclude that there is no individual source of information that cover the majority of the traffic accidents that occur. Police statistics in Sweden seem to cover around one fifth of all damage-only accidents and half of the injury accidents.

Theoretically, police statistics may be complemented by insurance or hospital statistics. The question remains, however, as to what degree these sources of information are representative of the majority of traffic accidents, individually or combined. Besides, the collecting of data other than from the police would be a very time-consuming and costly business.

For the reasons mentioned above police-statistics became our one source of information. Weighing between the two objectives of having a large sample and having a non-biased sample, we decided to exclude the damage-only accidents. The statistics represented only a small part of the total damage-only accidents and the risk of biased samples was considered high.

The accident sample was therefore defined as follows:

ACCIDENTS ARE IN THIS VALIDATION STUDY EQUAL TO POLICE-REPORTED INJURY ACCIDENTS

Regarding the bias of this sample, we found that the reporting-rate was fairly similar among the types of intersections that were included (Semi-central and central urban intersections).

For the comparison with conflicts, only the police reported injury accidents that occurred during time periods covered by the conflict studies were included, i. e. week days, (except Saturdays) 09.00 - 18.30. A division into four periods was made corresponding to the conflict studie's time divisions. Accidents on roads covered with ice are not included.

To be able to carry out a test on the relationship between serious conflicts and all police reported accidents, damage-only accidents for the first 50 studied intersections were also collected with reference to the principles that have been previously described for injury accidents.

For the three different studies accidents for the following years were collected:

For the 50 Malmö intersections: 7 years (1968-74).

For the following 15 intersections in Malmö: 8 years (1968-75).

In Stockholm: 7 years (1970-76).

5.3.4 Selection of intersections.

As was shown earlier, the comparative analyses are based on studies in a total of 115 intersections in three steps:

I. Malmö, 50 intersections

II. Malmö, 15 intersections (different from (I))

III. Stockholm, 50 intersections.

The intersections were randomly chosen among all the intersections in the two cities. The following secondary conditions have been applied:

1. No change in the intersection design, that may have lead to any significant influence on the safety, may have

occurred during the accident analysis period.

2. The change in traffic volumes must be considered "normal", i e the traffic in the intersection may not have been influenced by any additional traffic regulatory devices.

3. The traffic intensity in the intersection may not be "too low" with reference to the conflict-respective accident- intensity. The sum of the approaching vehicles in the intersection has to be greater than 10.000 per ADT, where there are at least 2.000 in the approach with the least traffic. In addition, the pedestrian and bicycle/moped traffic must also exist "in a certain minimum amount". (No absolute figures were given because there were no counts available).

All of the intersections have been classified and grouped as follows:

1. <u>Low speed intersection</u> (non-signalized intersection with a median speed of crossing motor vehicles - in the direction where the speed is the highest - below 30 km/h)

2. <u>High speed intersection</u> (non signalized intersection with a median speed in at least one flow exceeding 30 km/h)

3. <u>Signalized intersection</u>

For the first 50 Malmö-intersections, data has also been collected regarding the physical design of the intersections, i.e. traffic islands, pedestrian crossings and sight distances.

For the random selection of the 65 intersections in Malmö, a list was made of all the intersections in Malmö with at least one police-reported accident including damage-only during the period 1968-74 was used.

The selection was a little biased, as some of the intersections which had by chance not had any accidents during the chosen period, were not included in the list. This implies a regression to the mean effect, i.e. the average number of <u>accidents that have occurred</u> in the selected intersections may be bigger than the <u>expected number of accidents</u>. A sample test, however, among all intersections in Malmö showed that out of 100 randomly selected intersections which met the required traffic flow criteria, at least 96 were within the selection's limits. Besides the importance of the bias in selecting is minimized when considering the fact that there were a fair number of intersections (approx 20%) where no injury accidents were reported during the period of study for the 596 intersections involved.

The 50 intersections in Stockholm were selected from a list of the 300 most accident-prone intersections during the last five years. This list also included property damage accidents. Because of this, the list included a number of intersections that had no injury accidents whatsoever. For the same reasons as given for the Malmö intersections, this selection criteria must be considered acceptable.

For the classification of non-signalized intersections in high-respectively low-speed intersections, a primarily subjective judging was done. In uncertain cases and for control reasons, special speed recordings were carried out in 11 Stockholm intersections and 11 Malmö intersections.

In table 5.2 the results of the speed recordings are compiled.

TABLE 5.2 RESULTS OF SPEED RECORDINGS

Intersection	Median (km/h)	85-percentile (km/h)	Speed class
STOCKHOLM:			
Birger Jarlsgatan - Ingemarsgatan	46	53	High
Västberga Allé - Vretenborgsvägen	49	57	High
Västberga Allé - Karusellvägen	48	58	High
Upplandsgatan - Kungstensgatan	35	44	High
Tegnérgatan - Västmannagatan	32	41	High
Västmannagatan - Rådmansgatan	35	43	High
Vanadisvägen - Upplandsgatan	35	43	High
Rosenlundsgatan - Maria Bangata	42	52	High
Kontrollvägen - Juvelerarvägen	44	53	High
Telefonvägen - Mikrofonvägen	41	48	High
Hässelbyvägen - Värstagårdsvägen	34	41	High
MALMÖ:			
Amiralsgatan - Södra Promenaden	30	40	Low
Södra Förstadsgatan - Storgatan	26	36	Low
Ystadgatan - Claesgatan	18	30	Low
Östra Tullgatan - Stora Trädgårdsg	25	38	Low
Östra Förstadsgatan - Exercisgatan	17	37	Low
Djäknegatan - Snapperupsgatan	20	39	Low
Södra Förstadsgatan - Smedjegatan	24	37	Low
Lönngatan - N Grängesbergsgatan	47	55	High
Lantmannagatan - Norbergsgatan	50	59	High
Sallerupsvägen - Zenithgatan	38	49	High
Bergsgatan - Möllevångsgatan	43	52	High

5.4 Selection of model for the conversion between conflicts and accidents

5.4.1 Design of the analysis

The aim of this first analysis was to determine which variables were the most important ones in explaining the variation in accident to conflict ratios. For this purpose stepwise regression analysis was used on data from the 50 Malmö intersections.

Table 5.3 presents the variables that were tested.

TABLE 5.3 VARIABLES INTRODUCED IN THE FIRST STEPWISE REGRESSION ANALYSIS

Variable	Parameter value	Coefficient	Number of intersections	
Signal	Signal controlled	0	12	
	Non-signalized, low speed inters.	1	16	
	Non-signalized, high speed inters.	2	22	
Island	No islands	0	5	
	Islands in some approaches	1	45	
Sight distance	Good sight condit. in all approaches	0	27	
	Poor sight condit. in some approaches	1	23	
			Number of accidents	Number of conflicts
Kind of road-user	Car - Pedestrian	1	127	247
	Car - Bicyclist	2	52	109
	Car - Car	3	36	384
	Car - Moped-rider	4	32	25
Time period	09.00 - 16.00	1	130	345
	16.00 - 18.30	2	117	420
Direction of travel	Straight on	1	193	518
	Turning	2	54	247

Some comments on the variables introduced:

- Car includes private cars, lorries, buses, tractors and motor-bikes
- Direction of travel is only relevant for the cars involved. If two cars are involved "straight on", it means that <u>at least</u> one car was going (or intended to go) straight through the intersection. "Turning" means that if two cars are involved, both cars made (or intended to make) a turn at the intersection.

All of the variables have a discrete variation and the coefficients often have no logical meaning. In spite of this, it has been considered appropriate to use a computer program in the first preliminary analysis for stepwise linear regression. In this way, the ratio between the number of conflicts per time period and the number of accidents per time period have been the dependent variable, while the six variables introduced in table 5.3 have been the independent ones.

It should be noted that the purpose of using the stepwise regression is only to obtain a qualitative understanding of whether the introduction of an independent variable reduces the variation of the dependent variable. The procedure should work for variables with only two possible values. It becomes more doubtful for the variables which can have many values, particularly when there is no reasonable order in the relation between the values.

In our case, all the variables but "kind of road-user" and "signal" only have two values. Within the variable "kind of road-user", no probable order can be expected. Even though a variation is not shown at an early stage of the regression, it doesn't mean that there is no variance reduction division based on this variable. It only shows that no linear reduction based on the coefficients is effective.

Because of the extensive split of the data, the number of accidents and conflicts is often low. In the case when any of them is zero, the construction of the program made it necessary to disregard that case from the rest of the data. This has meant that more than half of the elementary cases have been sorted out.

5.4.2 Results of the stepwise regression analysis.

The first regression analysis gave the following result (see table 5.4)

TABLE 5.4 FIRST STEPWISE REGRESSION.
MALMÖ - 50 INTERSECTIONS.
ALL VARIABLES.

Step	Inserted variable[1)]	(Multiple correlation coefficient)^2 (R^2)	Increase in R^2	Significance
1	Time period	0.036	0.036	-
2	Kind of road-user	0.066	0.030	-
3	Direction of travel	0.094	0.028	-
4	Sight distance	0.103	0.009	-
5	Signal	0.115	0.013	-
6	Island	0.120	0.005	-

1) Explained in table 5.3.

The often small number of conflicts and accidents has led to the great fluctuation in their ratios. This is probably one of the reasons for the low correlation coefficient. According to the table, none of the variables gives a significant increase in the correlation coefficient.

One may observe that the variables that describe physical layout and regulation of the intersections seem to have less influence on the R^2-value than the remaining ones. In the second regression, therefore, no consideration has been given to the physical variables. "Kind of road-user" is split into four variables, namely pedestrian, bicycle, car and moped. These variables are equal to 1 with actual kind of road-user and equal to 0 otherwise.

TABLE 5.5 SECOND STEPWISE REGRESSION.
MALMÖ - 50 INTERSECTIONS
PHYSICAL LAYOUT VARIABLES AND REGULATION ARE EXCLUDED.

Step	Inserted variable	(Multiple correlation coefficient)^2 (R^2)	Increase in R^2	Significance
1	Bicycle	0.110	0.110	-
2	Car	0.212	0.102	-
3	Time period	0.248	0.036	-
4	Pedestrian	0.254	0.006	-
5	Travel situation	0.257	0.003	-

The result shows that the kind of road-user seems to have a large influence on the ratio. The multiple correlation coefficient has now increased to 0.257, compared with 0.120 in the first analysis.

Based on the theories behind this conflict technique, primarily that serious conflicts defined similarly for different kinds of road-users are related to police-reported <u>injury</u>-accidents, it is logical that the kind of road-user influences the ratio between conflicts and accidents.

The speed of the road-users also seems to be important for the ratio, both with regard to the probability that a conflict leads to a collision and that a collision leads to injuries.

The two variables "signal" and "direction of travel" partly reflect the speeds of the road-users involved, although primarily for cars. In order to obtain more homogeneous classes with regard to speed, the two variables were combined as follows by table 5.6.

TABLE 5.6 DEFINITION OF THE NEW VARIABLE "TRAFFIC CLASS"

Traffic class 1 =	All situations in low speed intersections and situations in high speed intersections with only turning cars involved
Traffic class 2 =	Situations in signalized intersections with only turning cars involved
Traffic class 3 =	Situations in high speed intersections with at least one straight forward going car involved
Traffic class 4 =	Situations in signalized intersections with at least one straight forward going car involved

A new regression analysis was made based on the new division of variables.

TABLE 5.7 THIRD STEPWISE REGRESSION
MALMÖ - 50 INTERSECTIONS
THE VARIABLE "TRAFFIC CLASS" INTRODUCED

Step	Inserted variable	(Multiple correlation coefficient)^2 (R^2)	Increase in R^2	Significance
1	Car	0.310	0.310	-
2	Traffic class 1	0.536	0.226	-
3	Time period	0.542	0.007	-
4	Traffic class 4	0.549	0.007	-
5	Traffic class 2	0.551	0.002	-

The result from this regression analysis confirms that the "kind of road-user" and "speed of the cars involved" seem to have the greatest influence on the variation in the ratio between conflicts and accidents. The multiple correlation coefficient has increased considerably,from 0.257 to 0.551.

The correlation is however still relatively low. This is probably due both to the limited data volume and to the random selection variation both in the number of accidents and conflicts, which is quite large.

It was at this stage considered that the stepwise regression analysis had produced as much information as it could. It was also believed that the variables describing the different kinds of road-users and the variable "traffic class" were optimal with regard to the information and data volume available.

Regarding the results of the regressions, the relation between the number of observed conflicts per time period and the number of accidents per time period should depend mainly on variables for "the kind of road-user" and "speed". Figure 5.1 shows how this can be done graphically.

	Car-Car	Car-Bicycle	Car-Pedestrian
Traffic class 1			
Traffic class 2			
Traffic class 3			
Traffic class 4			

FIGURE 5.1 SELECTION OF PARAMETER VALUES TO DESCRIBE ONE RELATION BETWEEN CONFLICTS AND ACCIDENTS

Moped riders were omitted. This is because the number of recorded conflicts and accidents is so small that no acceptable validity can be expected.

5.4.3 Selection of a first conversion model.

Definition: CONVERSION FACTOR = NUMBER OF ACCIDENTS PER TIME UNIT/NUMBER OF CONFLICTS PER TIME UNIT.

In appendices 5.1 and 5.2, accidents and conflicts for the 50 Malmö intersections from the 1974 and 1975 studies are listed. Data are split with regard to the variables "traffic class" and "kind of road-user". Besides, data are also split with regard to the variable "time period". As this variable in the stepwise regression analysis was not found to contribute significantly to the variation in the ratio between conflicts and accidents, the two time periods were combined.

Data from the two years 1974 and 1975 were also combined, because the ratios between accidents and conflicts were very similar. (Chi-square tests on the ratios 1974 and 1975 between number of accidents and number of conflicts showed no significant difference (5% - level) in any single case out of the 24).

The combined data for 1974 and 1975 are presented in table 5.8. In table 5.9, the first attempt with conversion factors between serious conflicts and accidents are presented.

TABLE 5.8 NUMBER OF ACCIDENTS AND CONFLICTS, AND TIME OF OBSERVATION
MALMÖ - 50 INTERSECTIONS, 1974 + 1975

Traffic class	Number of accidents[1)]/Number of conflicts[2)] Car-Car	Bicycle-Car	Pedestrian-Car	Time of observation: Conflicts[2)] (min) / Accidents[1)] (min)
1	5/191	13/53	27/156	$29.91 \times 10^3 / 5.60 \times 10^7$
2	3/ 25	9/19	12/57	$6.33 \times 10^3 / 1.14 \times 10^7$
3	15/125	18/27	72/48	$10.39 \times 10^3 / 2.28 \times 10^7$
4	13/ 82	12/12	15/ 4	$6.33 \times 10^3 / 1.14 \times 10^7$

1) Data from the 1974 study

2) Data from the 1974 + 1975 studies

TABLE 5.9 **FIRST ATTEMPT WITH CONVERSION FACTORS: THE RATIO BETWEEN NUMBER OF ACCIDENTS PER TIME PERIOD AND NUMBER OF CONFLICTS PER TIME PERIOD.**
MALMÖ - 50 INTERSECTIONS, 1974 + 1975

Traffic class	Car - Car	Bicycle - Car	Pedestrian - Car
1	1.4×10^{-5}	13.1×10^{-5}	9.2×10^{-5}
2	6.7×10^{-5}	26.3×10^{-5}	11.7×10^{-5}
3	5.5×10^{-5}	30.4×10^{-5}	68.4×10^{-5}
4	8.8×10^{-5}	55.5×10^{-5}	208.2×10^{-5}

There are two clear tendencies to be commenting on:

1) The conversion factor increases with increased speed, as defined through the traffic classes, within non-signalized and signalized intersections.

2) The factor is higher for bicyclists and pedestrians than for car drivers, within the same traffic class.

These tendencies are in line with the theories that form the basis for the technique. As was shown in chapter 3 the higher the initial speed is, the smaller the spatial margins are at a given Time to Accident value. Smaller spatial margins increase the probability of an accident. Besides, smaller margins produce higher average speeds at collisions. Altogether this implies that higher speeds produce higher conversion factors, just as is the case in table 5.9.

The fact that the conversion factors are higher for car-pedestrian and car-bicycle situations than for car-car ones is also logical mainly because conflicts are related to police-reported injury accidents.

5.4.4 Choice of final model for conversion between conflicts and accidents.

Table 5.8 shows that some of the 12 elements bear very small numbers of either conflicts or accidents. This leads to great uncertainty in estimations of the conversion factors for these elements. A merge of elements is, therefore, a necessity as long as there is no more data available. Such a merge should be based on traffic engineering considerations. The first consideration that was made was that the two groups of elements involving unprotected road-users, e.g. car-bicycle and car-pedestrian, could be merged into one group.

The second consideration had to do with traffic classes: As speed was the most important part in the traffic class definition, a merge was done of the non-signalized and signalized low speed situations (traffic class 1 and 2) and similarly for high speed situations.

The merge can be described graphically as in figure 5.2.

	Car-Car	Car-Bicycle	Car-Pedestrian
Traffic class 1 Traffic class 2	Cell 1	Cell 3	
Traffic class 3 Traffic class 4	Cell 2	Cell 4	

FIGURE 5.2 MERGE OF THE TWELVE CONVERSION FACTORS INTO FOUR

The important question that is left unanswered is whether this merge is justified or not.

This question has been tested statistically as follows;

One has 12 observation elements as defined in figure 5.1. Each element consists of a set of figures (x_i, y_i) where x_i is the number of recorded accidents and y_i is the number of observed conflicts. The index i stands for element i. It is defined by the kind of road-user involved and traffic class.

Model: $y_i \in Po\ (\lambda_i A_i)$, $x_i \in Po\ (\lambda_i \cdot \pi_i \cdot B_i)$

λ_i is an intensity that specifies the frequency of conflicts for the element in question

$$A_i = \sum_s A_{is} = \sum_s \sum_\nu \Phi_{i\nu} \cdot t_{i\nu}$$

s = intersection s

$\Phi_{i\nu}$ = The sum of the product of crossing flows, i.e. those flows that intersect at intersection s, for the period of observation

$t_{i\nu}$ = The length of the conflict recording period ν.

Thus $y_i \in Po\ (\lambda_i A_i)$ means that the number of conflicts belong to a Poisson-process with the mean intensity of $\lambda_i \cdot A_i$ which is defined by the conflict frequency λ_i and the product of intersecting flows, A_i.

Similarly for $x_i \in Po\ (\lambda_i \cdot \pi_i \cdot B_i)$

λ_i is an intensity that specifies the frequency of serious conflicts for the element in question.

π_i specifies the probability that in element i a serious conflict ends with an accident.

$B_i = \sum_s B_{is} = (\sum_s \sum_\mu \Phi_{i\mu} \cdot t_{i\mu}) \cdot T_{is}$

where

$\Phi_{i\nu}$ is the sum of the product of crossing flows for the time of conflict recording ($\Phi_{i\nu}$) multiplied by a factor that corrects for the difference in the flows between the time of conflict recording and the time of accident recording.

$t_{i\mu}$ is the length of the period of accident observation μ

T_{is} is the number of days included in the accident data.

x_i and y_i are independent of each other because the time periods are disjunct (no accidents were recorded during the conflict counts).

HYPOTHESIS: WITH THE PROPOSED SPLIT INTO 4 CELLS, π_i IS CONSTANT WITHIN EACH CELL.

We shall now see whether this hypothesis is consistent with the observations. The first step is to estimate the model's parameters under the assumption that the hypothesis is true.

One simplification to start with: All "accident times" are equal for all elements, i.e. $T_i = T$.

If one calculates B_i/T $(=\sum_s \sum_\mu \Phi_{i\mu} \cdot t_{i\mu})$ respective A_i

$(=\sum_s \sum_\nu \Phi_{i\nu} \cdot t_{i\nu})$, table 5.10 (page 77) shows that the ratio $A_i / \frac{B_i}{T}$

and consequently A_i/B_i are fairly constant within each cell.

We now introduce:

$\Lambda_i = \lambda_i A_i$ and $p_i = \pi_i \cdot B_i/A_i$

The model then becomes:

$x_i \in Po(\Lambda_i p_i)$, $y_i \in Po(\Lambda_i)$

Because A_i/B_i are approximately constant within each cell (see table 5.10) our hypothesis is approximately equivalent with the following:

REPHRASED HYPOTHESIS:

p_i IS CONSTANT WITHIN EACH CELL

To test the hypothesis it is enough to estimate Λ_i for the twelve elements and p for the four cells.

It is easily found with the maximum-likelihood method that the estimation of p within each cell becomes;

$$p^* = \frac{\Sigma x_i}{\Sigma y_i}$$

where the sums are drawn via the cell's elements.

For each element in the cell the estimation of Λ_i becomes;

$$\Lambda_i^* = \Sigma y_i \cdot \frac{x_i + y_i}{\Sigma x_i + \Sigma y_i} = \frac{x_i + y_i}{p^* + 1}$$

Now we look at the ratios $Q_i = x_i/y_i$. It is a random variable with a distribution dependent on Λ_i and p. The distribution has a maximum approximately at p and the diffusion around this maximum is dependent on both Λ_i and p.

The distribution functions are counted numerically for the different Q_i with Λ_i and p substituted by the estimations Λ_i^* and p^*.

The next step is to look at the observed ratios within each cell. If anyone is too far off "in the tale" in its distribution, then the hypothesis of the constant p in that cell must be rejected. What then is "too far off in the tale"? Let us assume that a cell contains N elements and that we want to choose a small number "a" so that Q_i is "too far off in the tale" if:

$F_i(Q_i) < a$ or $F_i(Q_i) > 1 - a$

One example of the result of the test is shown in table 5.11, while the whole test is shown in appendix 5.3. This shows that <u>the hypothesis may not be rejected at the 5% level</u>, i.e. that the suggested merging of the 12 elements into 4 cells is not unreasonable.

TABLE 5.10 RATIOS BETWEEN THE SUM OF FLOW PRODUCTS FOR THE CONFLICT AND ACCIDENT RECORDING PERIODS.
Malmö - 50 intersections

Traffic class	Car - Car	Car - Bicycle	Car - Pedestrian
1	$\frac{3422.35}{0.72 \cdot 5502024}$ [1)] $= 8.64 \cdot 10^{-4}$	$\frac{2410.87}{0.87 \cdot 4083017} = 6.79 \cdot 10^{-4}$	$\frac{9034.54}{0.85 \cdot 14932027} = 7.12 \cdot 10^{-4}$
2	$\frac{910.23}{0.72 \cdot 1517427} = 8.33 \cdot 10^{-4}$	$\frac{595.54}{0.87 \cdot 936086} = 7.31 \cdot 10^{-4}$	$\frac{1606}{0.85 \cdot 2427672} = 7.78 \cdot 10^{-4}$
3	$\frac{4405.72}{0.72 \cdot 7848750} = 7.80 \cdot 10^{-4}$	$\frac{2386.21}{0.87 \cdot 4017244} = 6.83 \cdot 10^{-4}$	$\frac{3853.65}{0.85 \cdot 6673043} = 6.79 \cdot 10^{-4}$
4	$\frac{2474.86}{0.72 \cdot 3806020} = 9.03 \cdot 10^{-4}$	$\frac{1130.83}{0.87 \cdot 1669193} = 7.79 \cdot 10^{-4}$	-

1) $$\frac{3422.35}{0.72 \cdot 5502024}$$

3422.35 = The sum of intersections of the product of intersecting flows x conflict recording period in days (= A_i).

5502024 = The sum of intersections of the product of intersecting flows x accident recording period in days (= B_i).

0.72 = Correction factor due to differences in flows between the conflict recording period and accident period, both with regard to the time of the year and differences between years. One correction factor for each kind of road-user is obtained. The car and bicycle are based on empirical data while the pedestrian factor is an assumption. (An assumption of no change)

Car - Car	85 = 0,72		
Car - Bicycle	0.85 x 1.02	=	0.87
Car - Pedestrian	0.85 x 1.00	=	0.85

TABLE 5.11 TEST OF PROBABILITY IN THE MERGING OF THE ELEMENTS INTO ONE CELL
Malmö - 50 intersections

Cell 1

$p^* = 0.037$

x=5 y=191 N=2 a=0.012

$\Lambda^*_i = 189.000$

Ratio=0.026 F=0.227 OK

x=3 y=25 N=2 a=0.012

$\Lambda^*_i = 27.000$

Ratio=0.12 F=0.959 OK

$$p^* = \frac{\Sigma x_i}{\Sigma y_i}$$

x = Recorded number of accidents

y = Observed number of conflicts

N = Number of elements in the cell

a = test value (5 %-level)

$$\Lambda^*_i = \frac{x_i + y_i}{p^* + 1}$$

$$\text{Ratio} = \frac{x}{y}$$

F = Distribution function

Figure 5.3 shows the final model for the conversion factors.

	Car - Car	Car-unprotected road-user
Traffic class 1+2	Cell 1	Cell 3
Traffic class 3+4	Cell 2	Cell 4

FIGURE 5.3 FINAL MODEL FOR CONVERSION FACTORS BETWEEN ACCIDENTS AND CONFLICTS

5.5 Final conversion factors for the 50 intersections in Malmö

5.5.1 Statistical procedure

The π-estimation (the probability that a conflict leads to an injury accident) for respective cell is made with the following formula (as is shown in section 5.4.4)

$$\pi_i = p_i \cdot \frac{A_i}{B_i}$$

The 90% confidence interval for respective cell "$_i$", is calculated as follows:

One states two numbers k_1 and k_2 ($k_1 < 1 < k_2$) with the characteristic that the interval ($k_1 p^*$, $k_2 p^*$) with a certain given probability $1 - \alpha$ (= 0.90 in our case) encloses the correct p-value.

For each division $\alpha = \alpha_1 + \alpha_2$, (where both α_1 and α_2 are ≥ 0) there are k_1 and k_2 so that: $P(p<k_1p^*) = \alpha_1$ and $P(p\geq k_2p^*) = \alpha_2$. Then k_1 and k_2 gives an interval with the degree of confidence equal to $1 - \alpha$ (= 0.90).

We have chosen $\alpha_1 = \alpha_2 = \dfrac{\alpha}{2} = 0.05$

We have earlier (see section 5.4.4) arrived at $p^* = \dfrac{\Sigma x_i}{\Sigma y_i}$

where $\Sigma x_i \in Po\ (p \cdot \Sigma \Lambda_i)$ and $y_i \in Po\ (\Sigma \Lambda_i)$.

The distribution function, F, for p^* is then determined by the two unknown parameters p and $\Sigma \Lambda_i$.

We are now to determine k_1 and k_2 so that:

$$\alpha_1 = 0,05 = P(p < k_1\ p^*) = P(p^* > \frac{p}{k_1}) = 1 - F\ (\frac{p}{k_1})$$

$$\alpha_2 = 0,05 = P(p \leq k_2\ p^*) = P(p^* > \frac{p}{k_2}) = F\ (\frac{p}{k_2})$$

The program for calculation of F as mentioned in section 5.4.4, has been used to solve the above mentioned equations, i.e. to calculate the two-sided confidence intervals for p with a 90% degree of confidence. The unknown parameteters p and $\Sigma \Lambda_i$ are replaced by their estimations. (Shown in para. 5.4.4). As also followed in para. 5.4.4, p_i is proportional to π_i within each cell. Then the corresponding confidence intervals for π will be ($k_1\pi^*$, $k_2\pi^*$) with the same k:s as above.

5.5.2 The 50 intersections in Malmö

The final estimation of conversion factors and confidence intervals for the 50 Malmö intersections are presented in table 5.12.

TABLE 5.12 FINAL CONVERSION FACTORS (π) BETWEEN CONFLICTS AND ACCIDENTS
Malmö - 50 intersections

	Car - Car	Car-Unprotected road-user
Traffic class 1+2	3.2 (2.0-6.9)	15.3 (12.2-19.6)
Traffic class 3+4	11.1 (8.2-16.1)	89.2 (70.5-113.3)

All values should be multiplied by 10^{-5}. Values in brackets are the confidence interval with a 90% confidence degree.

5.5.3 The 15 intersections in Malmö

The identical analysis was made of the 15 Malmö-intersections as of the 50 Malmö-intersections. Appendix 5.4 shows the number of accidents and serious conflicts, as well as the periods of observation.

Appendix 5.5 shows the test of merging the 12 elements into 4 cells. Even in this case, the merging was not found to be unreasonable.

Table 5.13 gives the final conversion factors for the 15 Malmö-intersections.

TABLE 5.13 FINAL CONVERSION FACTORS FOR THE 15 INTERSECTIONS IN MALMÖ

	Car - Car	Car-Unprotected road-user
Traffic class 1+2	3.5 (1.8-14.0)	16.0 (10.6-26.2)
Traffic class 3+4	13.7 (8.9-24.0)	81.4 (44.8-140.0)

The values should be multiplied by 10^{-5}
The 90% confidence intervals are within brackets.

5.5.4 The 50 intersections in Stockholm

The same analyzing procedure was followed for the 50 Stockholm intersections as for the Malmö intersections.

In appendix 5.6 the number of accidents and conflicts for kind of road-user and traffic class are given respectively as well as periods of observation.

Even in this case, the reasonableness of merging of twelve elements into four cells was tested. From the result in appendix 5.7 it is evident that one of the elements in cell 3 deviates a bit too much from the mean value of the cell. In spite of this we carried out the merge into four cells because the deviation was relatively small. It may be found within the test methods' margin of error. If there had been, for example, only one additional personal injury accident in this element, the test would not have rejected the hypothesis of a merge at the chosen 5% level.

Estimations of π (conversion factors) and calculation of confidence intervals was done as for the Malmö intersections. Table 5.14 presents the final conversion factors for the Stockholm intersections.

TABLE 5.14 FINAL CONVERSION FACTORS FOR THE 50 INTERSECTIONS IN STOCKHOLM

	Car - Car	Car-Unprotected road-user
Traffic class 1+2	3.1 (1.8-8.7)	12.8 (9.3-18.7)
Traffic class 3+4	14.1 (11.6-17.6)	62.1 (44.7-85.7)

The values should be multiplied by 10^{-5}.
The 90% confidence intervals are within brackets.

5.5.5 Common conversion factors for the two sets of Malmö intersections combined

The conversion factors and confidence intervals for both Malmö studies combined are shown in figure 5.4 and in table 5.15. The corresponding conversion factors are very similar, thus a merge is fully reasonable.

For the merge, new confidence intervals were calculated as in para. 5.4.4 with the total number of accidents and conflicts as a base. These common conversion factors are weighed by the length of the respective confidence interval for the cells, i e approximately according to the amount of data for the respective study.

TABLE 5.15 FINAL CONVERSION FACTORS FOR THE MALMÖ - 50+15 INTERSECTIONS TOGETHER.

	Car - Car	Car-Unprotected road-user
Traffic class 1+2	3.3 (2.2-6.0)	15.5 (12.7-19.1)
Traffic class 3+4	12.1 (9.4-16.3)	86.9 (70.4-106.9)

The values should be multiplied by 10^{-5}.
The 90% confidence intervals are within brackets.

5.5.6 Common conversion factors for all three sets of data combined

A comparison between the conversion factors for Malmö and Stockholm is shown in figure 5.5. It is evident that a deviation is present in cell 4. An aggregation of the data from the two cities was still considered feasible. This is further commented on in section 5.7. Conversion factors between conflicts and accidents for the total data set was derived in the same way as before. Table 5.16 and figure 5.5 present these conversion factors.

TABLE 5.16 FINAL CONVERSION FACTORS FOR ALL THREE DATASETS TOGETHER.

	Car - Car	Car-Unprotected road-user
Traffic class 1+2	3.2 (2.2-5.1)	14.5 (12.2-17.4)
Traffic class 3+4	13.2 (11.2-15.7)	77.2 (64.8-91.9)

The values in the table should be multiplied by 10^{-5}.
The 90% confidence intervals are within brackets.

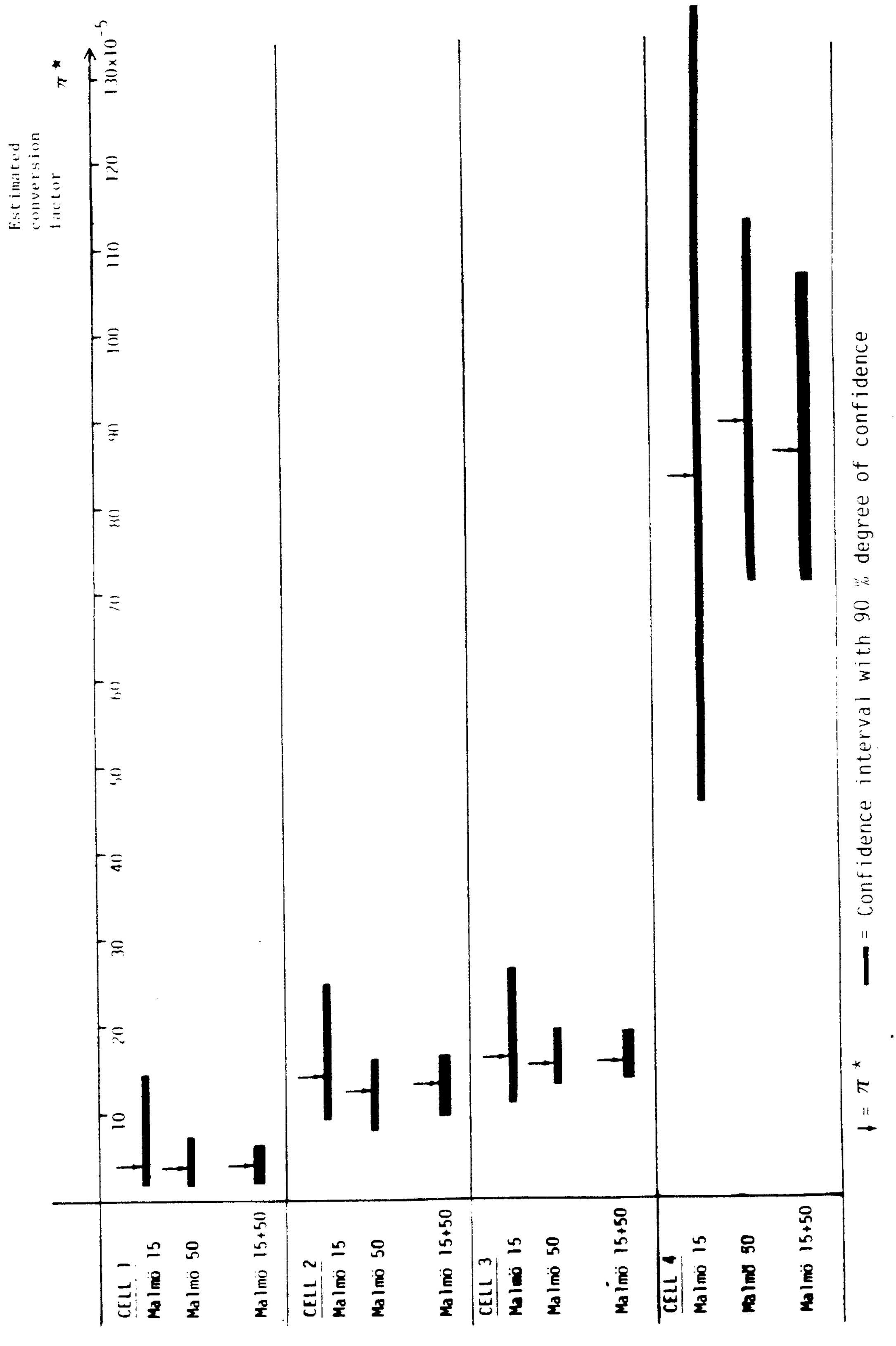


FIGURE 5.4 ESTIMATION OF CONVERSION FACTORS BETWEEN ACCIDENTS AND CONFLICTS FOR MALMÖ.

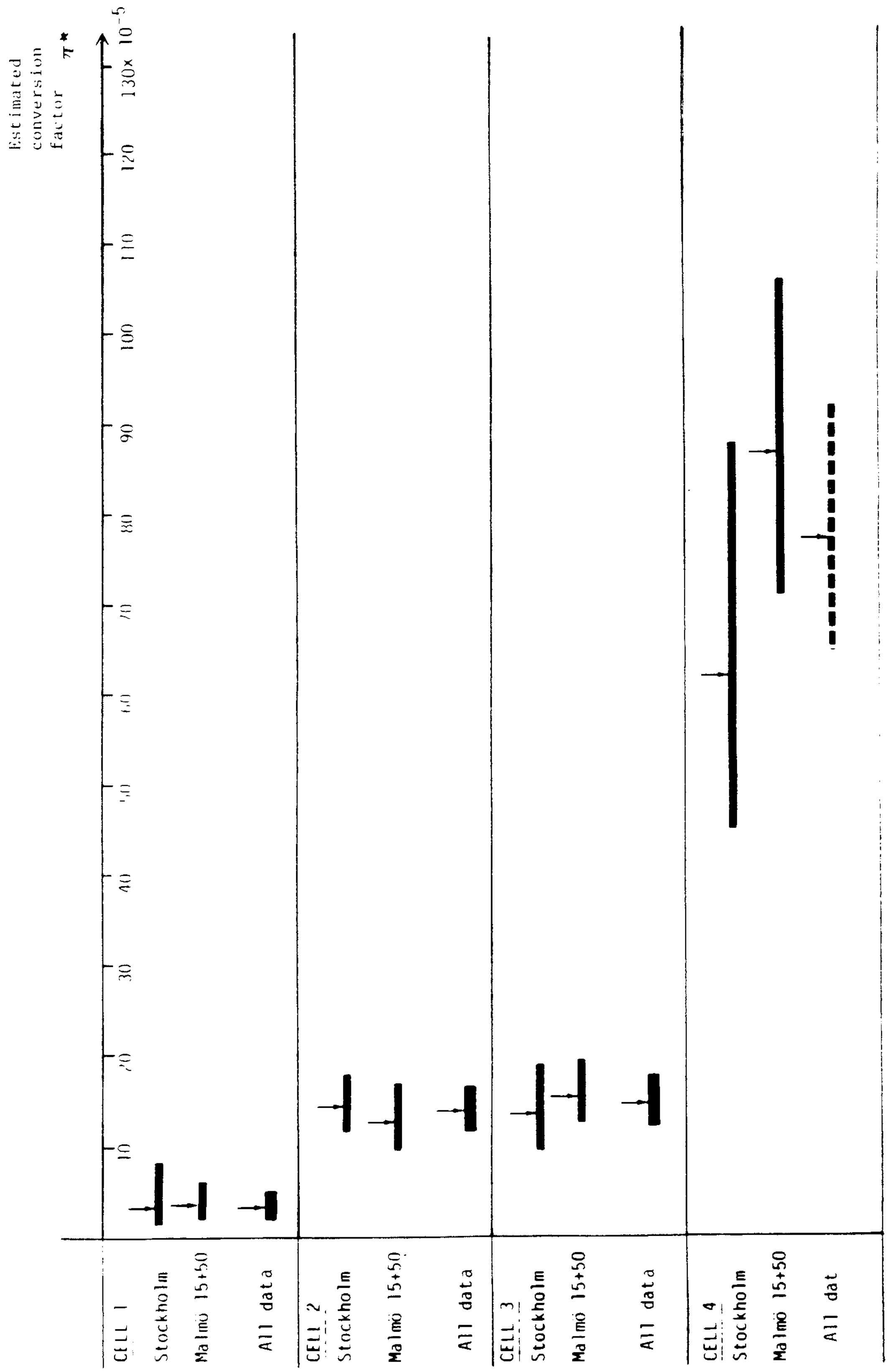


FIGURE 5.5 ESTIMATION OF CONVERSION FACTORS BETWEEN ACCIDENTS AND CONFLICTS FOR STOCKHOLM AND MALMÖ.

5.6 Conversion factors based on all police-reported injury and damage-only accidents for Malmö-50 intersections

For the 50 Malmö intersections, police-reported property damage accidents were collected as well. The relative amount of reporting of these accidents is low. The consequence of this is that the calculated conversion factors for the conflicts to the total number of accidents (including property damage accidents) indicates tendencies only. Table 5.17 gives these conversion factors.

TABLE 5.17 CONVERSION FACTORS BASED ON ALL POLICE-REPORTED ACCIDENTS
Malmö - 50 intersections.

	Car-Car	Car-Unprotected road-user
Traffic class 1 and 2	107.0	23.2
Traffic class 3 and 4	214.8	117.1

The values in the table should be multiplied by 10^{-5}.

The results were not completely surprising: the conversion factors for car-car situations increased much more than car-unprotected road-user situations did, compared with the earlier presented conversion factors (for the 50 Malmö intersections). The two factors for car-car situations increased approx 30 and 20 times respectively. The corresponding increases for car-unprotected road-user situations was only 1.5 and 1.3 times respectively. Besides we know that the underreporting of damage-only accidents is much bigger than for injury accidents. Consequently the "real" conversion factors for car-car situations would be a couple of times bigger, in relation to car-unprotected road-user situations, than in table 5.17. This implies that the "real" conversion factors for car-car are at least 5-10 times bigger than those for car-unprotected road-user, if property damage accidents were included.

In the earlier presented conversion factors, where only injury accidents were included, the factors for car-unprotected road-user situations seemed to be 5 times bigger than for car-car situations. On the other side, when all accidents are included, the relationship seems to be the opposite.

The first difference was explained partly by the fact that unprotected road-users are more vulnerable than car occupants, thus producing more injury accidents.

The second difference, that serious car-car conflicts more often lead to collisions than car-unprotected road-user conflicts, may be explained in one of the following ways (or both):

1) The average degree of severity among serious car-car conflicts may be higher than for the other serious conflicts.

2) The ability to avoid collisions, once in a serious conflict, may be higher for unprotected road-users than for car drivers.

At this stage of knowledge it is not possible to elaborate any further on these explanations. If one, however, in the long run may obtain reliable information about all collisions that occur, then it would be worthwhile to further analyze the different conversions factors. Such efforts might give valuable information on, for instance, road-user behaviour in critical situations, attitudes to risk, and (road-users) operational interpretation of risk.

5.7 Comments on the accuracy of the validation data

The results from the different Malmö studies show a very good correspondence regarding the estimated ratio (π^*) between accidents and serious conflicts for the different cells. However, this does not mean, with total certainty, that the real π-values are identical.

If we, having the maximum bad luck, have received the estimates of π which are the furthest away from the true π-values for respective data and in different directions, the π - estimates for the groups of data can give the same value even though the true π-values are different. This is shown in the following figure.

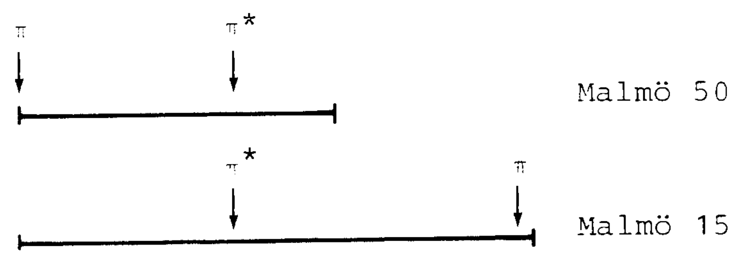


FIGURE 5.6 POSSIBLE VALUES ON THE TRUE CONVERSION FACTOR (π) AND THE ESTIMATE (π^*).

It is impossible to establish the existence of this situation. It could be stated though, that there is a 5% risk that in one group the data's true value falls outside the estimated π-value's confidence interval limit on one side. The risk that the other group of data's true π-value will fall outside of its confidence interval is equally large. The probability that this would be the case simultaneously for both estimates is very unlikely. (= 0.05x0.05)

The only way to establish whether two groups of data can be unified, through the reasoning of this kind, is to decrease their confidence intervals i.e. collect more conflict and accident data until it can be considered certain that the two data-group's real π-values lie close enough to each other.

In our case we had "to live" with the data-sets available. If one, to start with, compares the Malmö-50 and Malmö-15 data, we find that:

- the two π-estimates are very similar for each cell
- one π-estimate is always well covered by the confidence interval of the other
- the shortest confidence intervals are, almost entirely, covered by the longer ones.

These indications were "the best" we could provide and as the results were quite positive we thought it was tentatively reasonable to combine the two sets of data from Malmö.
If the combined Malmö data was compared with the Stockholm data we could draw similar conclusions as above for the car-car situations. For car-unprotected road-user situations the case was a bit different:

- the estimates of π for the Stockholm data produced somewhat higher values than for Malmö.
- the confidence intervals were not overlapping each other as well as before.
- the estimates of π for the one set of data, however, was still falling within the confidence interval of the other.

Thus, even though the differences we found were bigger when we compared Stockholm data with the two sets of data from Malmö, we did not think that the differences were so large that a unification was not considered appropriate.

It must be pointed out, however, that there are indications in the accomplished tests that a merge into four cells may prove to be too rough if the data sets were extended. Primarily, it looks as if a division of pedestrians and bicyclists is the most probable one.

We have not been able to test the reasons why Stockholm and Malmö data are different for car-unprotected road-user situations. One possible explanation is that the proportion of bicycle situations is much higher in the Malmö data. Thus if there should be separate estimates of π for pedestrians and bicyclists, this might be one possible explanation.

Another explanation may be differences in behaviour between the two cities. These differences in behaviour may ultimately create different types of conflicts leading to accidents with different probability.

5.8 Prediction of accident intensity through conflict studies

What do the uncertainties in the estimated ratios imply, when trying to estimate the expected number of accidents occurring at a certain location? Let's look at the part of the traffic at a certain intersection, which falls within a certain cell for which we have the estimation π^* and the 90% confidence interval $(k_1 \pi^*, k_2 \pi^*)$. We count the conflicts during time periods of the total time t and observe y conflicts. We shall see what information this results in regarding the expected accident-frequency.

The model is based on y being an observation of $y \in Po(\lambda \cdot t)$, where λ is an unknown conflict-intensity, which is dependent on the flow levels, the intersections physical characteristics, etc. The number of accidents during the time T is $x \in Po(\lambda \cdot \pi \cdot T)$ according to our model. If the goal is to predict x, then it must be realized that even if the intensity $\alpha \cdot \pi$ was known exactly, a spread in x would occur, which is measured by the standard deviation $\sqrt{\lambda \cdot \pi \cdot T}$.

More interesting, however than to predict x is to get a good estimate of the <u>accident-intensity</u> $\lambda \cdot \pi$, as this is a direct measure of the intersections safety.

A direct method to accomplish this is to actually wait a period of time (T) and see how many accidents, x, actually occur. This gives

the estimate $(\lambda \cdot \pi)^* = \frac{x}{T}$, which has a standard error

of $d((\lambda \cdot \pi)^*) = \sqrt{\frac{(\lambda \cdot \pi)^*}{T}}$

The longer the T, the better the estimate. If we now consider our model to be correct and that π is known from earlier studies, we can estimate λ with help of our conflict count:

$$\lambda^* = \frac{y}{t}$$

with a standard error $d(\lambda^*) = \sqrt{\frac{\lambda^*}{t}}$

This estimate becomes, of course, more certain the larger t is. Then one may ask how large must t be to give the same accuracy in the estimation of accident intensity $\lambda \cdot \pi$, as a direct accident count during the time T? Our estimation becomes $\lambda^* \cdot \pi$, which has the standard error (if π is known):

$$d(\lambda^* \cdot \pi) = \pi d(\lambda^*) = \pi \sqrt{\frac{\lambda^*}{t}} = \sqrt{\frac{\pi \lambda^*}{t/\pi}}$$

It then follows that t should be selected, so that $\frac{t}{\pi} = T$.

This can be expressed in this way: For determining the accident intensity, a conflict-count during the time t gives the same accuracy as an accident-count during the much longer time t/π.

With help of the previously constructed confidence intervals for π_i (the total data set) the confidence intervals for T can be calculated as shown in table 5.18.

TABLE 5.18 MINIMUM TIME (T) FOR AN ACCIDENT COUNT TO BE COMPETITIVE WITH A CONFLICT COUNT DURING THE TIME t.

Cell 1:	$\frac{t\ 10^5}{5.1}$ 1) $= 20.000t < T < 45.000t = \frac{t\ 10^5}{2.2}$ 2)
Cell 2:	$\frac{t\ 10^5}{15.7} = 6.400t < T < 8.900t = \frac{t\ 10^5}{11.2}$
Cell 3:	$\frac{t\ 10^5}{17.4} = 5.700t < T < 8.200t = \frac{t\ 10^5}{12.2}$
Cell 4:	$\frac{t\ 10^5}{91.9} = 1.100t < T < 1.500t = \frac{t\ 10^5}{64.8}$

1) Upper limit in the confidence interval for π (see also table 5.16)
2) Lower " " " " " " " " " 5.16)

It is true that π is unknown, but the error one encounters by using the estimated π^* scarcely contributes to making the error in the estimate of the accident intensity larger.

When the conflict-technique is used for prediction of the accident intensity it is important, however, to remember that the number of conflicts and the number of accidents must be related to the same traffic conditions (flows, etc).

5.9 Comparison of accident and conflict distributions with regard to type of conflict

The collected conflict and accident data for the 50 + 15 Malmö intersections and the 50 Stockholm-intersections, has also been used to test the distribution of conflicts and accidents with other variables than those used in the validation studies previously described. This was done in order to see to what extent the conversion factors that were derived could discriminate between different conflict types.

5.9.1 Car - Pedestrian situations

Accidents and conflicts were split in the following way:

1) The conflict/accident is occurring when the car is entering the intersection.

2) The conflict/accident is occurring when the car is leaving the intersection.

The results of the comparisons are found in tables 5.19 and 5.20.

TABLE 5.19 COMPARISON OF CAR-PEDESTRIAN CONFLICTS AND ACCIDENTS WITH REGARD TO TYPE OF SITUATION. Low-speed and high speed intersections (non-signalized).

Situation 1)	Malmö -15 inters. Conflicts % 2)	Malmö -15 inters. Accidents %	Stockholm-50 inters. Conflicts % 2)	Stockholm-50 inters. Accidents %
1	18	25	23	31
2	82	75	77	69
Total #	(30)	(8)	(62)	(20)

1) Situation 1): The car is entering the intersection
Situation 2): The car is leaving the intersection

2) Conflicts are weighed with regard to the relevant conversion factor

TABLE 5.20 COMPARISON OF CAR-PEDESTRIAN CONFLICTS AND ACCIDENTS WITH REGARD TO TYPE OF SITUATION. Signalized intersections.

Situation 1)	Malmö-15 inters. Conflicts % 2)	Malmö-15 inters. Accidents %	Stockholm-50 inters. Conflicts % 2)	Stockholm-50 inters. Accidents %
1	0	5	33	24
2	100	95	67	76
Total #	(17)	(13)	(42)	(54)

1) See table 5.19.
2) Conflicts are weighed with regard to the relevant conversion factor.

The comparisons show a very high degree of similarity. No difference in accident and conflict proportions was found to be significant. It is particularly interesting to see that situation 1 is creating <u>both</u> more accidents <u>and</u> more conflicts in the Stockholm intersections than in the Malmö intersections. To conclude: The conflict technique seems to discriminate well between the two situations in this case.

5.9.2 Car - Bicycle situations

A comparison of car - bicycle situations was only made for the Malmö - 50 intersections. Besides, conflicts were not weighed with regard to the relevant conversion factor between conflicts and accidents. Still I have chosen to include it, hopefully to give some valuable indications. The results are shown in table 5.21.

The table shows that conflict numbers, without any weighing seem to be very proportional to accident numbers when types of situations are compared. There is not one single significant difference, either for the intersection types individually or for the total.

At low-speed intersections the same conversion factor between conflicts and accidents applies to all conflicts. Thus the numbers are in that case comparable. Even though the numbers are fairly low one can see that the proportions are fairly similar. Besides, the most common accident type of situation, "perpendicular", is the most common conflict type of situation as well.

TABLE 5.21 COMPARISON OF CAR-BICYCLE ACCIDENTS AND CONFLICTS WITH REGARD TO TYPE OF SITUATION. Malmö - 50 intersections.

Type of situation	Low speed intersections Con-flicts #	Acci-dents #	High speed intersections Con-flicts #	Acci-dents #	Signalized intersections Con-flicts #	Acci-dents #	TOTAL Conflicts #	%	TOTAL Accidents #	%
Perpendicular	30	12	31	44	3	12	64	46	68	49
Left-turning vehicles vs on-coming vehicles	3	4	6	15	23	16	32	23	35	25
Left-turning bicyclists vs vehicles from behind	3	3	1	8	1	3	5	4	14	10
Weaving + rear end	10	3	8	7	1	5	19	14	15	11
Others	6	0	5	2	8	6	19	14	8	6
Sum	52	22	51	76	36	42	139	101	140	101

5.9.3 Car - Car situations.

In the same way as for car-bicycle situations, only numbers have been compared, without weighing conflicts with regard to the relevant conversion factors.

The results are presented in table 5.22.

TABLE 5.22 COMPARISON OF CAR-CAR ACCIDENTS AND CONFLICTS WITH REGARD TO TYPE OF SITUATION
Malmö - 50 intersections

Type of situation	Low speed intersections		High speed intersections		Signalized intersections		T O T A L Conflicts		T O T A L Accidents	
	Con-flicts	Acci-dents	Con-flicts	Acci-dents	Con-flicts	Acci-dents				
	#	#	#	#	#	#	#	%	#	%
Perpendicular	58	9	63	19	10	14	131	31	42	47
Left-turning vehicles vs oncoming vehicles	13	0	6	4	37	26	56	13	30	34
Rear-end	34	2	28	3	36	4	98	23	9	10
Weaving	43	1	24	1	23	4	90	21	6	7
Others	15	0	21	1	13	1	49	12	2	2
Sum	163	12	142	28	119	49	424	101	89	100

In this comparison we find some larger differences. These seem to refer to signalized intersections primarily. The main difference at this type of intersections seems to be the underrepresenting of "perpendicular" conflicts.

A general difference, at all three types of intersections, is that the "rear-end" and "weaving" conflicts are much more numerous than the corresponding accidents. This seems to be particularly true for signalized intersections.

Even though the differences mentioned above are due in part to the fact that other conversion factors should have been used, this can not entirely explain the differences. So, a general conclusion would be that the "accident-potential" seems to be somewhat underestimated in "perpendicular" and "left-turning vehicles versus oncoming", while it seems to be overestimated in "weaving " and "rear-end" situations. Another conclusion is that the over- and underestimations seem to be bigger for signalized intersections. Thus it seems as if special conversion factors should be produced for signalized intersections, when the data-file is big enough to allow it.

5.10 Comparison of accident - and conflict distributions at before and after studies.

The common model as presented in section 5.5 has been used since 1976. In quite a few studies since then, the Traffic Conflicts Technique has been used to evaluate the effect of countermeasures, through before and after studies. After a couple of years, the results of such conflict studies can be compared with accident-analysis from the same locations. This can produce some valuable information about the "operational" validity of the technique. Information of this kind has, however, not been collected systematically. Still I want to include some examples, just to give an idea of what can be achieved, even though the examples may not be very representative.

Table 5.23 summarize the results from the included before and after studies.

TABLE 5.23 A PREDICTION OF AVERAGE NUMBER OF ACCIDENTS FROM CONFLICT AND ACCIDENT DATA.

Intersection	Type of counter-measure	Recorded number of conflicts		Predicted number of accidents per year [1]		Recorded number of police-reported accidents		Predicted number of accidents per year [2]	
		Bef.	After	Bef.	After	Bef.	After	Bef.	After
Ystadg.-Claesg., Malmö	Installing of humps	109	55	1.8	0.8	2	3	0.4	0.5
Rådmg.-S:t J.g., Malmö		30	9	0.8	0.4	3	0	0.4	0
S.Parkg-Ystadg., Malmö		3	7	0.3	0.2	2	0	0.3	0
S.Parkg-Simrhg., Malmö		4	3	0.2	0.3	3	0	0.4	0
Σ		146	74	3.1	1.7	10	3	1.5	0.5
Stud.g.-St.Nyg., Malmö	Signalization	103	48	6.1	4.0	3	4	1.3	1.8
Köph.v.-Bellev., Malmö		76	22	3.2	0.9	4	3	2.0	1.5
Σ		179	70	9.3	4.9	7	7	3.3	3.3
Malmb.g-HagaP.g, Västerås	Bicycle Path	9	19	0.3	0.5	1	2	0.1	0.4
Ahlmansg.-Bang., Malmö	Four-way stop	11	4	0.2	0.1	3	0	0.6	0
Idrottsg.-Ö.Bernadg., Malmö		17	3	0.3	0.1	9	0	1.8	0
Σ		28	7	0.5	0.2	12	0	2.4	0
ΣΣ		362	170	13.2	7.3	30	12	7.3	4.2
Diff.				(-45 %)				(-42 %)	

1) The prediction is dependent on the number of days of observation, number of hours per day and the conversion factors applicable.

2) The prediction is dependent on the number of years included in the recording period.

A proper evaluation of these results should of course include a comparison of the variance for the two predictions as well. The, most probable, regression-to-the-mean effect in the accident study should also be considered.

The limited amount of data makes, however, this kind of comparison less valuable. Such a comparison is instead included in an on-going project at our Department, where the data volume is considerably bigger.

Table 5.23 anyway indicates some interesting things:

- The accident prediction from conflict studies seems, on the whole, to produce a considerable overestimation of accidents. It is difficult to find a bearing explanation, especially as most of the intersections were selected in Malmö, where most of the validation studies had taken place. One explanation may be the transformation of "conflicts per part of weekdays" to "accidents for a whole year". Another explanation may be that the conflict studies have been carried out in the end of the before period of accident recording and in the beginning of the after-period, without any corrections for the accident trend. A third explanation might be a regression to the mean effect. If, normally, the sample of intersections that were selected for the validation had a higher average of occurred accidents than the expected average, then the conversion factors would be 'to high'. This in turn might lead to an overestimation of expected number of accidents in a conflict study, when the conversion factors are used at 'new' intersections.

- The estimation of safety effects seems to produce more similar results. The overall effect seems to be in the same range even though the regression to the mean effect would reduce the effect that was predicted from recorded accidents. In 6 out of 9 individual comparisons, the prediction of either a reduction or an increase, was the same for the conflict- and accident-based prediction.

The comparisons, however, only contains a part of the total information. One must also take into account that these studies were parts of a larger "process evaluation", i.e. conflict studies were part of a larger program for short-term evaluation of the effects. These studies were, for instance, combined with behavioural studies in order to find out whether the countermeasures influenced behaviours and risks in a desired and favour able way.

From this point of view one must conclude generally that conflict studies have contributed to an increased knowledge about safety effects. This has been particularly obvious in the developing and testing of new (for Sweden) countermeasures, such as humps at intersections and four-way stop.

In these cases the conflict studies have contributed to a gradual improvement of the know-how and thereby opened up for a wider application of these countermeasures.

6 EVALUATION OF THE ORIGINAL TECHNIQUE

Ten years of experience with the original technique has proven its usefulness both for research purposes and for practical use.

These years, however, have also made it clear that different parts of the technique could have been designed differently - and hopefully made the technique better. Besides, the whole nature of this complex problem has made it inevitable that a lot of questions, doubts, ideas and expectations are raised.

In this chapter, I will introduce all the questions, etc that I have found to be of potential interest with regard to any possible improvements of the technique. By putting all these questions together and trying to put them in a theoretical framework, I hope to set the scene for any future activities with regard to development of the technique.

Some of these questions will be analyzed further in chapter 7.

Carrying out reliability and validity tests is a demanding task which requires heavy resources. Due to this it will be difficult to incorporate all my ideas regarding changes of the theoretical and operational definitions of conflicts in individual studies. It is therefore of great importance to widen the scene. One such opportunity is the on-going international cooperation described in chapter 7.

Chapter 6 is split into three main parts. Section 6.1 will deal with questions concerning severity rating of conflicts and the definition of a serious conflict. Section 6.2 deals with the problems regarding the observer's reliability while 6.3 brings up questions concerning the validity of traffic conflicts.

6.1 Definitions

6.1.1 Basic principles

The original technique is based on the following hypotheses and procedure:

- Serious conflicts are scored by trained observers on ground level. These conflicts should reflect the likelihood that an event leads to a collision.

- The likelihood that a serious conflict could lead to a (police-reported) injury accident is calculated after the field study, using a risk matrix that gives the conversion from the number of serious conflicts to the number of (police-reported) injury accidents.

The first part - the likelihood that a serious conflict could lead to a collision may depend on a number of factors. The most important ones seem to be:

a) Time and space margins between the road-users involved.

b) Type of evasive manoeuvre and type of road-users.

c) Vehicle-linked capability of performing evasive manoeuvres.

d) Road user-linked capability of performing evasive manoeuvres.

e) Road and weather conditions.

The original definition of a serious conflict - Time to Accident $\leq$ 1,5 seconds, takes into account the time margin and, partly, the space margin.

It is presupposed that all the factors mentioned above do have similar distributions over the sample, normally being intersections. So it is, for instance, presupposed that the distribution of vehicles or road-users within each category with regard to capability of performing evasive manoeuvres of different kinds is the same at different intersections.

This was the main reason why these factors were not tested in the definition of a serious conflict. Another reason that the likelihood of a collision was not tested was due to problems with the reliability of police-reported damage-only accidents. The option to include damage-only accidents has increased since then.

In a new study taking into account "all accidents", it should be worthwhile to incorporate and test all the five factors mentioned above.

In the following part of section 6.1 I will present different ideas concerning potential improvements of the definition of a serious conflict.

6.1.2 Speed dependent threshold for the time-margin

The rigid definition used originally (TA $\leq$ 1,5 seconds) was accepted by most observers as being a working compromise for urban situations, still some different problems were still acknowledged regarding the speed-dependence:

- In conflicts at low speeds ($\leq$ 20-25 km/h) the severity of a conflict was underestimated when the observer estimated the TA-value through experienced suddenness and harshness in the evasive manoeuvre. The problem could partly, but not entirely, be compensated for by a special estimation of speeds and distances. Even so, however, there remained hesitation with regard to reliability on low-speed conflicts.

- In conflicts at high speed (> 50-55 km/h) the problems were the opposite: the severity was overestimated. This was, however, a minor problem in the studies we carried out in urban areas, simply because conflicts at speeds higher than 50 km/h were very infrequent. Things are, however, different for rural intersections. In a pilot-study (Gårder, 1982) the need for modifications of the "urban" technique were checked. At two rural intersections the "urban" technique of classifying serious conflicts with regard to the experienced suddenness and harshness of the evasive manoeuvre was compared with TA-values. These were obtained through an estimation of approach speeds and distances to the collision point. Conflicts were classified in three groups:

  - Serious conflicts
  - Border cases
  - "Preventive action" (non-serious conflicts).

The results of the two studies can be seen in figure 6.1 and figure 6.2.

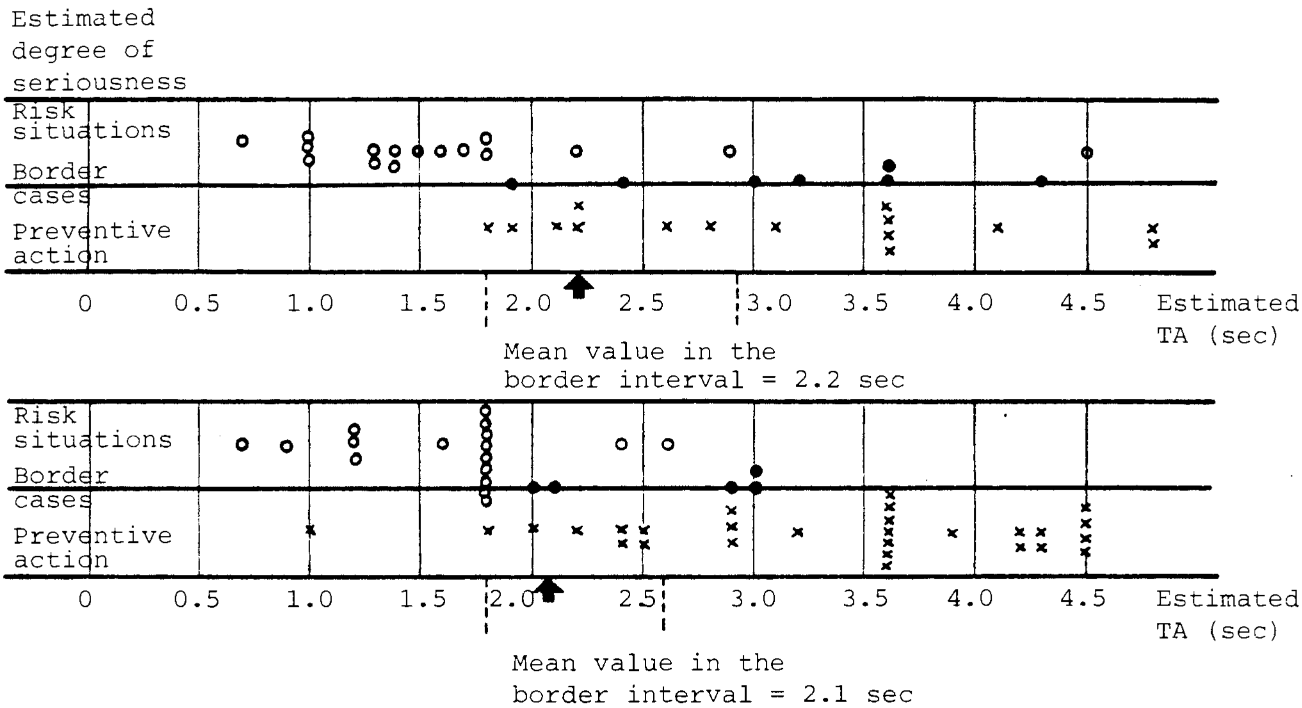


FIGURE 6.1 RELATION BETWEEN TIME TO ACCIDENT AND ESTIMATED DEGREE OF SERIOUSNESS
The rural intersection of Ringelikors
Mean speed - 65 km/h
Two case-studies
Derived from Gårder, 1982.

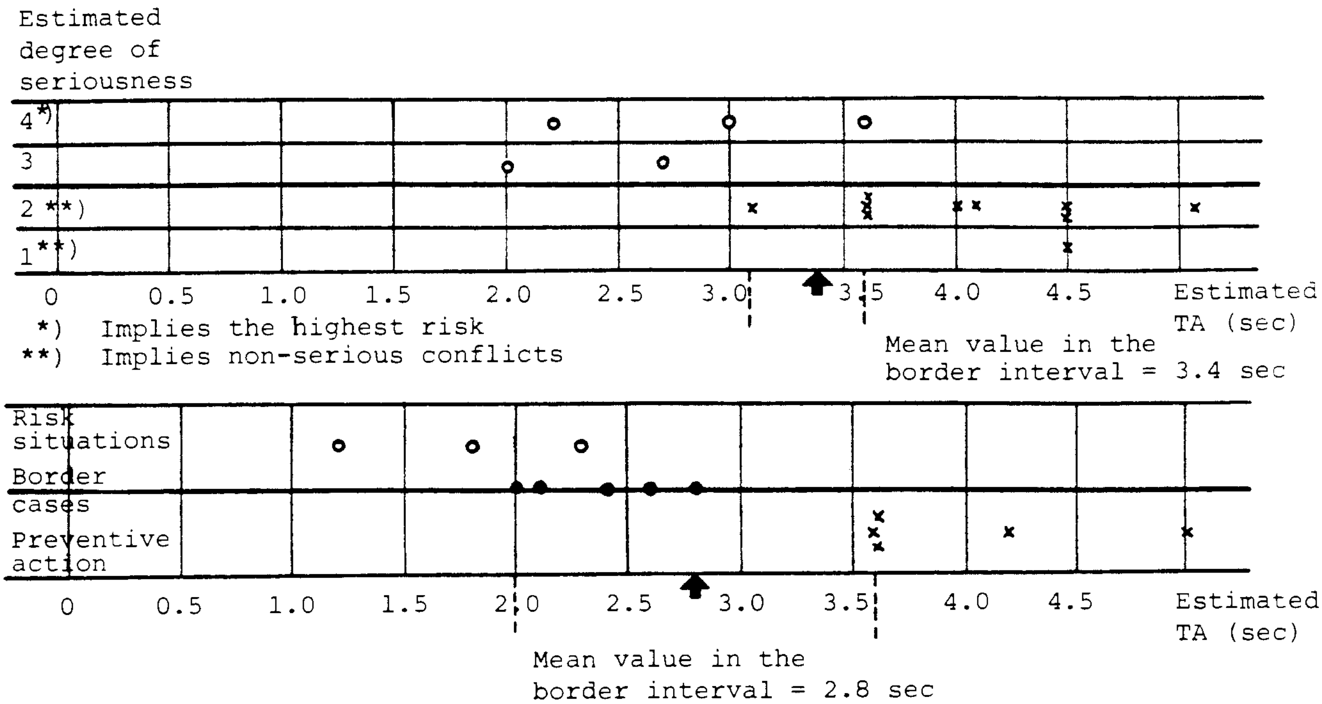


FIGURE 6.2 RELATION BETWEEN TIME TO ACCIDENT AND ESTIMATED DEGREE OF SERIOUSNESS
The rural intersection of Gualöv
Mean speed - 80 km/h
Two case studies
Derived from Gårder, 1982.

Even though the technique used to identify the threshold level may be argued about, the results indicate one interesting thing: When speeds of the road-users involved in conflicts are increasing, the TA-value for the border between serious and non-serious is increasing as well. At Gualöv the mean speed for straight ongoing cars is 80 km/h and at Ringelikors the corresponding mean speed is 65 km/h. The border values of 2.8 - 3.4 seconds at Gualöv and 2.1 - 2.2 seconds at Ringelikors, and the border value of 1.5 seconds in urban areas at a mean speed of 40-50 km/h are clearly indicating a speed-dependence of the threshold between serious and non-serious conflicts.

If this relation bears any truth, it also indicates that the threshold level is below 1.5 seconds at low speeds.

The results presented here are, however, too limited to draw any strong conclusions from. Still it seems to be a relation of great importance and it should, therefore, be incorporated in the definition in some way. This will be done and further evaluated in chapter 7.

6.1.3 Time to Accident versus other time measures

The time margin can primarily be measured in three different ways (as long as we are dealing with conflicts that presuppose a collision course):

- Time to Accident (TA)
- Minimum Time to Collision (MTTC)
- Time to Collision - continous over time (TTC).

Figure 6.3 illustrates the three alternatives.

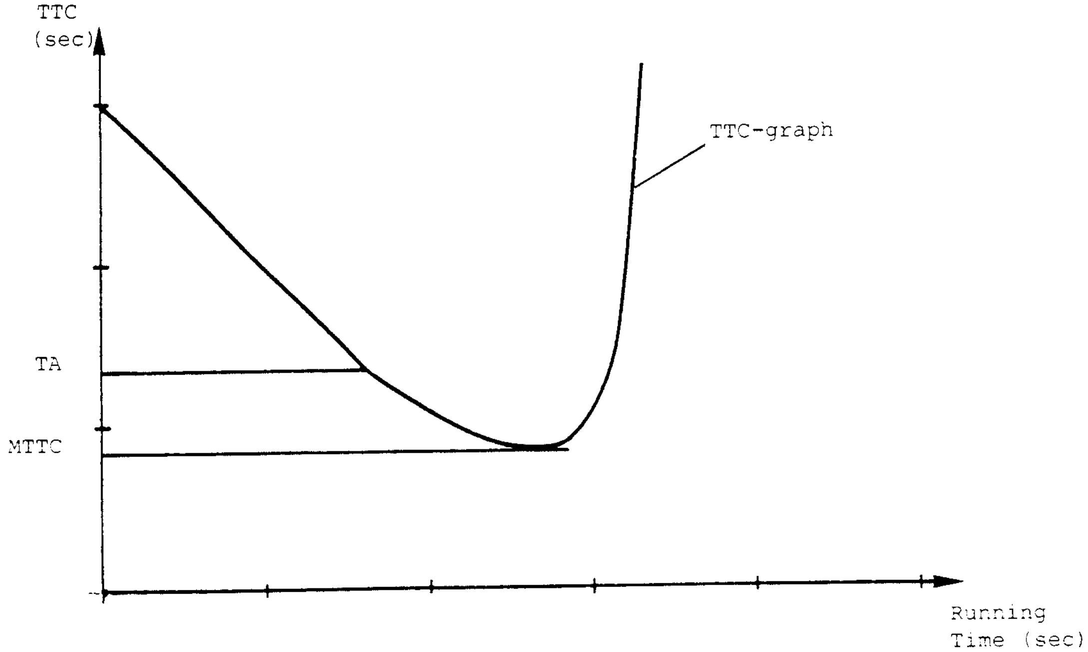
TA - which is the measure our technique is built on - reflects the time margin in the initial phase when the road-user has detected the hazard and just started to take evasive action.

MTTC is the time margin that remains at the end of the critical phase of the evasive manoeuvre. It therefore reflects the latter phase of the conflict.

TTC reflects both the initial phase, the further development (intensity, etc) and the latter phase.

Generally speaking, it is of course of interest to know the time margin both in the initial phase and then in the final phase. If the initial speed is then known as well as the development of the TTC the possibilities of describing the severity of the conflict should be much higher than with any of the measures individually. A technique for obtaining these data is still, however, very time-consuming and expensive to use. This creates big problems both in valididating such a technique and in using it on a larger scale. Such a technique is therefore not considered feasible for our purposes.

The choice between Time to Accident (TA), and Minimum Time to Collision (MTTC) is also discussed now and then.



TTC = The time until the two road-users would have collided, had they continued with unchanged speeds and directions (continous over time)

TA = The TTC-value in the moment one of the road-users starts taking evasive action

MTTC= The minimum value of TTC.

FIGURE 6.3 A TIME TO COLLISION (TTC) GRAPH ILLUSTRATING TA AND MTTC.

Until lately MTTC has not been part of a recording technique for human observers on ground level. Therefore we only know about the observer reliability for TA. The possibility of accurately using MTTC is, therefore, not known today.

Different development of different conflicts may lead to various situations with regard to TA and MTTC. In one case the TA can be the same in two conflicts while the MTTC is different. In two other conflicts the MTTC may be the same while TA is different. This fact may lead to the conclusion that either two measure is as good as the other. There are some reasons, however, that make me more in favor of the TA concept. These are:

- The TA-value describes the most critical moment in the whole series of events, namely when one of the road- users has detected the hazard and is just starting an evasive manoeuvre. At MTTC the road-user has already reacted to the hazard. He has had the opportunity to interpret the situation more closely and in theory may then produce a conflict with a low MTTC on purpose, even though the initial time margin would have been "big". To conclude: TA is the most "honest" value because it focuses on the moment when the unexpected event is just detected, before any "manipulation" of the event is made.

- The second reason why I am in favour of TA is of a theoretical nature: a serious conflict with a low TA-value can lead to an accident, while a serious conflict with a low MTTC (but greater than zero) can never lead to an accident. Thus in theory, serious conflicts with a TA-value above zero and accidents overlap while there is no such overlap for serious conflicts with a MTTC-value above zero.

Still I want to repeat what I stated in chapter 3, namely that I think that it might be of value not only to consider the initial phase of the conflicts, reflected by the TA-value, but also the outcome of the conflicts, reflected by MTTC.

Further work will be done on the reliability of the MTTC-value recorded by human observers on ground-level. If these results are positive, then it might be worthwhile trying to record both TA and MTTC for all conflicts.

6.1.4 Space margin

If the TA-criterion were changed so that it included a speed dependence, the basic idea would be that this would reflect both time- <u>and</u> space margins in the initial phase when the road-user has just detected the danger and is about to start evasive action. The shape of this speed dependence in order to obtain an optimal description will be dealt further with in chapter 7.

6.1.5 The duration of the conflict

A special case when dealing with the time and space margins is the duration of the conflict. The following example illustrates the problem: a pedestrian is crossing a road, and a car is approaching just before he is leaving the path of the on-coming vehicle. One of the road-users has to take some kind of evasive action in order to avoid the accident. There is collision course and the TA-value is 1.1 seconds. The further development of the serious conflict may be very different, depending on the behaviour of the two road-users. The different developments of the conflict is illustrated in figure 6.4 and the outcomes are summarized in table 6.1.

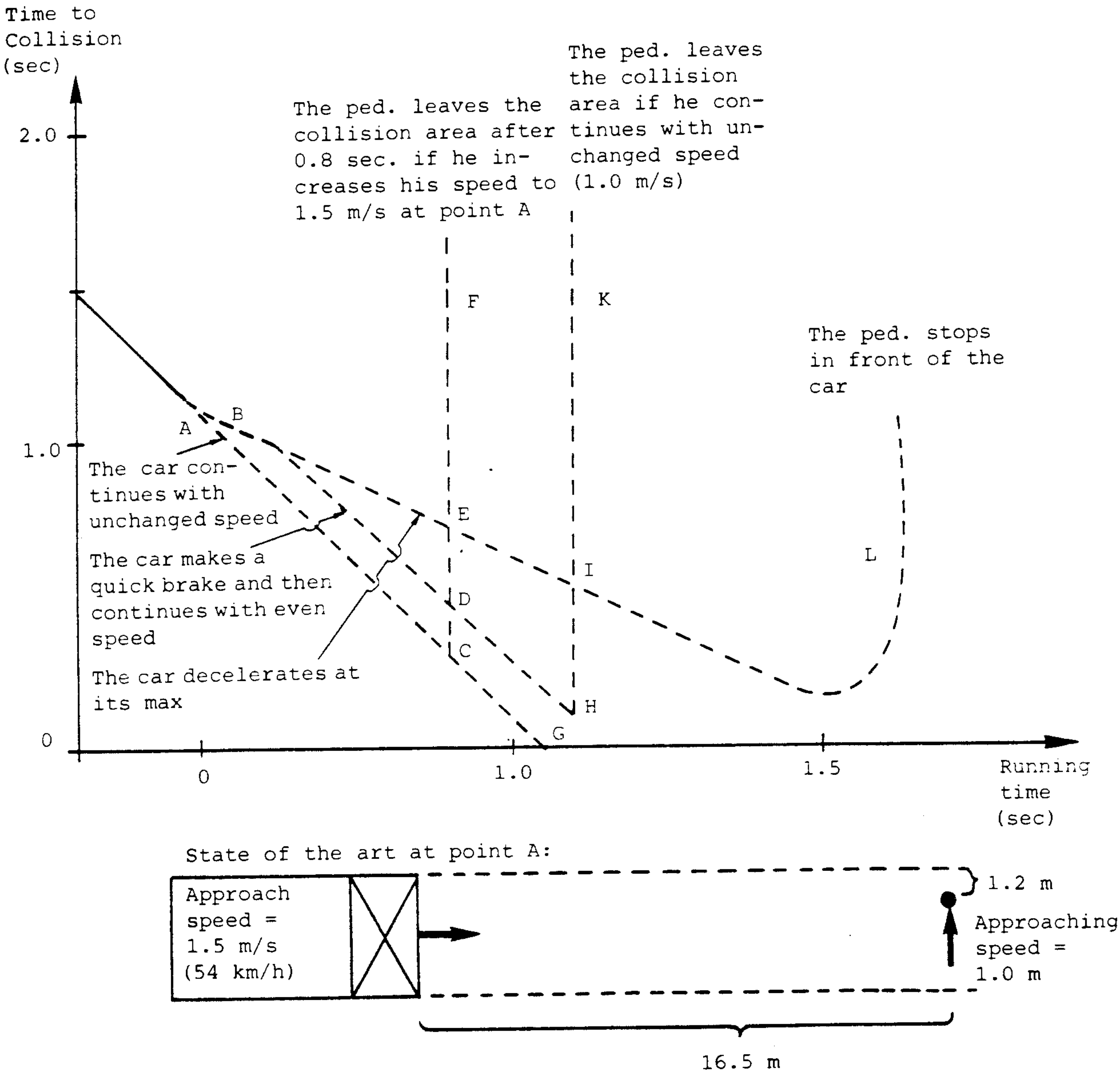


FIGURE 6.4 TIME TO COLLISION GRAPHS FOR DIFFERENT OUTCOMES OF A CAR-PEDESTRIAN CONFLICT.

TABLE 6.1 SOME DIFFERENT OUTCOMES OF A CAR - PEDESTRIAN CONFLICT WITH REGARD TO TIME TO ACCIDENT (TA) AND MINIMUM TIME TO COLLISION (MTTC)
(The different outcomes are visualized in figure 6.4).

Driver action	Pedestrian action	Graph in figure 6.4	TA (sec)	MTTC (sec)	Duration of the conflict[1]
Quick braking	No change (1.0 m/s)	ABHK	1.1	0.1	1.2
Quick braking	Accelerates (1.5 m/s)	ABDF	1.1	0.5	0.8
No braking	Accelerates (1.5 m/s)	ACF	1.1	0.3	0.8
Max., cont. braking	No change (1.0 m/s)	ABIK	1.1	0.5	1.2
Max., cont. braking	Accelerates (1.5 m/s)	ABEF	1.1	0.7	0.8
Max., cont. braking	Stops (0 m/s)	ABL	1.1	0.2	2.0

1) The time that passes from the moment the evasive action starts till the conflict is solved (TTC goes versus infinity)

The different examples represent only some of the possible outcomes. They do, however, represent some rather different ones. As was mentioned earlier, the TA-value is the same in all conflicts. Initially, I may refer to para. 6.1.3 and intuitively conclude that knowledge about both TA and MTTC would produce more information about the hazard involved than one of the measures individually. So, for instance, a reaction by both road-users leads to a higher MTTC and intuitively a higher accident-preventing potential.

At the same time the outcomes illustrated by the graphs ABHK and ABL in figure 6.4 produce almost the same TA <u>and</u> MTTC, while they are quite different in nature. One possible way of describing the difference between the two conflicts may be through the duration of the conflict, i.e. the time that passes from the moment an evasive action starts till the conflict is solved and the TTC-value approaches infinity.

The duration of the conflict can probably be estimated by human observers in a similar way as the TA is (successfully) estimated by observers. I would suggest that three classes be tested. "Long duration", "medium" and "short" duration. An introduction of this aspect had - as usual - to start with tests of the observer's reliability.

6.1.6 "Almost" collision course

A special problem, linked to the time and space margin arises when there is no actual collision course but almost one between two road-users, i.e. if both road-users continued with unchanged speeds and directions they would not collide but pass each other very closely.

The example in figure 6.4 can be slightly changed in order to illustrate this problem:

If the pedestrian had been only 0.3 meters further ahead in the initial phase, then there would have been no collision even if both road-users had continued with unchanged speeds and directions.

Theoretically, this event causes no problem: there is no collision course and consequently it is not a conflict with regard to our definition.

From an operational point of view it is much less clear how to interpret and treat an event like this:

- it is very similar to the events in the example (figure 6.4) all classified as serious conflicts.

- it is an impossible task for an observer to estimate if there is a collision course or not, if the margins are very small and an evasive action is undertaken.

- the observer's task is probably even more complicated as it is most probable that one (or both) road-users will react and take some kind of evasive action. This will emphasize the impression that there actually is a collision course, and it may therefore mislead the observer into making a biased estimation.

The solution to this problem, I think, has to be a pragmatic one. In the same way as road-users' action (suddenness and harshness) is used by observers to detect a serious conflict, the action at close-cuts can be used to detect whether a road-user thought that either there was a collision course, or that it was close enough to demand some action. In the latter case the road-user somehow extends the space covered by another road-user, thus including some kind of safety margin. If the road-user acts as if there was collision course, the conflict should be scored. The proposal for a new definition of a conflict then contains one hard element and one soft:

"A conflict is either an event that would have led to a collision if both road-users had continued with unchanged speeds and directions or a near-miss situation where at least one of the road-users acts as if there were collision course".

This extended definition of a conflict is of course not quite clear from a theoretical point of view. On the other hand it is hard to find a better way of treating these events in real life. Hopefully, international cooperation will give guidance in this matter as well. Reliability studies using an objective technique to evaluate the conflicts and then comparing them with estimations by human observers, could indicate the frequency of this type of event.

6.1.7 Type of evasive manoeuvre and type of road-user

Basically there are five different ways of avoiding an accident, once in a conflict:

- Braking
- Swerving
- Accelerating
- Braking + Swerving
- Accelerating + Swerving

The avoiding manoeuvre can be carried out by either road-user involved or by both.

It is likely that different alternatives do have different "accident-preventing potentials". Linderholm (1981) has for instance shown (see figure 6.5) that the theoretical threshold level between collision and non-collision in a "Conflicting Speed[1]-TA-graph" is different for similar situations where braking or swerving are the evasive manoeuvres, i.e. the time margin is bigger when swerving is performed. It is then most likely that the accident potential is different as well.

Different road-user types do have different characteristics with regard to stopping distances at braking, swerving ability, accelerating ability, etc. This factor should therefore be included as well and combined with the type of evasive manoeuvre that is carried out.

1) Conflicting Speed = The approach speed of the vehicle that takes the evasive action.

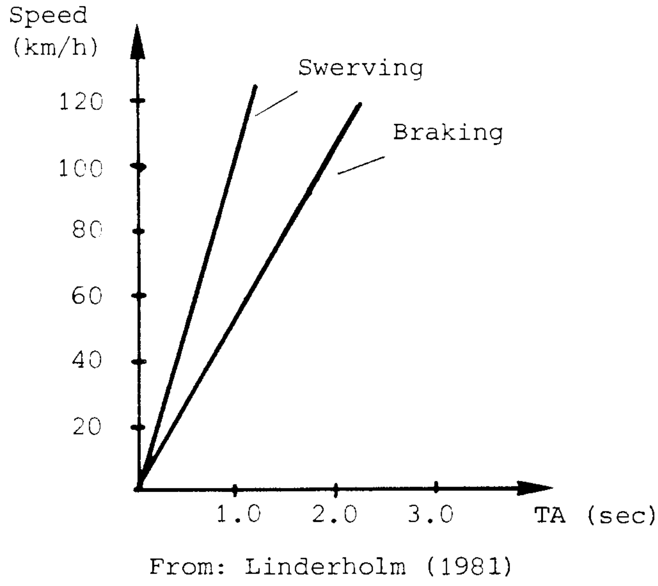


FIGURE 6.5 THE THRESHOLD LEVEL BETWEEN COLLISION AND NO COLLISION AT BRAKING AND SWERVING.
Two examples.
Derived from Linderholm, 1981.

6.1.8 Vehicle-linked capability of performing evasive manoeuvres

Relevant under this heading is primarily the braking capacity of a vehicle or the swerving abilities.

Basically I think it is wise to do as we have done, namely to presuppose that all motor-vehicles have the same technical capability to perform in evasive manoeuvres. Even though there is a steady improvement of the cars in this sense, this has been fairly slow so far.

An exception that might arise, is the use of a so called ABS-braking system. Such a system prevents the wheels from being locked at hard braking and the braking distance may therefore be reduced. The probability of a conflict leading to an accident will, most likely, be reduced. A large-scale introduction of such a system might therefore contribute to a significant change in this probability and consequently, in the conversion factors between conflicts and accidents.

The use of two brakes in stead of one on bicycles is another factor that might contribute to significant changes in (some) conversion factors.

The most interesting, and fruitful, approach to this problem, is probably to link up to the road-user's capability and to study the process of performing evasive manoeuvres. Such in-depth studies might produce a better insight into what factors explain the final outcome of a conflict and how these factors contribute to the probability that conflicts lead to accidents. It would be possible to use this knowledge when planning future validation work, and to ascertain whether any factors that describe technical capability would be worthwile including.

6.1.9 Road-user linked capability of performing evasive manoeuvres

Different road-users are differently skilled in making evasive manoeuvres. On the average, different road-users therefore produce different accident potential at equally defined conflicts. (The question of how often the different road-users get involved in a certain type of conflict is a completely different matter).

On the other hand a specific road-user's behaviour probably has a variation over time as well, i.e. sometimes she is acting "worse" and sometimes "better" than her average.

It would be very difficult to introduce this aspect operationally:

- It would be difficult to score the performance

- It would be impossible to find the "performance" distribution for a road-user.

6.1.10 Road and weather conditions

Most important here is probably the road conditions. Earlier validation work (chapter 5) showed that geometrical factors, such as sight distance, did not seem to influence the accident-to-conflict ratio. It is therefore unlikely that weather conditions as such, excluding the influence on the road surface, would influence the likelihood of a conflict leading to an accident.

Different types of road surfaces and friction in different weather conditions, however, produce quite different braking and swerving abilities. An accident may be easily avoided on dry asphalt while exactly the same type of conflict may easily lead to an accident on an icy road. This problem is taken care of so far by excluding winter conditions, both in conflict studies and in accident records (for validation purposes).

This is unsatisfactory in the long run and it is also likely that a split on more than two road conditions might improve the accuracy of the conversion factors.

The recording of road conditions may be done indirectly by scoring both TA and MTTC or by scoring TA and "Minimum distance between the road-users".

6.1.11 Final comments on different aspects that might have relevance for the definition of a serious conflict

Quite a few proposals have been made with regard to possible improvements of the definition. It is, however wise to bear in mind that it is a very delicate problem to introduce any new variables. The following aspects must be noted:

1) The reliability

   Some of the proposed changes would be difficult to test

2) The validity

   A split of data like the ones proposed would demand very big sets of data. Besides, some of the proposed splits of conflicts data can not be followed by a similar split of accident data. This makes a validity study even more complex.

3) Conflict frequencies

   At a specific conflict study the "expected average number of conflicts" of different types must be estimated. A greater split of data, therefore, demands bigger studies, which might easily become too expensive to carry out.

4) Transformation

   If the yearly expected number of accidents is going to be calculated from a conflict study, then the yearly distribution of conflicts with regard to the different factors should be known. This demands conflict studies at different times of the year, different road conditions, etc.

If the above mentioned mementos are considered, it may not seem worthwhile trying to introduce any new aspects into the definition. I still think it is worthwhile to try and find out about both distributions in general and about the average accident-to-conflict-ratios for different splits of data. At that stage of knowledge it would be possible to estimate whether it is worthwhile or not to introduce a specific new aspect.

6.2 Reliability

The results of the reliability studies on the original technique (section 4.4) are quite encouraging. Observers seemed to be capable of recording conflicts based on the Time to Accident criterion in a fairly precise way. The extensive use of the technique since then has not produced any major objections to this statement.

The equipment available at that time (around 1975) and the general state of knowledge were such, however, that there are today a couple of aspects of the reliability problem that should be dealt with in a more comprehensive study:

1) The quality of the extended reliability tests were not exactly clear. The key was produced by a couple of trained observers who evaluated all conflicts from video, independently. Their scores were compared with objective measures as far as possible. So, for instance, were speeds checked by measuring of the time-consumption of a vehicle over a known distance. Distances were checked similarly. Still the general problem was that the key-data could not be checked (or produced) systematically with an objective technique where errors of any kind were known.
   There is, for instance, a semi-automatique technique available today that is developed at IZF-TNO in the Netherlands (Van der Horst, 1981).

   An international cooperative study in Malmö 1983 gave the first opportunity to compare observer estimations of TA and vehicle speeds with results obtained with the Dutch technique. The design of the study and results are presented in chapter 7.

2) There is an interest in designing a more comprehensive study to find out more about differences between observers. Do different observers face different kinds of problems and would it be, for instance, cost-effective to train more observers than actually needed and then select the most reliable ones?

3) The kind of observer reliability tests that we have carried out only give an answer to the question of how well an observer performs under controlled testing conditions. It does not say anything about how well the observer performs in the long run, in the field, by himself. This problem is linked to questions about "keeping the know-how", motivation, study design etc. To study these problems there is a need for another study design other than the one used in the earlier reliability studies.

   The closest we have come to this problem is our tests of the day to day variation in studies where different observers recorded on different days. The results of these tests were encouraging; there seemed to be a very small bias introduced by the observer. (See section 4.4).
   These studies still did not produce any definite answer to the question of "normal day reliability", not only because the aim of studying the reliability was mixed with studies of the day to day variation, but also because observers knew that this kind of test was going to be carried out. Finally there were no tests on missing data and no tests on the scores of the recorded events.

6.3 Validity

Primarily, it looks as if the technique has a good validity The accident-to-conflict ratios that were produced were basically in agreement with later before- and after studies where "the expected average number of accidents" were compared with the actual number of accidents that occurred (Section 5.10), even though there seemed to be an overestimation of accidents through the conflict counts.

These were intersection-based comparisons. If data were split according to type of road-user and type of manoeuvre the agreement was not as high. This was, however, anticipated. In the original validation studies the data-set was too small to allow all those splits of the data that were motivated from a traffic engineering point of view.

Even though some problems were identified already at the time of the original validation studies, other problems were realized in a later phase when the technique had been in use for some time. The main concern was linked to the technique of calculating the variances in the estimated accident-to-conflict ratios:

Conflicts and accidents were finally split into four cells with regard to "type of road-user" (protected and non-protected) and "speed class" (flows with low speed, $\leq$ 35 km/h, and flows with high speed, > 35 km/h). Pre-supposing one true conversion factor (expected accident-to-conflict ratio) for each cell, these factors were estimated. The accuracy was presented as a 90%-confidence interval. These intervals were produced theoretically in the following way:

> The number of conflicts per time unit and the number of accidents per time unit were supposed to follow Poisson-distributions. The confidence intervals were then given by the number of conflicts and accidents in each cell.

With todays knowledge I consider the chosen procedure less fortunate. I am now convinced that there are more variables, than those detected by us, that influence the conversion factors. There might be quite a few such variables but normally the distribution over intersections is so similar that the conversion factor within each cell remains fairly constant. But not exactly similar! If the actual variation in the recorded conflicts had been used on our original data, we might have detected variations within different cells that might be due not to a random variation only but also due to the existence of some more variable that produced significantly different conversion factors. Linderholm (1981) has pointed out one such variable. He showed that when our original data on car-car situations were split in 'parallel' and 'perpendicular' then two quite different accident-to-conflict ratios were obtained (table 6.2, page 112). Linderholm's results also seem to be quite logical:

Car-Car perpendicular conflicts ought to produce higher risks of getting involved in a (police-reported) injury accident than for instance rear-end and weaving conflicts ('parallel').

TABLE 6.2 ACCIDENT-TO-CONFLICT RATIOS IF CAR-CAR SITUATIONS ARE SPLIT IN TWO TYPES
Original validation data

Situation	Car-Car 'parallel'	Car-Car 'perpendicular'	Car-Ped Car-Bic
Conflict class:			
<u>Class 1:</u> Speed < 35 km/h $1.0 \leq TA \leq 1,5$ s	0	2.4	9.6
<u>Class 2:</u> All other conflicts when $TA \leq 1,5$ s	2.8	11.9	33.9

N.B. All values should be multiplied by a factor 10^{-5}.
From: Linderholm (1981).

A second problem with the original validation study is that the predictive quality of the conversion factors could not be checked.

Predictive quality in this connection means the accuracy in predicting (objective) safety. Safety is then defined as the "average expected number of accidents" (for instance at an intersection). In a quality check, the variation in prediction of safety from conflict counts should be compared with the variation in prediction based on other measures. The main alternative measure to predict safety is "actually occurred accidents". The result of a comparison based on these two measures would tell us to what extent conflict counts are competative with accident analysis <u>in this respect</u>. (It is quite a different matter to compare accidents and conflicts, for instance, with regard to the potential ability for diagnostic studies).

Hauer and Gårder (1986) have presented a procedure for comparison of predictions based on conflicts and accidents. At our Department there is an on-going project primarily aiming at producing a "new generation" of validation results and making comparisons based on the Hauer and Gårder procedure.

A third problem with the original validation studies has to do with the classification of events in two "speed-classes". The classification was based on <u>flows</u> in "low-speed" or "high-speed" intersections according to median speeds of the flows.

The reason for this classification was that conflicts and accidents should be completely comparable, i.e. conflicts from one cell should explain accidents from the same cell.

One consequence of this, however, was that two exactly similar conflicts with regard to type of road-users involved, actual speeds and "Time to Accident" could be put in different cells (and thus given different conversion factors) just because the median speeds in the relevant flows were different. This did not seem to be logical and efforts were, therefore, made to overcome this problem. Linderholm (1981) made a first try by using actual vehicle speeds in the original validation data. The results are presented in table 6.2. He used a model where he tried to explain all (police reported injury) accidents of a certain type with regard to road-user involved and manoeuvre (for car-car only), from two types of conflicts with regard to actual speed and "TA". His results seem to be logical in the sense that low speeds and high TA-values produced lower accident-to-conflict ratios than high speeds and low TA-values. It is not possible, however, to discern from his results what role was played by the actual speed individually. Therefore further studies have to be undertaken. One such effort is the on-going "new-generation" validation studies at the Department. Another effort is presented in chapter 7, where I have compared actual speeds and TA-values in both conflicts and accidents.

Finally, I want to make two comments that have implications for the kind of validation work we have carried out:

1) Even though our technique was meant to be used not only for prediction of accident numbers, but also for diagnostic purposes, the first generation of validation studies only included statistical comparisons of conflict and accident numbers.

   For diagnostic purposes conflicts also have to be valid for some model explaining the causual connections behind an accident. The model, and consequently, the type of validation needed, depends on the kind of approach that is taken.

   I have, in chapter 7.3, presented a first approach to comparing the processes leading to accident and serious conflicts.

2) Our definition of a serious conflict is, among other things, based on the hypothesis that serious conflicts represent a break-down in the interaction between two road-users, i.e., the road-users did not voluntarily get involved in the event. Serious conflicts would, therefore, represent some kind of threat to the road-users. Doing so they would be valid by themselves as "events that we want to prevent ourselves from".

   The question of serious conflicts as indicators of threats to the individual is examined further in chapter 8, where the results of interviews with road-users involved in conflicts with various degrees of severity are presented.

7 MODIFICATION OF THE ORIGINAL TECHNIQUE

In this chapter, I will introduce some of the ideas presented in chapter 6 and analyse them further.

In section 7.1, I will present some alternative definitions for severity of conflicts and in section 7.2 and 7.3 these definitions will be tested against conflict and accident data.

In section 7.4, I will present the on going international cooperation in this area and, specifically, present the results and conclusions from a comparative study carried out in Malmö, Sweden, 1983. In this study eight different techniques were compared with regard to their severity classification, among other things.

In section 7.5, the results from the Malmö study are used in order to compare Swedish scorings with objective measurements.

7.1 A further improved definition of a serious conflict

7.1.1 General considerations

There has appeared no evidence that is strong enough to change the basic concept of using Time to Accident (TA) as the basic criterion when describing the severity of a conflict. Of all the proposed changes in chapter 6, there is one major modification that I consider to be highly relevant. That is to include the actual road-user speeds in the severity rating.

Two main approaches with regard to TA-speed relationships will be introduced in this section. In section 7.2 three more relationships are introduced and then all five are compared and discussed.

7.1.2 The basic principle for a definition of a serious conflict based on a Time to Accident - speed relation

The original definition of a serious conflict, i.e. $TA \leq 1,5$ seconds, can be illustrated in a "TA-speed" graph, as follows in figure 7.1.

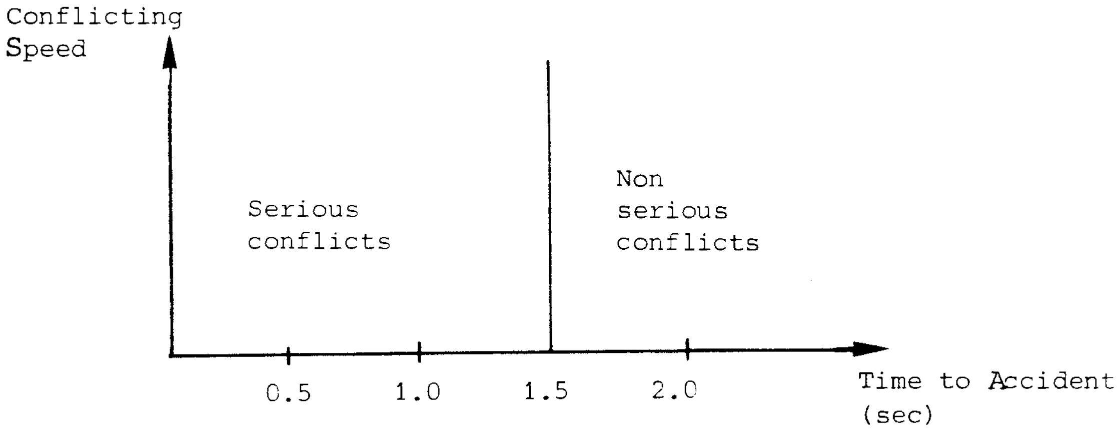


FIGURE 7.1 THE ORIGINAL DEFINITION OF A SERIOUS CONFLICT IN A TA-SPEED GRAPH

The severity of a serious conflict should, as stated before, reflect the probability of a collision. Thus the threshold level (TA=1.5s) should represent a uniform level of severity from the above-mentioned point of view. This is obviously not completely true. At low speeds the probability of avoiding a collision is greater than at high speeds, given the same TA-value. Thus a more relevant uniform level of severity should be speed dependent as well.

The main question then, is to find out the character of this speed dependence. For this purpose I have defined five different speed dependant uniform levels of severity. (From now on called "alternative definitions of severity"). Two of them are presented in this section and three in the next. The five levels are based on different approaches. They are compared in section 7.3 and 7.4 through analyses of "the processes leading to accidents and conflicts". (To be defined later).

The comparisons are carried out with the same preconditions for all five levels. These are: (See also figure 7.2)

1) A uniform severity level is defined, based on some theoretical approach. (Five approaches altogether).

2) Uniform severity zones are defined by equidistant, parallel curves to the uniform severity level.

3) Severity, finally, is defined as the position along a line, which is perpendicular to the uniform severity level.

The following comments must be made regarding the three preconditions.

1) The back-up for each definition of a uniform severity level will follow at the presentation of each of them. The curve defining the uniform severity level will either be straight or bent.

2) and 3) The definition of severity zones, i.e. that the curves are parallel, is a hypothesis that will be tested in further analysis.

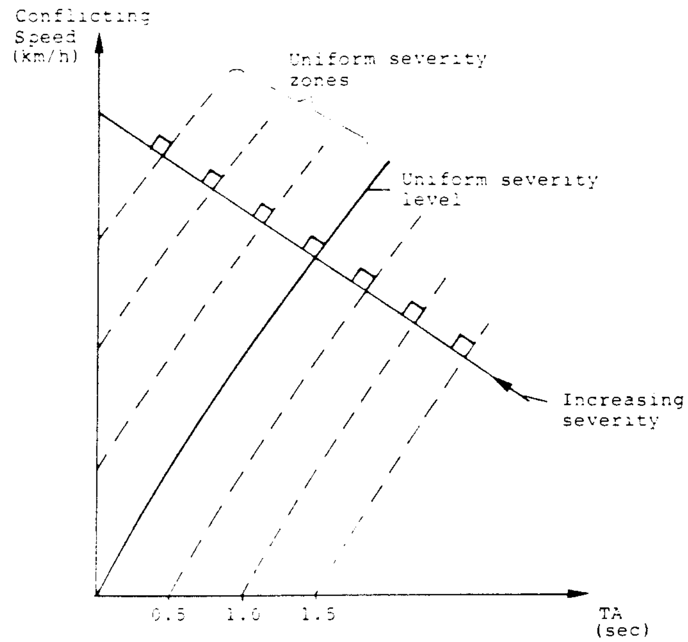


FIGURE 7.2 GENERAL DEFINITION OF UNIFORM SEVERITY LEVEL AND UNIFORM SEVERITY ZONES.

7.1.3 First alternative definition of severity

One way of picking up a uniform severity level, is to define the threshold between collision and no collision. This threshold, however, depends on a number of factors, such as type of evasive manoeuvre, vehicle and road-user abilities, road friction, etc. As all combinations probably produce different thresholds, it is not possible to calculate an average threshold. Instead, I will try to use the most common combination. In section 7.3 it is shown that "braking only" is by far the most common type of evasive manoeuvre. As a starting point I have, therefore, chosen "maximal braking on dry asphalt."

The relation between Time to Accident and approach speed, presupposing that a vehicle manages to stop just at the collision point, can now be calculated:

$$TA_{min} = \frac{s}{v_1} = \frac{{v_1}^2}{2gf} \cdot \frac{1}{v_1} = \frac{v_1}{2gf}$$

where s = distance to the collision point at the start of an evasive manoeuvre
v_1 = is the initial speed in the same moment as above
f = friction coefficient

- The Swedish National Road Administration (Statens vägverk, 1983) is using the following mean friction coefficient:

$$f=0.55 \cdot e^{-0.0137\ v_m}$$

where v_m (m/s) approximately equals

$$v_m = \frac{(v_1 - v_2)\times 2}{3} + v_2$$

where v_m = mean speed (m/s)
v_1 = initial speed (m/s)
v_2 = final speed (m/s)

The coefficient 0.55 in the formula above is chosen so that there is a safety margin built in. Without this margin the coefficient 0.55 should be 0.85 and thus $f=0.85 \cdot e^{-0.0137\ v_m}$

In our case v_2 always equals zero, which means that v_m equals $2/3\ v_1$. These values produce the following minimum TA-value:

$$TA_{min} = \frac{v_1}{16.7 \cdot e^{-0.0137\ v_m}}$$

Through TA_{min} the first alternative uniform severity level (ALT.DEF. 1) is defined. This is visualized in figure 7.3, together with severity zones.

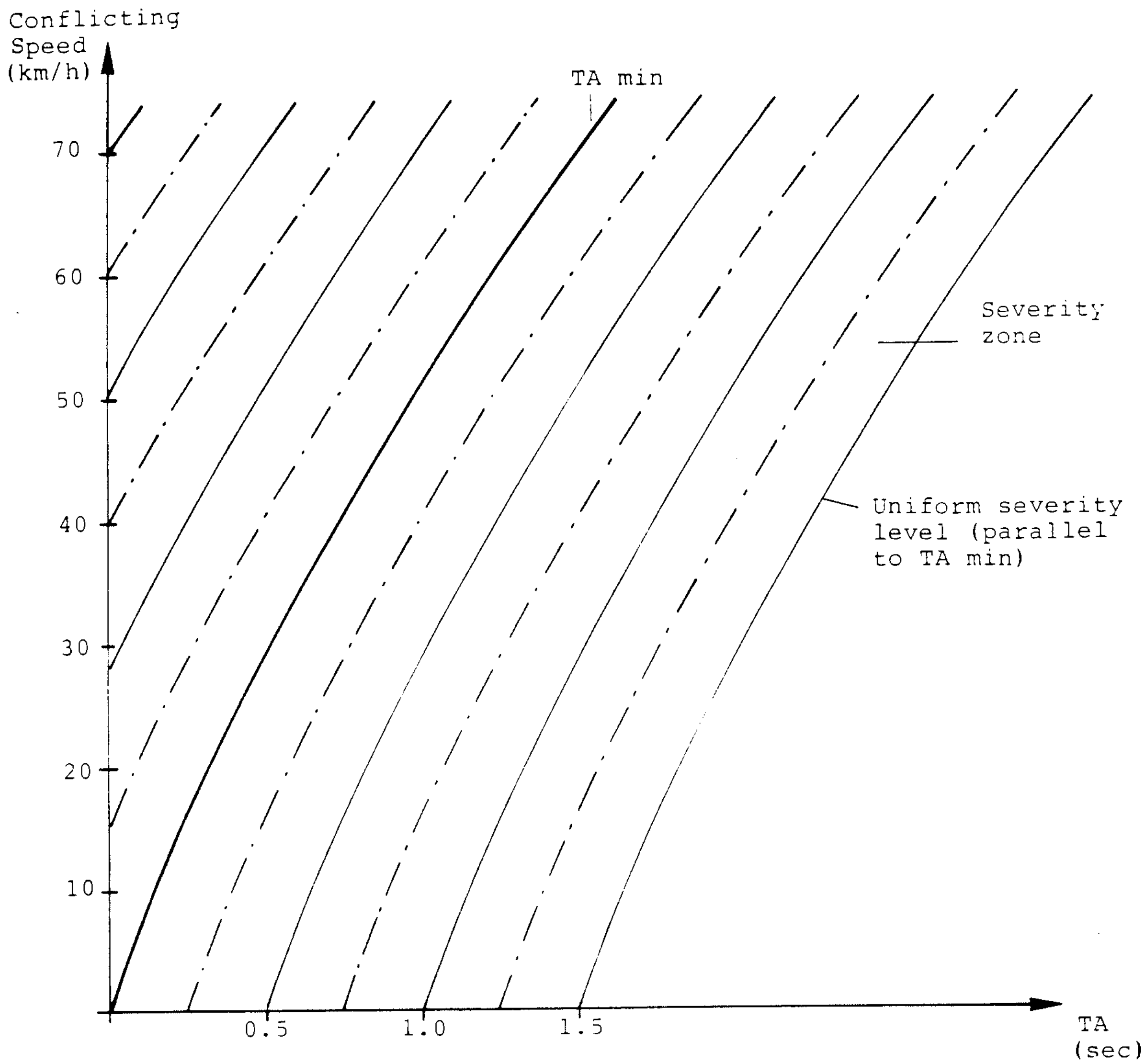


FIGURE 7.3 FIRST ALTERNATIVE DEFINITION OF SEVERITY (ALT.DEF.1)

7.1.4 Second alternative definition of severity

Gårder (1982) proposes that the uniform severity level is set so that the TA-value at a certain speed equals the necessary braking time at that speed. Time to Accident is defined as the time that remains to the collision point <u>if speeds and directions are kept unchanged</u>, while "necessary braking time" is defined as the time needed to come to a complete stop just at the collision point. If the deceleration is linear, then the average speed during the braking is half the initial speed. Thus the braking time is twice as big as the necessary TA-value.

Thus Gårder has built in a safety margin which is half the necessary braking time. Due to this difference with ALT.DEF.1, it is of interest to introduce it as a second alternative, ALT. DEF 2. It is visualized in figure 7.4.

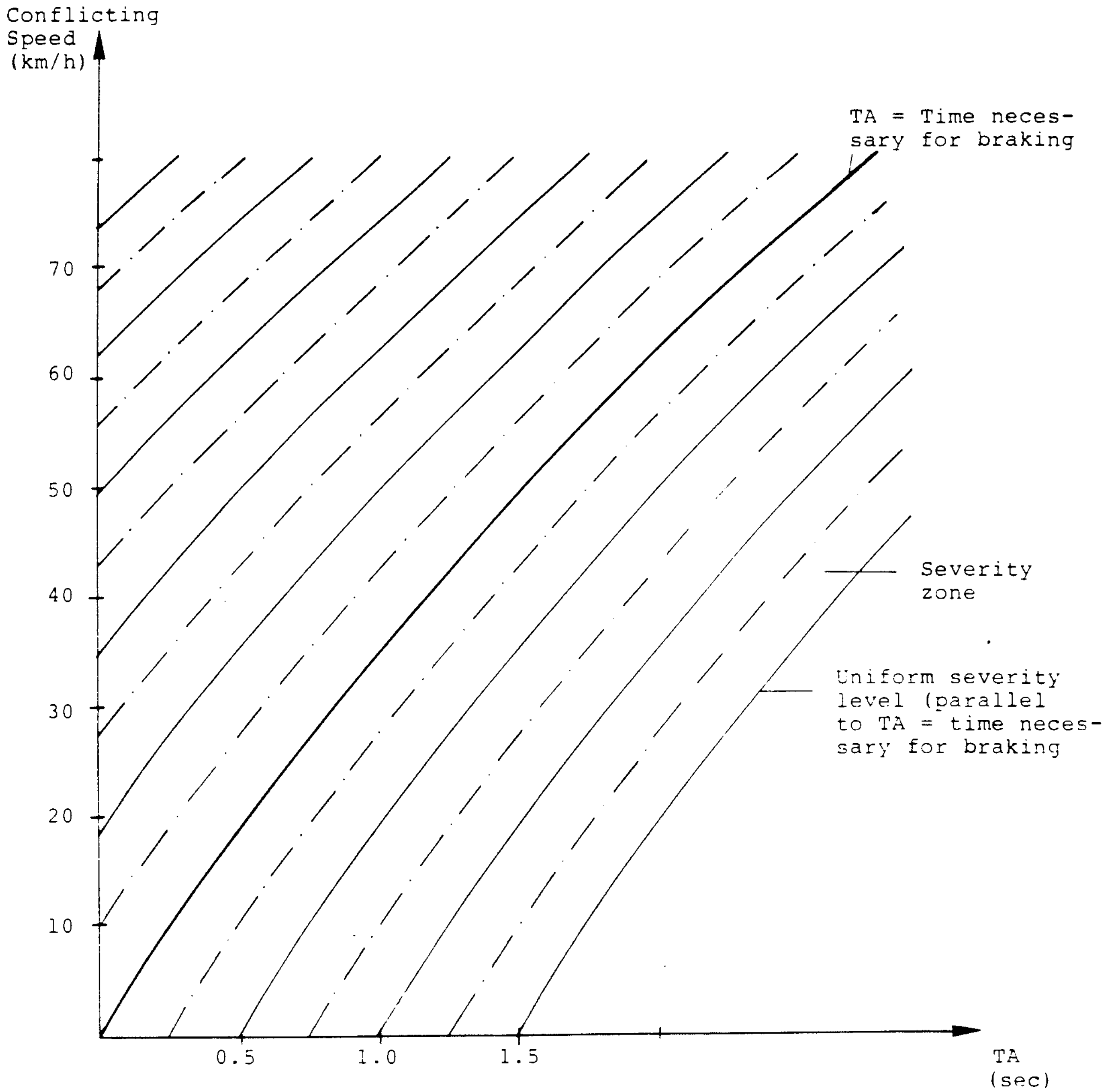


FIGURE 7.4 SECOND ALTERNATIVE DEFINITION OF SEVERITY (ALT.DEF.2)

7.2 The process leading to accidents

7.2.1 Introduction

I will, in this section and the next one, introduce a new approach for the comparing of accidents and conflicts.

Through analyses of both accident data and conflict data it has become possible to compare the last part in both the accident process and the conflict process, namely from the moment one road-user takes evasive action. The comparison includes:

- Kind of evasive manoeuvre
- Type of road-user that takes the evasive action.
- Time to Accident
- Conflicting Speed.

The data will be used for two main purposes:

1) to compare five different alternative definitions of the severity of a conflict and propose a new definition of serious conflict

2) to compare the different characteristics for conflicts and accidents in order to obtain a "process validation"

7.2.2 A pilot study

Looking at the process leading to accidents, i.e. parts of the "pre-crash" phase, is a demanding task as it is almost impossible to obtain any observational data. The analysis therefore has to be based on historical data. The information needed is, however, not easy to get from accident reports either. The best source would be any that describes the accidents in more depth. Accident investigation studies would, therefore, fulfill this need in the most relevant way.

In Sweden, there is only one major pilot study that has been carried out making thorough accident investigations. In this study (TRK 1978) 23 accidents were examined. The sampling technique was such that accidents of different severity (from damage-only to fatal), different types of road-users (cars, bicycles, pedestrians and types of environments (urban, semi-urban and rural) were represented.

The Time to Accident and Conflicting Speed was obtained by me through estimates of speeds of the road-users involved and distance to the potential collision point.

The data-sources were quite different in nature:

- Brake-marks measured on the road
- Interviews with road-users involved, about speeds and (partly) about distances
- Ditto with witnesses to the accidents.

One of the 23 accidents was of the single vehicle type and is therefore excluded in the further analysis.

The results are summarized in table 7.1 (page 122). In figure 7.5 (page 123) the TA-values and Conflicting Speeds are plotted for those 18 accidents where speeds and distances could be estimated.

Some conclusions can be drawn:

- In 19 out of 22 accidents (86%) there was an evasive action taken by at least one of the road-users involved prior to the accident.

- In 15 of the 19 accidents (79%) the evasive manoeuvre was "braking only". In the other 4 (21%) "swerving only" was the evasive manoeuvre.

- In all accidents but one the Time to Accident was below 1.2 seconds. When speeds were below 40 km/h the TA-value was below 0.5 seconds. There were, however, only two such accidents.

Even though there has to be some hesitation with regard to the reliability of the data used, the study still produced a lot of interesting indications that were backing up the need for a more comprehensive study.

There were, however, some facts that had to be considered before the implementation of a new study:

1) Accidents and conflicts were not compared in this study.

2) "Damage only" accidents were included. They were not in our validation studies (see chapter 5).

3) The road environment from which the accidents in this study were collected varied quite a lot. For instance, there were urban, semi-rural and rural environments represented, while in our original validation studies only urban areas were included.

4) The number of analyzed accidents was very small and even though the reliability of the data was the highest possible (at least for a retrospective study), the number was too small to produce anything but indications.

TABLE 7.1 ESTIMATED TIME-TO-ACCIDENT AND CONFLICTING SPEED IN A SAMPLE OF ACCIDENTS
Pilot study
Data from TRK, 1978

Num-ber	Road-users involved*)	Conflict type	Speed limit Road 1	Road 2	Evasive action Yes	No	Type of evasive manoeuvre Brak-ing	Swerv-ing	Type of indication Brake marks	Wit-ness	Estim. TA (sec)	Estim. speeds (km/h)	Severity of the acci-dent**)
1	C-C		50	50	x		x		12 m		0.66	65	DO
2	C-C		50	50	x		x		17 m		1.2	50	DO
3	C-C		50	50		x				x	0	45	SI
4	C-C		50	50	x		x		17 m		1.2	50	LI
5	Bu-C		50	50	x		x		10 m		0.9	40	LI
6	C-C		50	50	x		x		21 m		1.0	75	DO
7	C-C		50	50	x			x		x	<1.0	<30	DO
8	C-C	Rear-end	70	70	x		x		8 m		0.44	65	LI
9	C-Tr	"	90	90	x		x		38 m		2.0	70	LI
10	C-C	"	70	70	x		x		18.4 m		0.9	70	DO
11	C-C	"	50	50	x		x		18 m		1.1	60	DO
12	C-C	"	70	70	x		x		14 m		0.7	70	DO
13	C-Lo	Weaving	50	50	x			x					DO
14	C-C	Perpen-	50	50		x				x	0	45-50	DO
15	C-Bi	dicular	50	50	x			x	5 m		0.4	40-50	SI
16	C-C	"	50	50	x		x		2 m		0.48	15	DO
17	C-C	"	50	50		x				x	0	20	DO
18	C-C	Rear-end	70	70	x		x		22 m		1.2	60-70	DO
19	C-Lo	"	50	50	x		x		16 m		1.15	50	DO
20	Bu-C	"	70	70	x		x						DO
21	C-Lo	Nose to nose	70	70	x		x		13 m		0.7	70	F
22					x			x					DO
23		Single	-	-	-	-	-	-	-	-	-	-	-

*) C = Private car, Bu = Bus, Lo = Lorry, Bi = Bicycle, Tr = Tractor
**) DO= Damage only, LI = Light injury, SI = Serious injury, F = Fatal

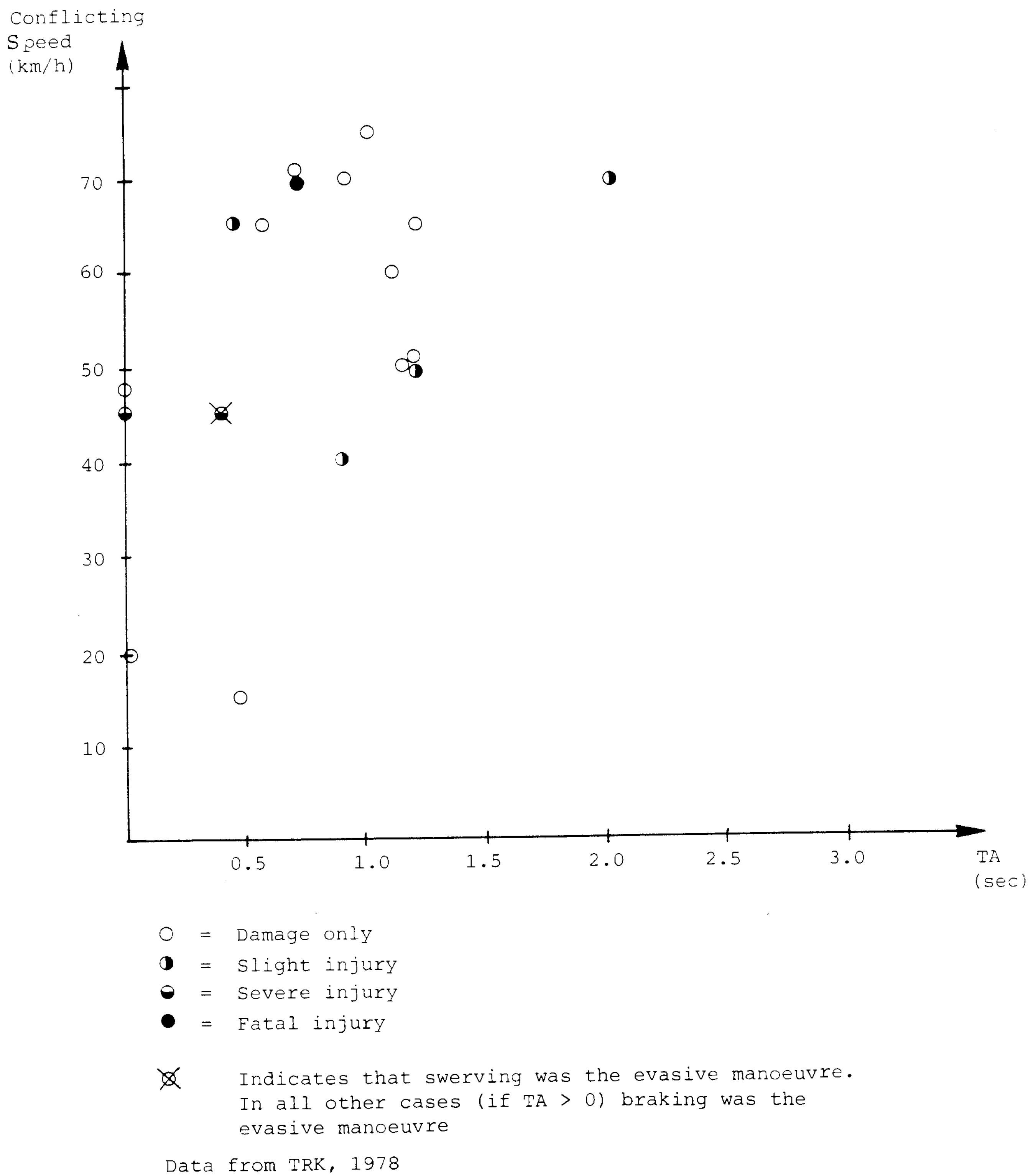


FIGURE 7.5 THE RELATION BETWEEN CONFLICTING SPEED AND TIME TO ACCIDENT
Pilot study
Data from table 7.1

7.3 Comparison between the processes leading to accidents and conflicts: an alternative validation approach

7.3.1 Introduction

The second best alternative, after in-depth studies, for analyzing the "pre-crash" phase in accidents, was to go through accident investigations carried out by the police. These investigations are made in order to control whether accidents are caused by a non-compliance with the existing traffic laws. All "severe" accidents are investigated, including almost all injury accidents.

Ideally, the accident and conflict process should be studied at the same intersections. In 1982 and 1983 conflicts were recorded at 107 intersections in the city of Malmö. These recordings were carried out primarily as part of a large validation study based on statistical comparisons between accidents and conflicts. (Earlier referred to as the on-going new generation validation project). The information could, however, also be used for my purposes.

Consequently, accidents should be selected from this sample of 107 intersections. It was found fairly soon, however, due to the fact that the accidents were filed in a time-order, that it was too time-consuming to restrict the sample. All intersections within the city borders of Malmö were, therefore, included.

The 107 intersections were a randomized sample from all intersections, with two main side-conditions to be fulfilled:

- Traffic volumes were not supposed to be "too small".
- No major changes of the lay-out or traffic pattern were supposed to have taken place during the last seven years.

It is not reasonable to believe that the sample of 107 intersections is biased compared with all intersections in Malmö regarding the information from accidents that I used, i.e. speeds and distances at evasive manoeuvres.

No accidents on icy roads were included, in the same way as they were not included in the original validation studies.

As mentioned earlier, serious conflicts should reflect the probability of a collision. My accident sample, however, mainly consists of injury accidents. Damage-only accidents are not included for the same reasons as in the original validation studies (see chapter 5), namely that those accidents are much less reported to the police than injury accidents. Besides, the missing data is more biased. The consequence, however, when selecting injury accidents is that the accidents do not exactly reflect the probability of a collision. This is particularly true for car-car accidents. For car-bicycle and car-pedestrian accidents, the difference can be overlooked. The bias due to this will be commented in the analysis.

For both conflicts and accidents the following information was collected:

- Conflicting Speed, i.e. the approach speed of the road-user that takes evasive action, or if both road-users do so the road-user that stands for the "least severe" conflict. "Least severe" is here defined in the same way as in the original technique, i.e. it is defined by the road-user that has the highest TA-value. This road-user will from now on be called the relevant road-user. If no action is started before a collision, then the speed of the road-user that hits the other is relevant in the moment he hits the other.

- Distance to the collision point, for the relevant road-user.

- Type of evasive manoeuvre.

- Type of road-user that was defined as the relevant road-user. (Car driver, bicyclist or pedestrian in car-bicycle and car-pedestrian situations).

- Speed and distances was combined and the Time to Accident for the relevant road-user was calculated.

Information from the conflicts was collected straight from the recording sheets.

To collect information from the accidents, a similar procedure had to be used as in the pilot-study (para. 7.2.2). Thus, the main sources for information were:

- Brake-marks measured by the police. The length of these brake-marks, from the start till the collision point, defined the "distance to the collision point" from the start of the evasive manoeuvre.

- Interrogations with road-users involved in the accident, regarding speeds, distances and type of evasive manoeuvre.

- Interrogations with witnesses to the accidents regarding the same aspects as above.

For each accident all relevant information was synthesized in order to obtain the most accurate estimates. Each of these were followed by a "confidence interval", estimated by the researcher. The mid-value in this interval was supposed to be the most likely value. In all the following analyses this mid-value is used.

In approx. 25% of all accidents the estimations could not be done due to lack of information. These accidents are omitted in most of the analyses.

7.3.2 Data base, general

Altogether, 312 accidents were analyzed, out of which 108 were "car-car" accidents (including lorries, buses, vans, private cars, motorbikes), 125 were "car-bicycle" accidents ("bicycles" included mopeds as well) and 79 were "car-pedestrian" accidents.

In total, of the 761 serious conflicts that were analyzed, 396 were "car-car" conflicts, 128 were "car-bicycle" conflicts and 237 were "car-pedestrian" conflicts.

7.3.3 The distribution of accidents and conflicts with regard to TA-value and Conflicting Speed

In order to obtain a basic knowledge about the accidents and conflicts studied, Time to Accident (TA) and Conflicting Speed (CS) are evaluated and plotted in graphs. Figures 7.6 to 7.11 (page 128 - 133) present these basic graphs.

The main conclusion that can be tentatively drawn is that the patterns are fairly similar in all six graphs. This indicates that conflicts and accidents seem to have some basic similarity with regard to the studied dimension.

The other major observations that can be made from the graphs are:

- The accidents are located more to the left in the graphs, i.e. the TA-values are lower for accidents than for conflicts. The overlap, however, seems to be quite big in all three cases.

- Car-car accidents also have higher speeds on average than car-car conflicts. Specifically, very few accidents have speeds below 30 km/h, while more than half of the conflicts have speeds below 30 km/h.

  The main reason for this is probably that conflicts are supposed to reflect the likelihood of collisions and not injury accidents. It is obvious that the conflicting speeds at car-car accidents have to be above 30 km/h, in most cases, to produce injuries, while collisions also occur at lower speeds.

  This is also confirmed by the analysis of car-bicycle and car-pedestrian events where injury accident and collision are almost equal terms. The analysis shows, namely, that there are quite a few unprotected road-users that are injured at speeds below 30 km/h.

- The number of accidents where the TA-value equals zero varies between 6.5% in car-car accidents, 29.5% in car-bicycle accidents and 24.0% in car-pedestrian accidents.

The shape of the data-sets in all six graphs (figures 7.6 to 7.11) is primarily rectangular to its nature, with the longer sides standing up inclining somewhat to the right.

The right hand side in these rectangular distributions for accidents represent the lowest uniform severity level, namely the threshold between accidents and non-accidents. It is, however, quite a demanding task to calculate the equation of these sides. Instead, regression lines for the data-sets (for accidents) is calculated in order to obtain a parallel line to the one representing the lowest uniform severity level. The inclination of this regression line then defines the uniform severity level for each of the three accident data sets.

Regression lines are also calculated for the three conflict data sets. These lines represent mean severity values for those conflicts scored. (The observers had a threshold level for recording that was equal to the uniform severity level for ALT. DEF. 2 (see figure 7.4) starting at TA = 1.5 seconds. Some conflicts were shown afterwards to fall outside the threshold level. They are still included in the analysis, as the sample of conflicts is "those conflicts that fall within the recording limits with regard to the observer's initial judgment").

It is to be noted that the regression is linear. The data volumes did not allow any other type of analysis.

Figure 7.12 (page 134) illustrates the six regressions between Time to Accident (dependent variable) and Conflicting Speed (independent).

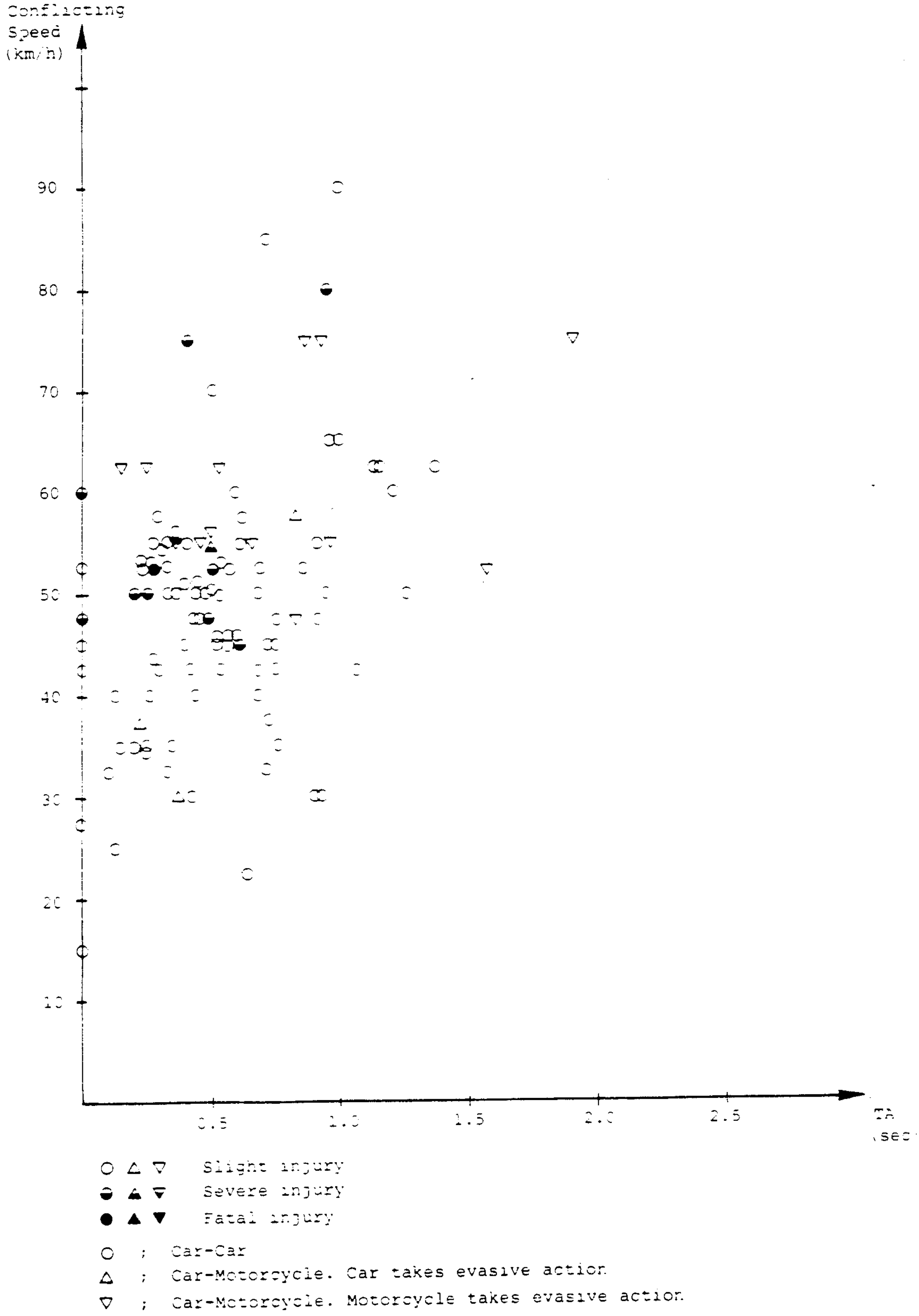


FIGURE 7.6 TIME TO ACCIDENT AND CONFLICTING SPEED IN CAR-CAR ACCIDENTS
108 injury accidents, Malmö 1978 - 1980

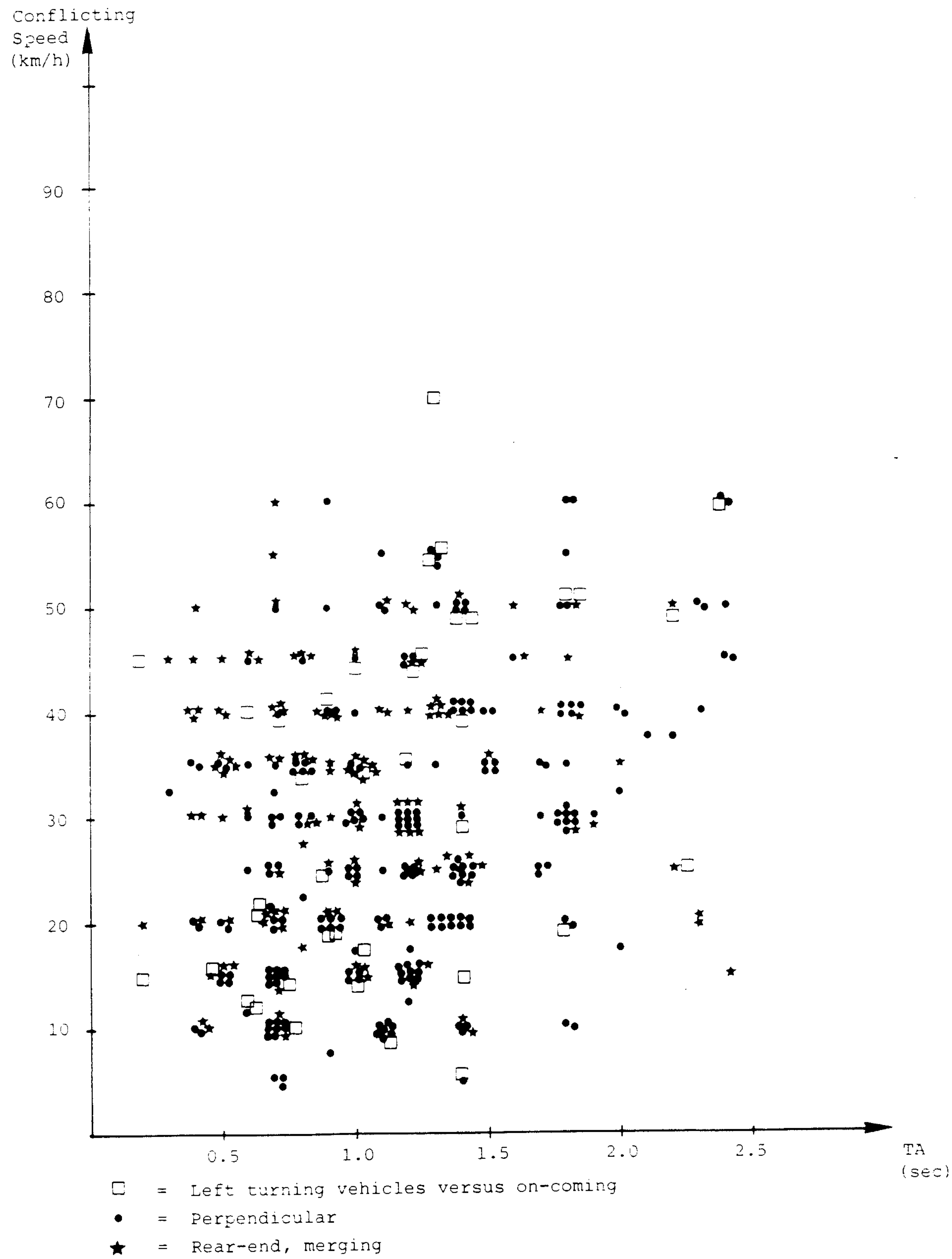


FIGURE 7.7 TIME TO ACCIDENT AND CONFLICTING SPEED IN CAR-CAR CONFLICTS
396 serious conflicts recorded in Malmö, 1982-1983

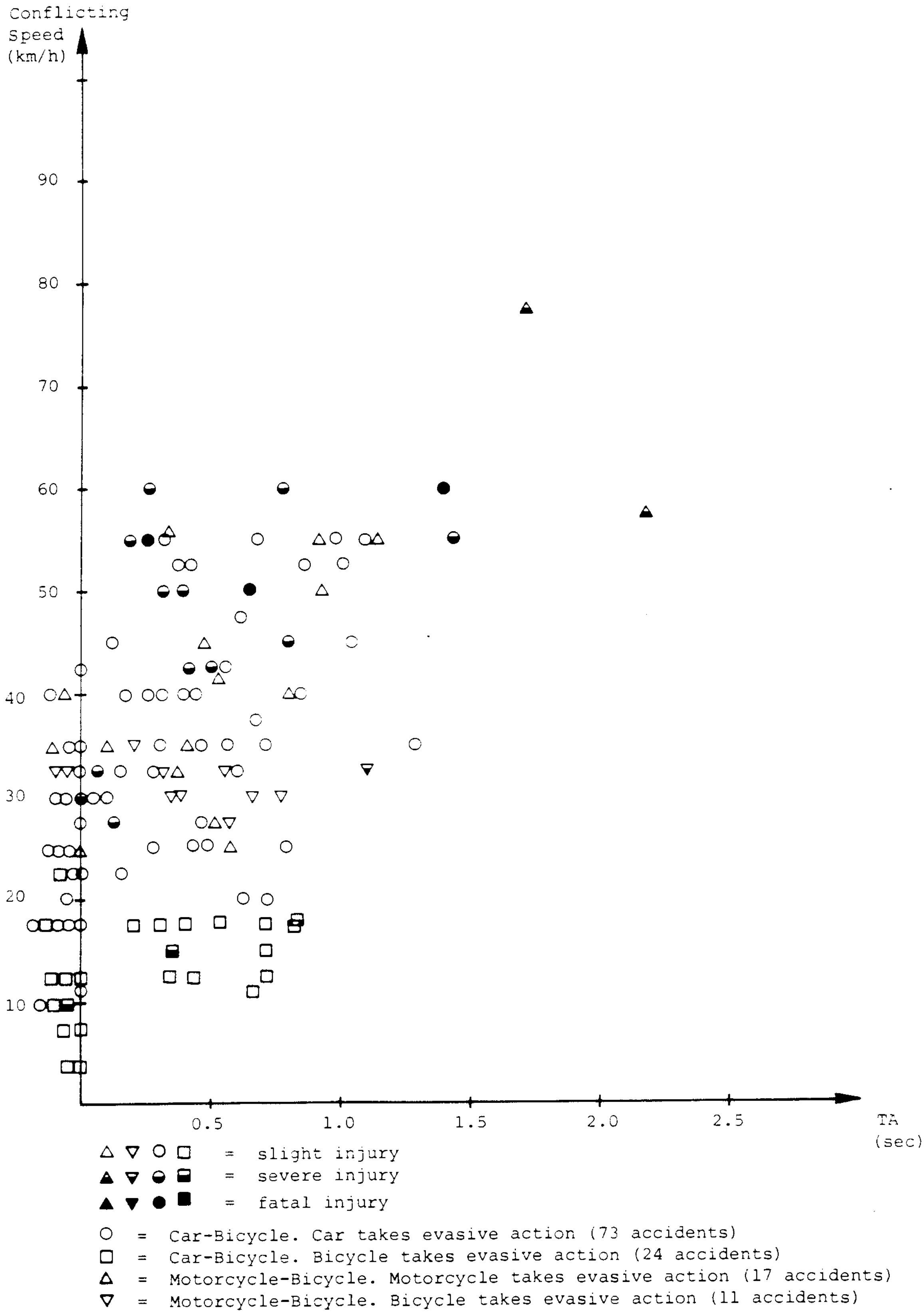


FIGURE 7.8 TIME TO ACCIDENT AND CONFLICTING SPEED IN CAR-BICYCLE ACCIDENTS
125 injury accidents, Malmö 1978 - 1980

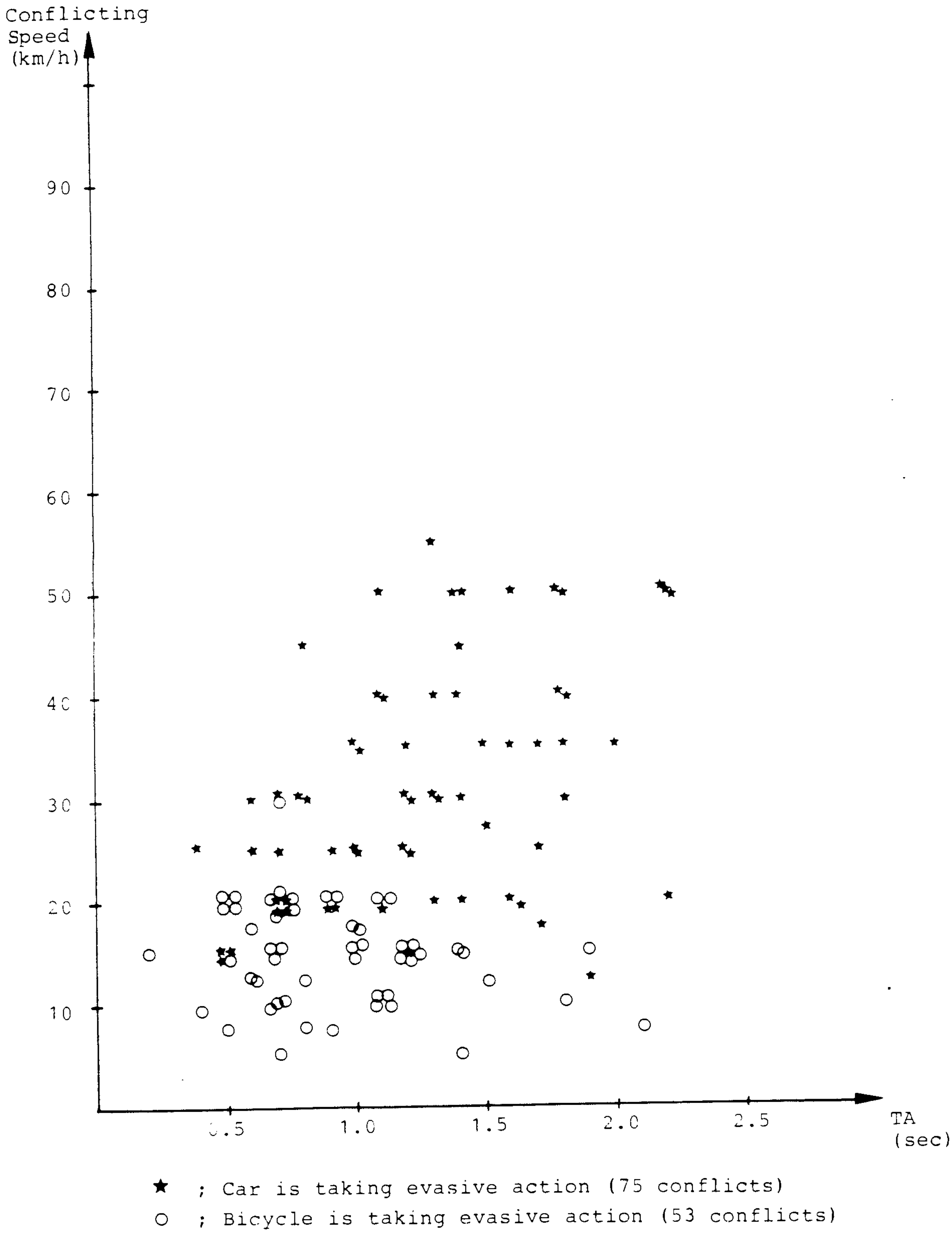


FIGURE 7.9 TIME TO ACCIDENT AND CONFLICTING SPEED IN CAR-BICYCLE CONFLICTS
128 serious conflicts recorded in Malmö, 1982-83

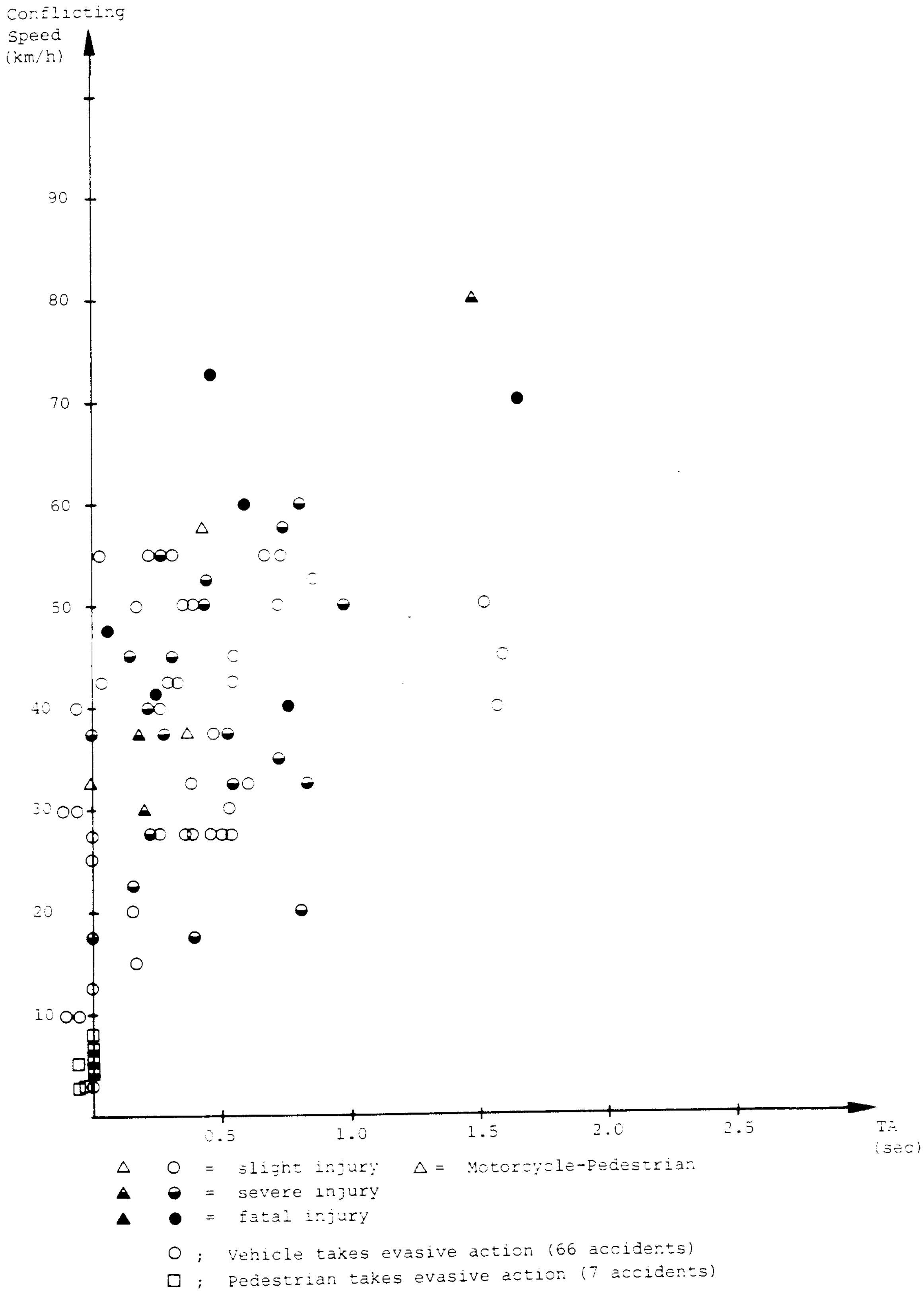


FIGURE 7.10 TIME TO ACCIDENT AND CONFLICTING SPEED IN CAR-PEDESTRIAN ACCIDENTS
79 injury accidents, Malmö 1978-80

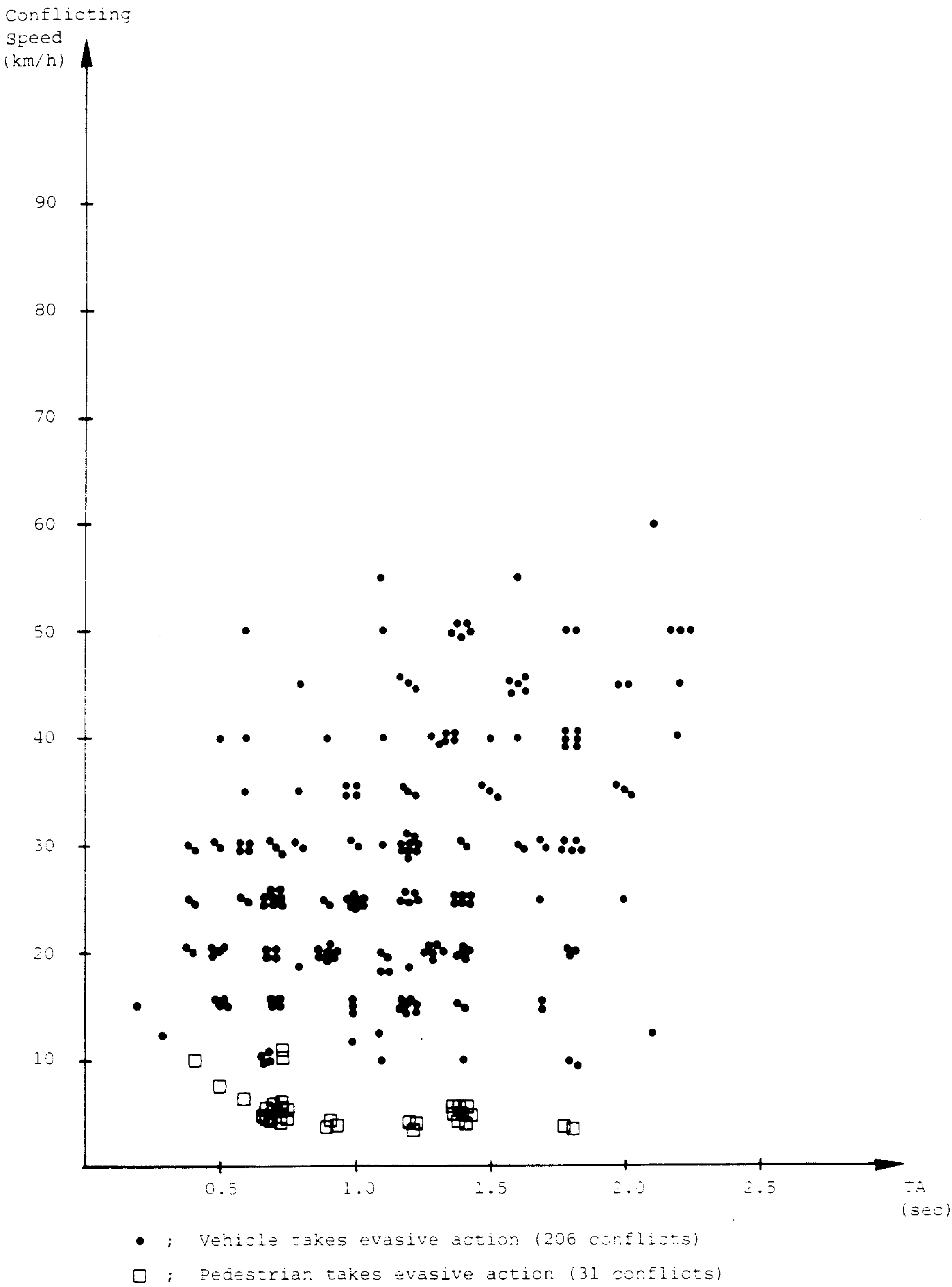


FIGURE 7.11 TIME TO ACCIDENT AND CONFLICTING SPEED IN CAR-PEDESTRIAN CONFLICTS
237 serious conflicts recorded in Malmö, 1982-83

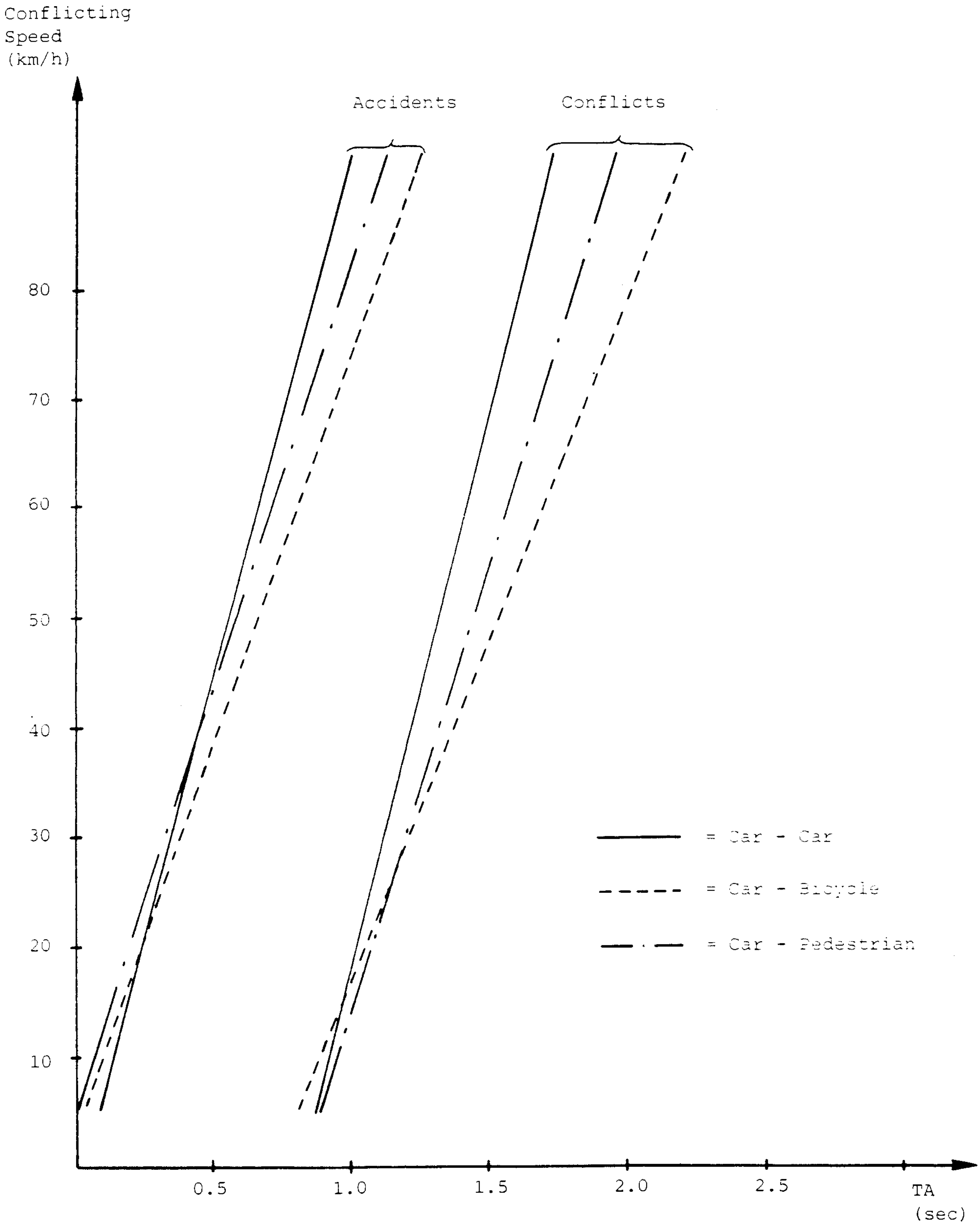


FIGURE 7.12 REGRESSION LINES FOR TA-CONFLICTING SPEED PLOTS FOR DIFFERENT ROAD-USER TYPES

It can be seen from figure 7.12 that all six lines have very similar inclinations. This primarily indicates two things:

1) The uniform severity level for all three categories of accidents seems to be the same.

2) The uniform severity level for accidents and serious conflicts as scored by our observers, seems to be the same.

There is one problem, however, with the data:

The TA-value equals zero in a number of accidents. In theory, TA equals zero only when the road-user starts an evasive action exactly at the moment of collision. It is obvious that this must be unusual. It is more likely that the road-users, when TA equals zero, would not have started their evasive action until after the collision. The TA-value should then be negative. I do not, however, have any reliable information on when the road-user intended to start his action and consequently I do not know the size of the negative TA-values.

The accident graphs show that TA most often equals zero at low speeds.(This phenomena is dealt with later on in this section). This means that if the correct value for the vast majority of accidents where TA=0 should be negative, then a great part of the observations in the lower part of the graph should be moved straight to the left. Consequently, the regression lines, primarily for "car-bicycle" accidents and "car-pedestrian" accidents, should incline more than is indicated by the lines in figure 7.12. The problem is that I do not know the exact position for the connected observations and I can, therefore, not make any new regression on the data.

In order to get an idea of the quality of the results so far, I have specifically analyzed those accidents which I consider most reliably recorded. In this category I include those accidents where brake marks are measured. Even though speed estimates are achieved in the same way as for the other accidents, it is of interest to see whether more reliable data on "distance to the collision point" change the pattern. I have chosen to include those accidents where no evasive action is taken before the collision, i.e. TA=0, in the same proportions as they are in the total sets of accidents.

Figures 7.13, 7.14 and 7.15 (page 136-138) present the "TA-Conflicting Speed" graphs for the three sets of reliable accidents.

In figure 7.16 (page 139) the regression lines based on the plots of more reliable data are compared with the regression line for the total number of accidents.

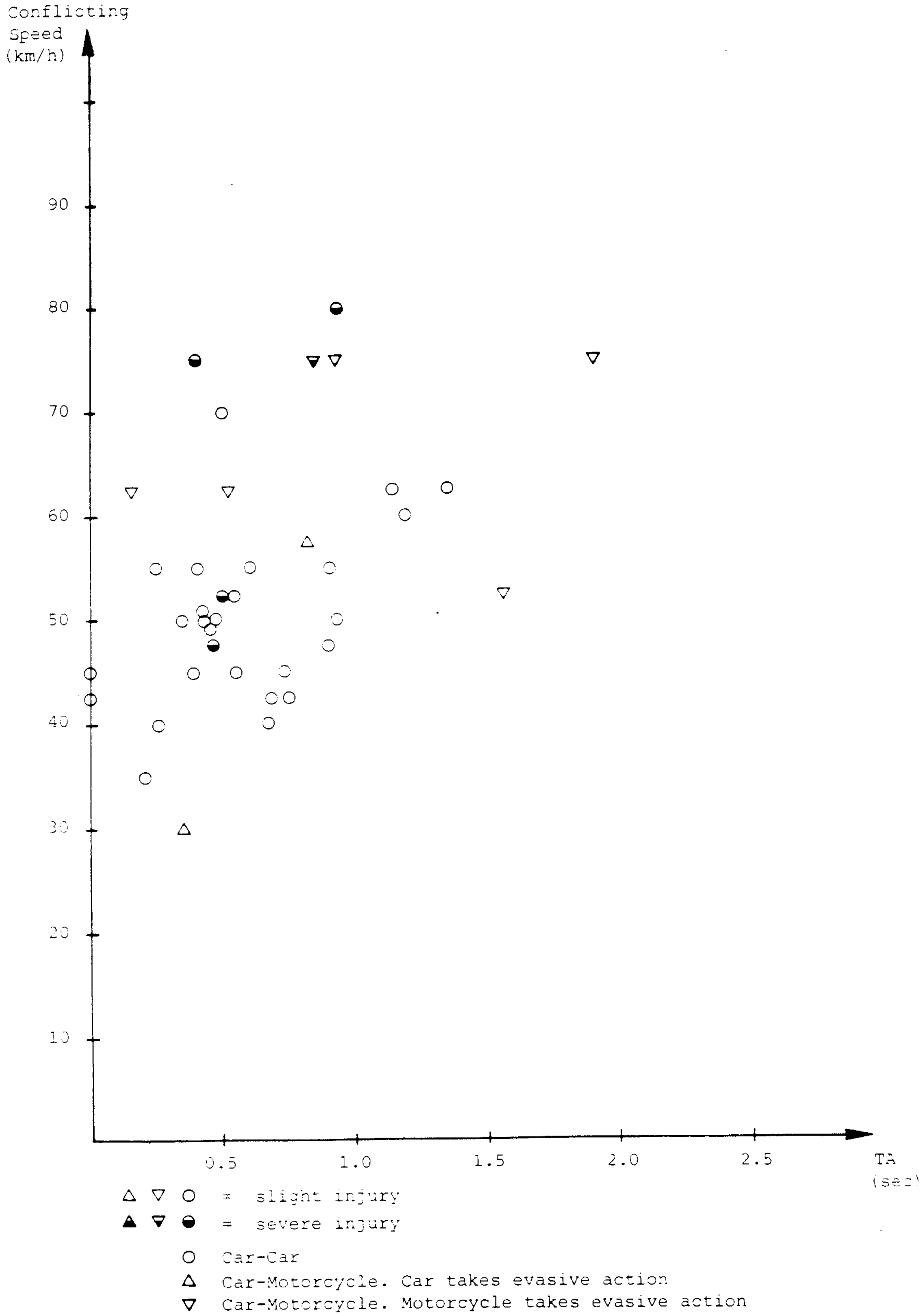


FIGURE 7.13 TIME TO ACCIDENT AND CONFLICTING SPEED IN "RELIABLE" CAR-CAR ACCIDENT
Brake marks measured + a proportional part of accidents where TA = 0

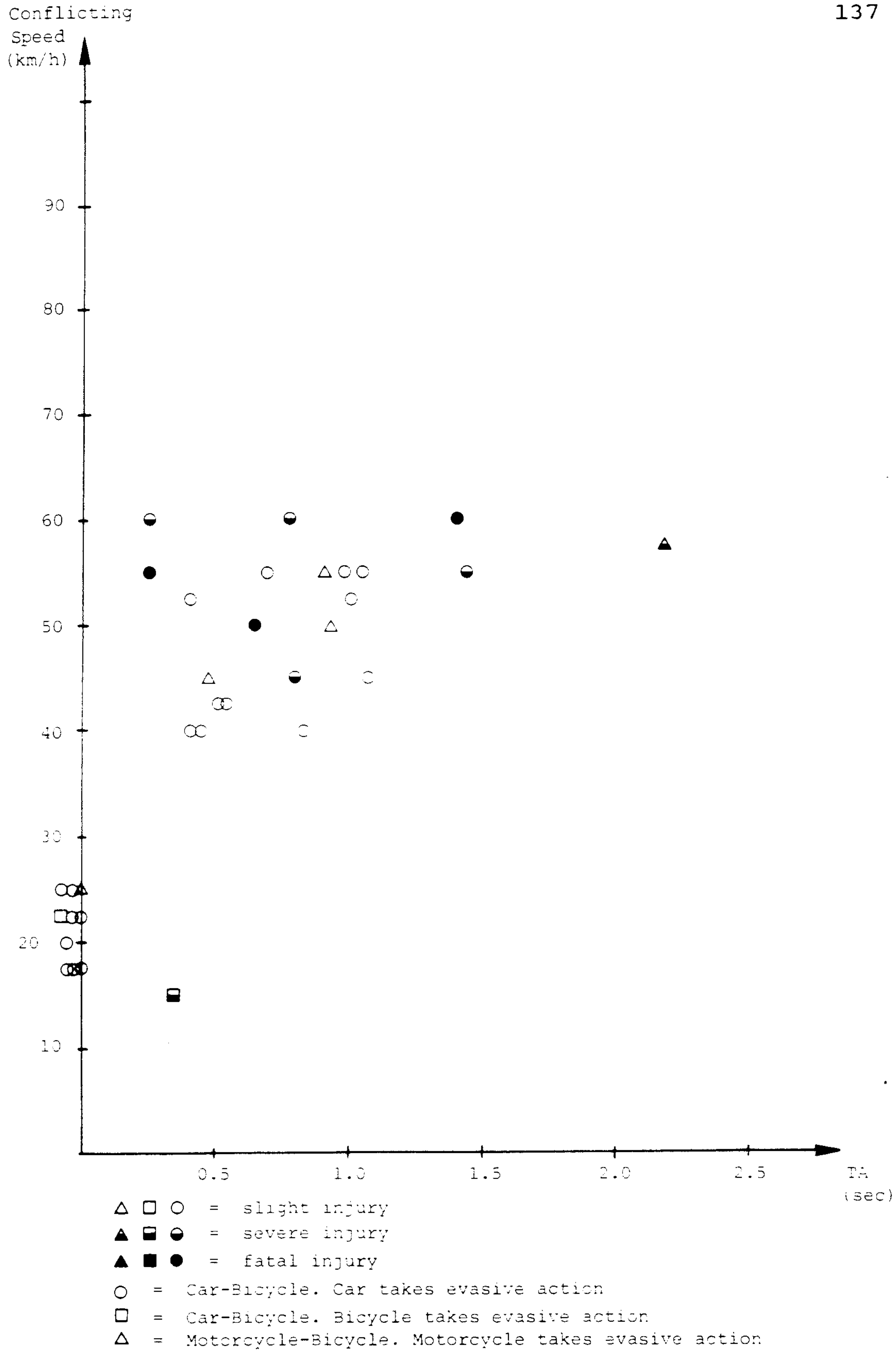


FIGURE 7.14 TIME TO ACCIDENT AND CONFLICTING SPEED IN "RELIABLE" CAR-BICYCLE ACCIDENTS
Brake marks measured + a proportional part of accidents where TA = 0

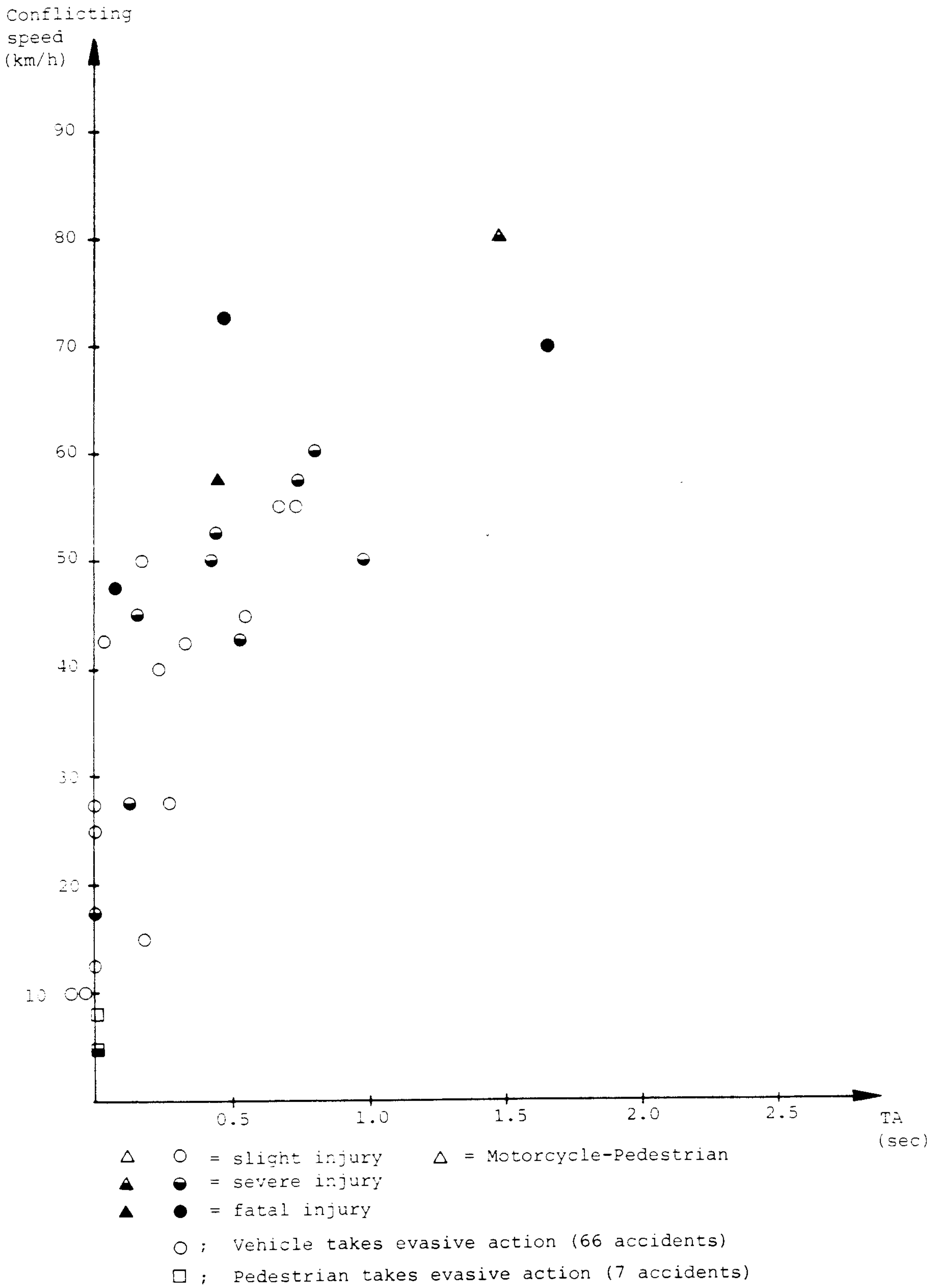


FIGURE 7.15 TIME TO ACCIDENT AND CONFLICTING SPEED IN "RELIABLE" CAR-PEDESTRIAN ACCIDENTS
Brake marks measured + a proportional part of accidents where TA = 0

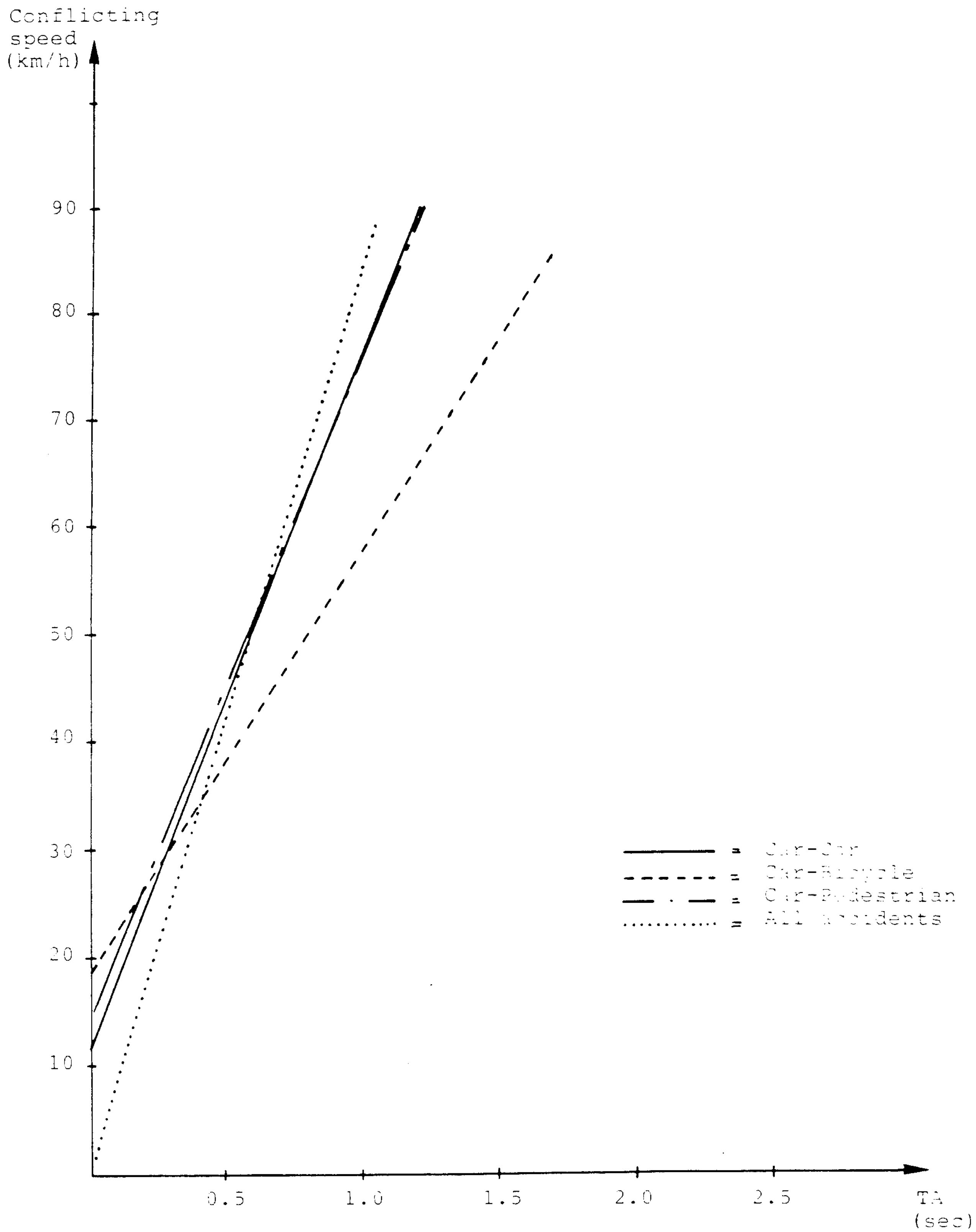


FIGURE 7.16 REGRESSION LINES FOR "RELIABLE" ACCIDENTS COMPARED WITH THE REGRESSION LINE FOR ALL ACCIDENTS

As can be seen from figure 7.16 the lines for "reliable" car-car and car-pedestrian accidents are very close to the line for all accidents (which in turn was very close to that of all car-car and all car-pedestrian accidents).

The regression line for car-bicycle accidents is, however, of a steeper incline than the line for all accidents. The main reason for this is that in a great part of the car-bicycle accidents the cyclist or moped rider takes the evasive action. (29% of all car-bicycle accidents). The average Conflicting Speed at these accidents is much lower than that for the other accidents. Brake-marks that are found and measured are very uncommon for accidents where the cyclist or moped rider takes the evasive action. These kinds of accidents are consequently underrepresented in the set of "reliable" accidents. Therefore, there are practically no accidents with low speeds in the set of "reliable car-bicycle accidents", and this is the primary reason why the regression line for these accidents has a different incline from other regression lines.

Basically, the comparison with the 'reliable' data showed that there were very small differences.

7.3.4 Choice of five alternative definitions of severity

In order to have a good representation of definitions based on different "TA-Conflicting Speed" relationships, I have for further testing, selected three additional ones to those two presented in section 7.1. The three definitions represent two extremes and one in between:

- The third alternative severity definition (ALT.DEF,3) is based on the regression line for all accidents. This alternative is less speed related than the first two alternatives.

- The fourth definition is based on Time to Accident only, thus no speed-relation at all. (ALT.DEF.4)

- The fifth is based on Conflicting Speed only, thus no TA-relation at all. (ALT.DEF.5).

The five different severity definitions and the definition of severity zones are found in figure 7.17.

The hypothesis regarding severity and uniform severity level can be split in two parts:

- The degree of severity is defined by the position in the graph in relation to the perpendicular distance to a border line between two uniform severity zones, i.e. the degree of severity is the same as long as this perpendicular distance is the same. (Hypothesis about uniform severity level).

- The degree of severity is increasing with the severity of the zone, i.e. severity is higher the more "to the left/upwards" a conflict is positioned in the graph.

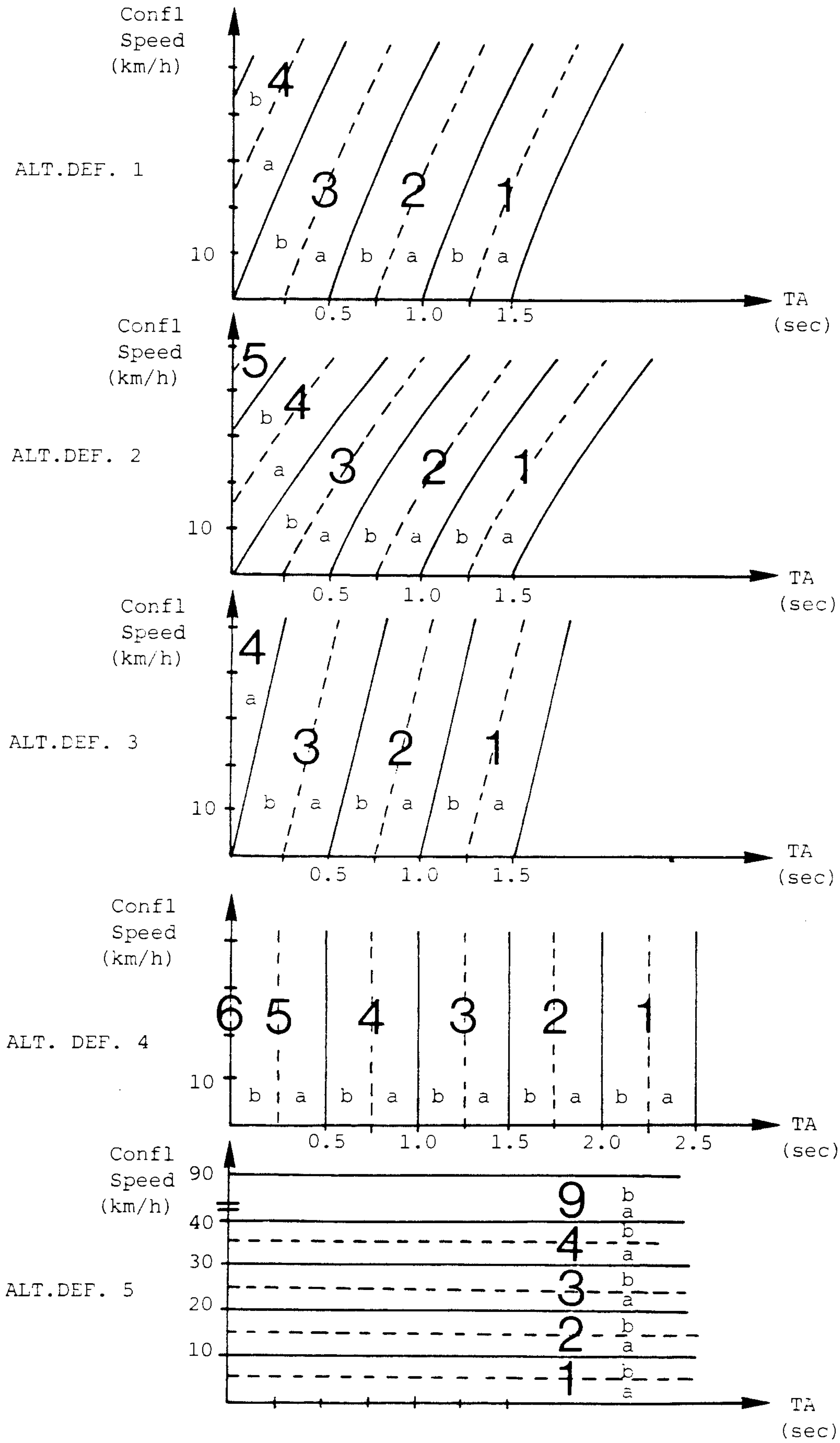


FIGURE 7.17 DEFINITION OF SEVERITY AND SEVERITY ZONES FOR THE FIVE ALTERNATIVES

7.3.5 Comparison of the alternative severity definitions

There are four types of comparisons between the five different severity definitions, based on the following aspects:

1) Severity of conflicts

2) Severity of accidents

3) The proportion of accidents similar to conflicts for the different severity definitions

4) The relevance of the combined conflict and accident distributions.

1) Severity of conflicts

The second part of the aforementioned hypothesis is that the severity of conflicts increases with the severity zones. This part of the hypothesis will be used here to compare the five alternative definitions of severity.

Severity of conflicts is, in our case, operationally defined as the probability of a conflict leading to a police-reported injury accident. This probability is calculated as the number of injury accidents divided by the number of conflicts per severity zone.

In appendix 7.1 the number of accidents and conflicts are listed for each of the zoning systems that go with the five severity definitions.

Appendices 7.2, and 7.3 present relations between accidents and conflicts, appendix 7.2 with a greater break-down of the data than appendix 7.3.

Figures 7.18 - 7.22 (page 143 - 145) presents results corresponding to appendix 7.2.

The results indicate that the first three alternatives all show a more stable increase of severity than the last two. From this point of view, it is implied that the severity dimension should include both speed and TA.

The first three alternatives seem to be rather similar and it is, therefore, more difficult to select one of them. There are, however, two aspects that do imply that the ALT.DEF.2 seems to be the most appropriate one:

- It does show the smallest number of irregularities in the graphs (decreases instead of increases or other larger discontinuities)

- It has the highest proportion of statistically significant increases, in the number of accidents to conflicts, when consecutive zones are compared. (See table 7.2, page 146).

The results also show that ALT.DEF.4 is more appropriate than ALT.DEF.5. This implies that the TA-dependence should be greater than the speed dependence. This is also the case with both ALT.DEF.1, ALT.DEF.2 and ALT.DEF.3.

To conclude: The first three definitions seem to fulfill the hypothesis regarding increased severity. The ALT.DEF.2 is the most appropriate one. The first part of the hypothesis, regarding uniform severity, will be tested individually in para. 7.3.6.

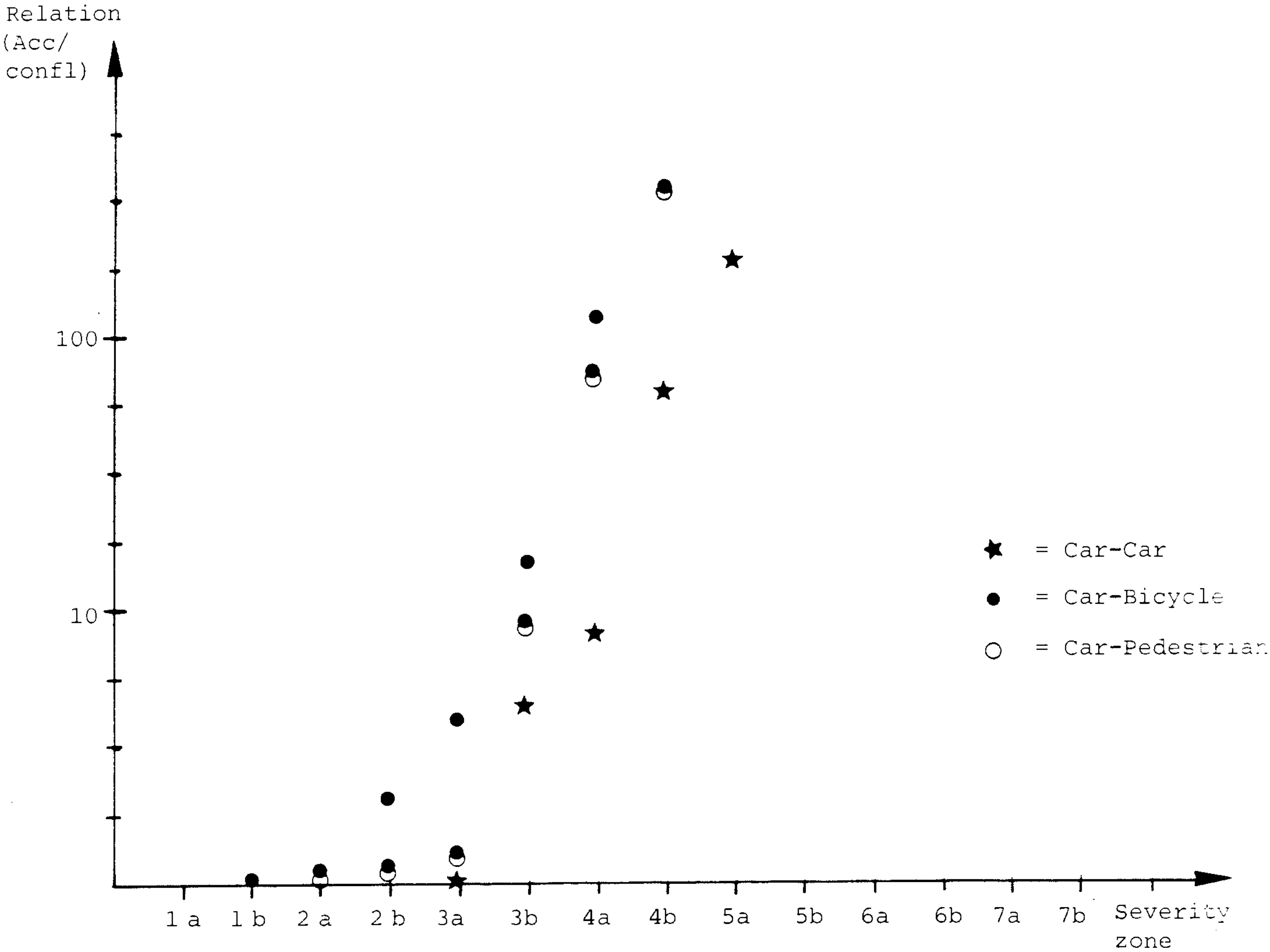


FIGURE 7.18 RELATION BETWEEN NUMBER OF ACCIDENTS AND NUMBER OF CONFLICTS PER SEVERITY ZONE
Logarithmic scale
Severity def. ALT.DEF.1

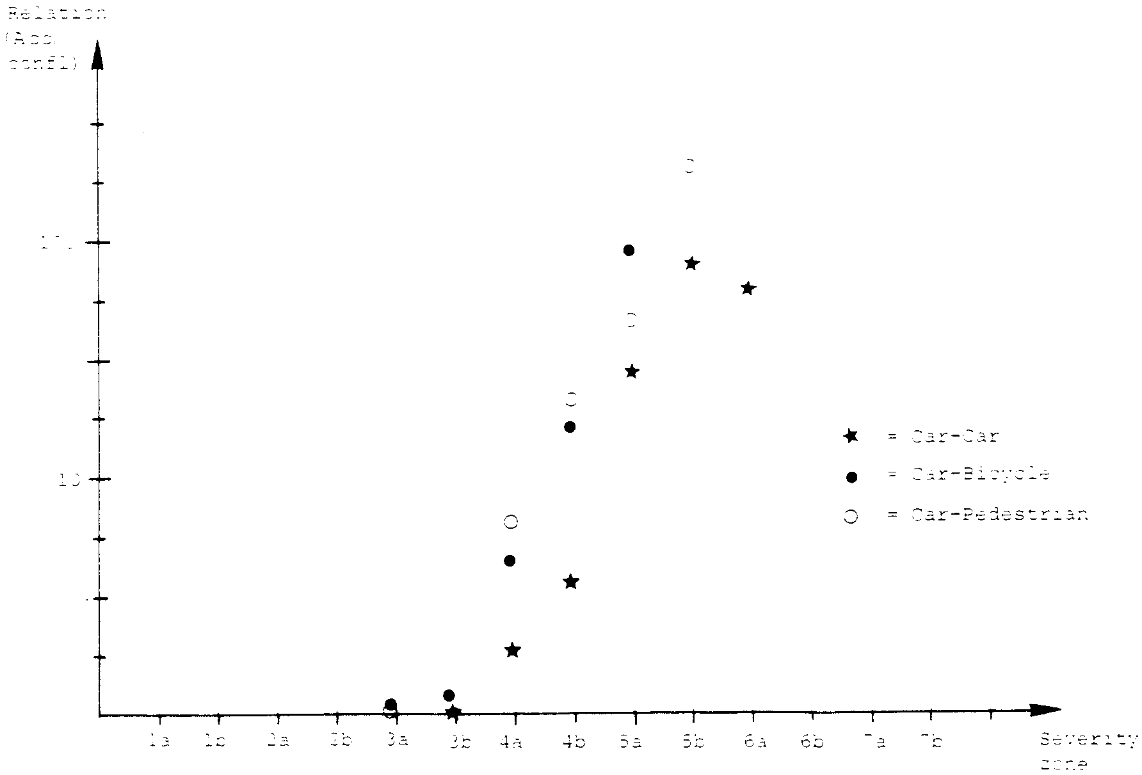


FIGURE 7.19 RELATION BETWEEN NUMBER OF ACCIDENTS AND NUMBER OF CONFLICTS PER SEVERITY ZONE
Logarithmic scale
Severity def. ALT.DEF.2

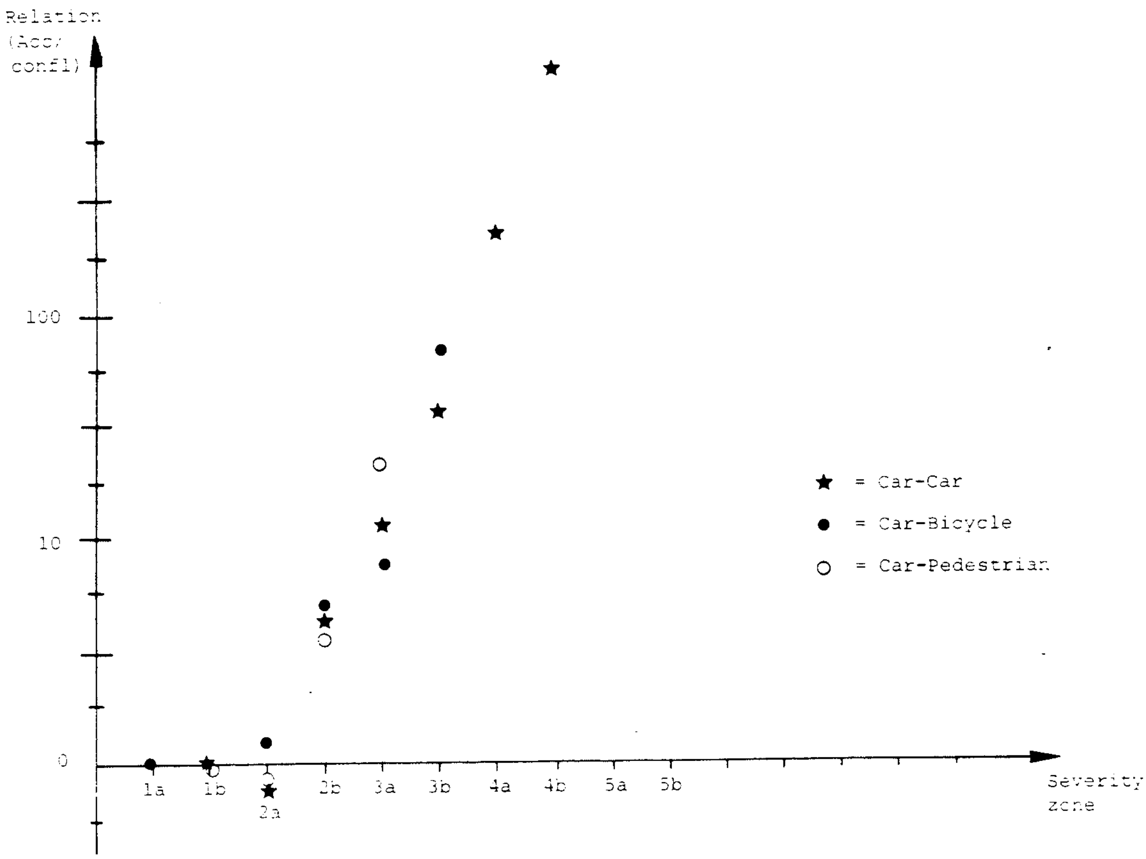


FIGURE 7.20 RELATION BETWEEN NUMBER OF ACCIDENTS AND NUMBER OF CONFLICTS PER SEVERITY ZONE
Logarithmic scale
Severity def.: ALT.DEF.3

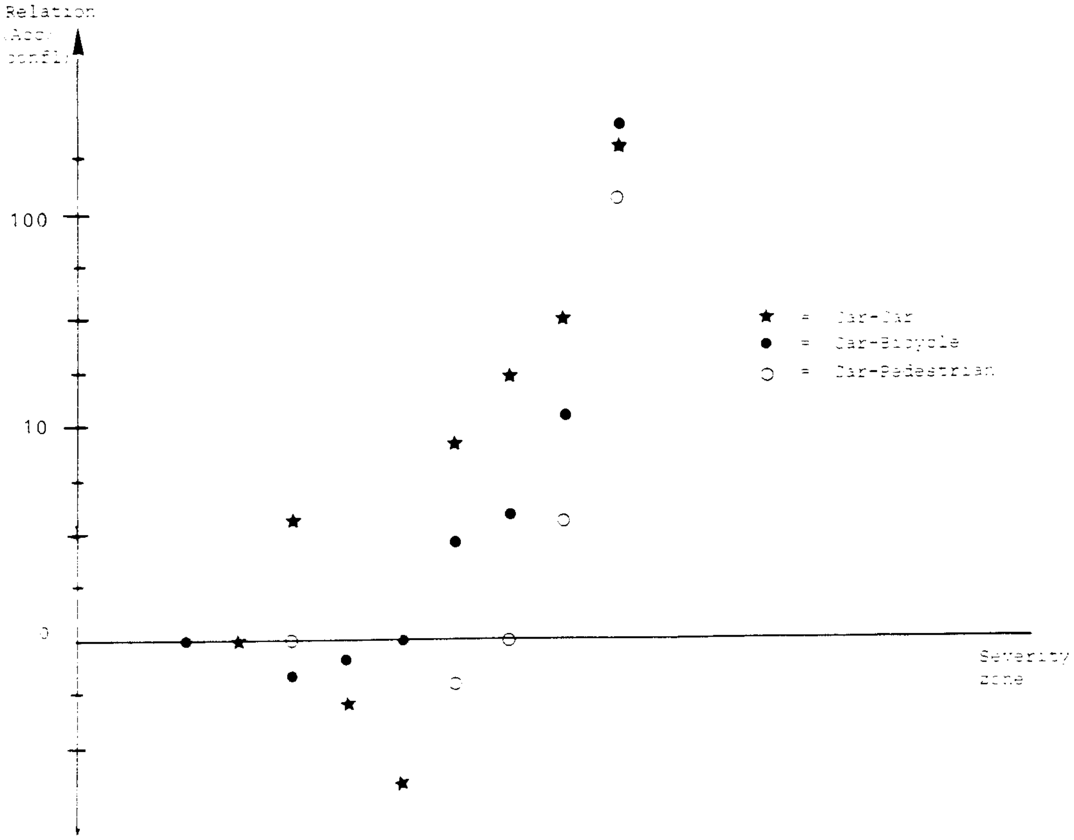


FIGURE 7.21 RELATION BETWEEN NUMBER OF ACCIDENTS AND NUMBER OF CONFLICTS PER SEVERITY ZONE
Logarithmic scale
Severity def.: ALT.DEF.4

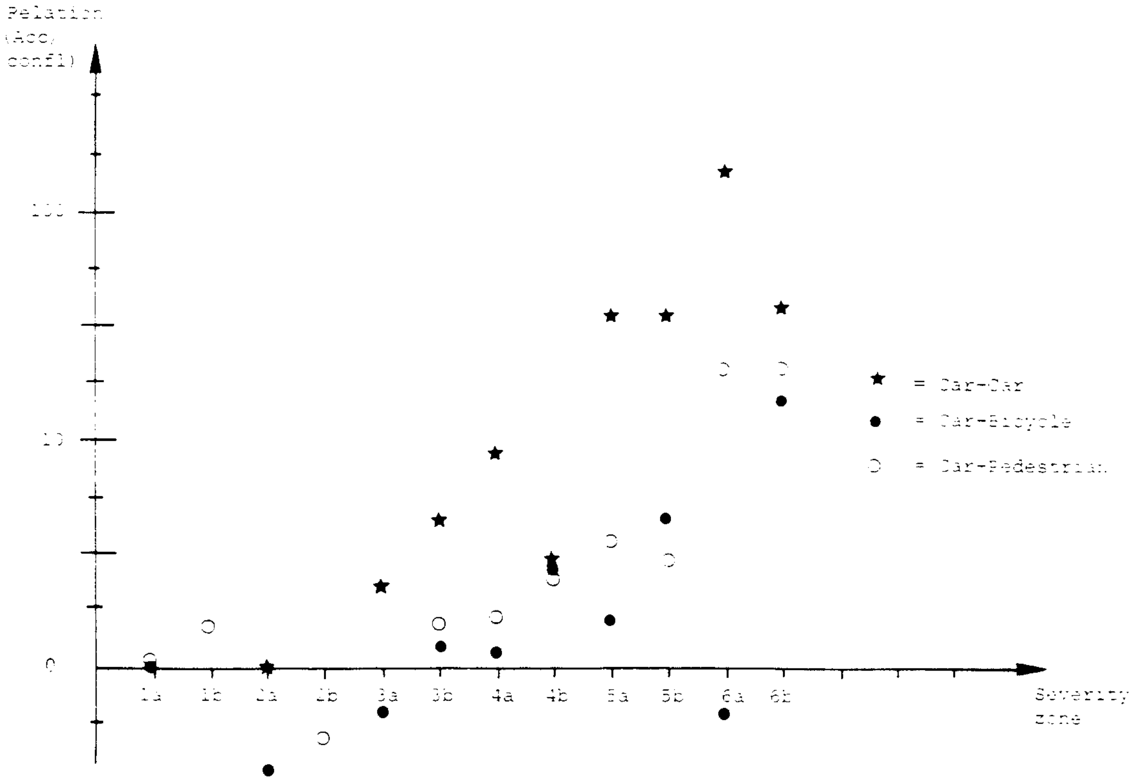


FIGURE 7.22 RELATION BETWEEN NUMBER OF ACCIDENTS AND NUMBER OF CONFLICTS PER SEVERITY ZONE
Logarithmic scale
Severity def.: ALT.DEF.5

TABLE 7.2 PAIR-WISE COMPARISONS OF SEVERITY ZONES

Sev zoning	ALT.DEF 1		ALT.DEF 2		ALT.DEF 3		ALT.DEF 4		ALT.DEF 5	
	0.5sec [1]	0.25sec [2]	0.5sec	0.25sec	0.5sec	0.25sec	0.5sec	0.25sec	0.5sec	0.25sec
Number of pair-wise comparisons	8	21	7	20	7	20	10	24	15	36
Number of statistical significant increases	7	10	7	11	5	10	7	11	8	7
Proportion of ditto (%)	88	48	100	55	71	50	70	46	53	19

1) Severity zones with 0.5 seconds interval (see app 7.3)

2) Severity zones with 0.25 seconds interval (see app 7.2)

2) Severity of accidents

As was shown in part 1), the conflict severity increases with "increased" severity zone. The same should, of course, be true for the accidents as well. Higher conflicting speeds combined with lower TA-values should produce higher collision speeds and, consequently, more severe accidents.

In my sample only injury-accidents are included. The first "severity grade" among accidents can, consequently, not be studied. Severity, therefore, has to be defined as the outcome of the injury accidents as defined by the police (slight injury, severe injury or fatal). The three different severities of injuries are given indexes based on the total costs for each type of accident. Some unpublished data on these costs (for individuals, local councils, hospitals, insurance companies, etc.) for accidents was used. The following cost relations between police-reported injury accidents were obtained:

Slight injury accident: 1
Severe " " 6
Fatal " " 36

Based on these values, a severity index is calculated in each zone and for each definition. The severity index is the mean value for all accidents in the relevant zone. The results are presented in table 7.3 and figure 7.23.

TABLE 7.3 SEVERITY RATING OF ACCIDENTS PER SEVERITY DEFINITION

SEVERITY DEFINITION	ZONE	SEVERITY INDEX*) CAR-CAR	CAR-BICYCLE	CAR-PEDESTRIAN
ALT.DEF 1	1	-	(6.0)	-
	2	(1.0)	2.0	(1.0)
	3	1.0	2.7	11.0
	4	1.2	2.0	2.7
	5	2.7	3.6	8.5
	6	2.2	-	(18.5)
ALT.DEF 2	1	-	-	-
	2	-	-	-
	3	1.0	1.6	2.1
	4	1.0	1.4	3.9
	5	1.2	3.0	5.2
	6	2.6	4.9	3.5
	7	2.1	(6.0)	(18.5)
	8	2.7		
ALT.DEF 3	1	(1.0)	(6.0)	(1.0)
	2	1.0	4.8	12.2
	3	1.3	2.3	4.3
	4	2.1	2.2	6.3
	5	2.7	-	(1.0)
ALT.DEF 4	1	-	(6.0)	-
	2	(1.0)	(6.0)	(9.8)
	3	1.0	6.6	(6.0)
	4	1.0	2.4	6.8
	5	2.1	2.1	5.2
ALT.DEF 5	1	-	1.7	2.5
	2	(1.0)	1.2	3.5
	3	1.0	1.4	2.1
	4	1.0	1.3	5.4
	5	1.7	5.3	6.3
	6	2.6	6.3	8.5
	7	1.0	-	(36.0)
	8	3.0	(6.0)	(21.0)
	9	(1.0)		

Values in brackets; < 5 observations

*) Based on total costs for accidents.
The index is the mean value for the relative cost values for each definition, zone and road-user type.

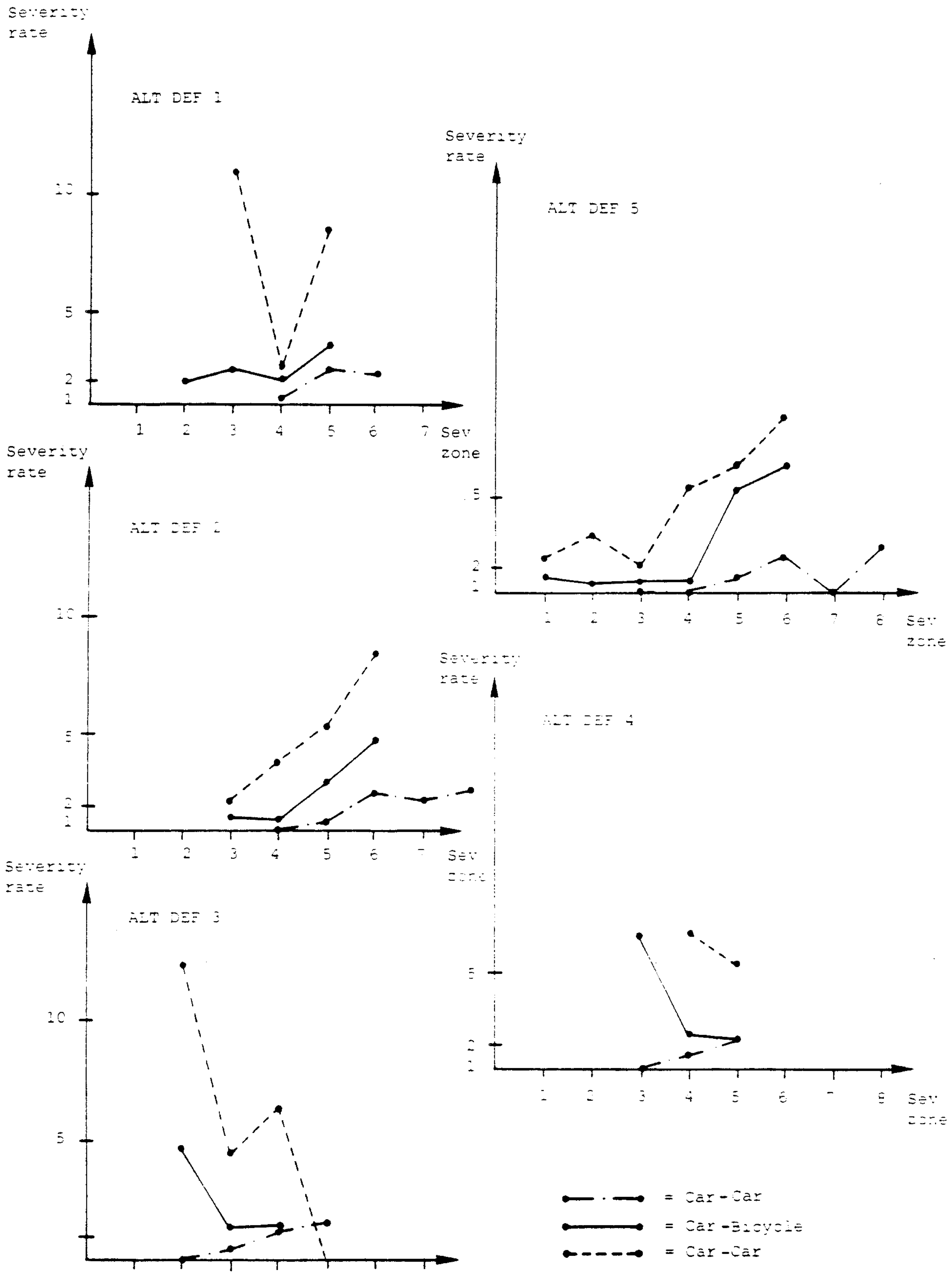


FIGURE 7.23 SEVERITY RATING OF ACCIDENTS PER SEVERITY DEFINITION (≥ 5 observations)

The results from table 7.3 and figure 7.23 indicate very clearly that ALT.DEF.2 produces the most relevant severity scale, with the smallest number of irregularities and a steady increase of the severity for all three types of road-users.

The "ALT.DEF.1 and 3" seem to be much less relevant in this case, while ALT.DEF.5 (speed) seems to be more relevant than ALT.DEF.4 (TA). Thus, speed seems to be more important than TA when explaining the severity of the accident, while the opposite seems to be true when explaining the severity of conflicts (defined as the probability of a conflict leading to an accident, no matter what severity of the (injury) accident).

At the same time the ALT.DEF.2 is combining the two aspects much better than any of the other definitions.

3) The proportion of accidents similar to conflicts for the different severity definitions

The aim of this comparison is to see to what extent conflicts are similar to accidents from one important aspect, namely from the last part of their respective processes, defined by the TA-value and Conflicting Speed. The comparison is made between the five different definitions of severity, again in order to find the most appropriate definition.

The "opposite" comparison, i.e. to see to what extent accidents are similar to conflicts will be dealt with later on, in connection with the question concerning the threshold between serious conflicts and non-serious ones. (See section 7.3.9).

The analysis of the "cover" aspect is carried out in the following way:

a) The distribution of accident and conflict proportions are drawn in figures 7.24 - 7.28 (page 150 - 152) for all road-user types. In appendix 7.4 the same distribution is found, split between road-user types. In order to calculate to which extent accidents are covered by conflicts, the area in figures 7.24 - 7.28 covered by accidents and conflicts could be compared with the area covered by accidents only. Then, however, the graphs would have to be based on absolute numbers per time unit.

As the number of conflicts on average is five to seven and a half thousand times as frequent as accidents (see app. 7.5), an approximate way of getting comparable graphs in figures 7.24 - 7.28 is to replace the ends of the conflict distributions with vertical lines. This is also done in figures 7.24 - 7.28.

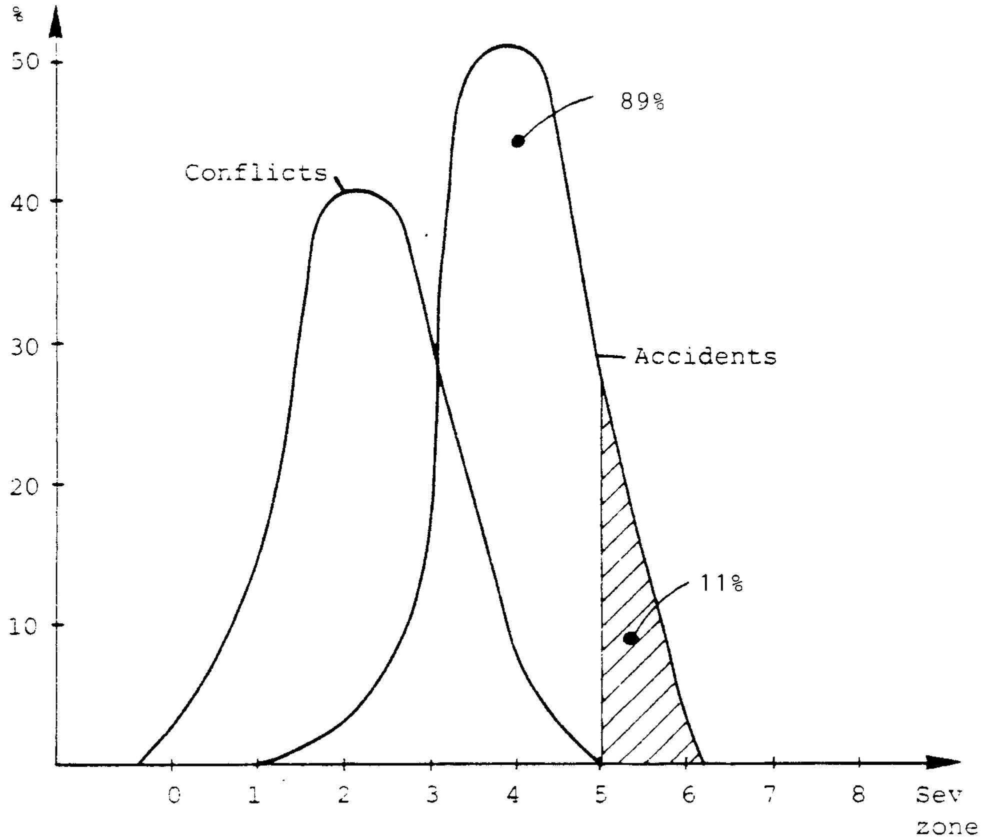


FIGURE 7.24 DISTRIBUTION OF CONFLICTS AND ACCIDENTS WITH REGARD TO SEVERITY ZONES
All accidents and conflicts
Severity definition: ALT.DEF.1

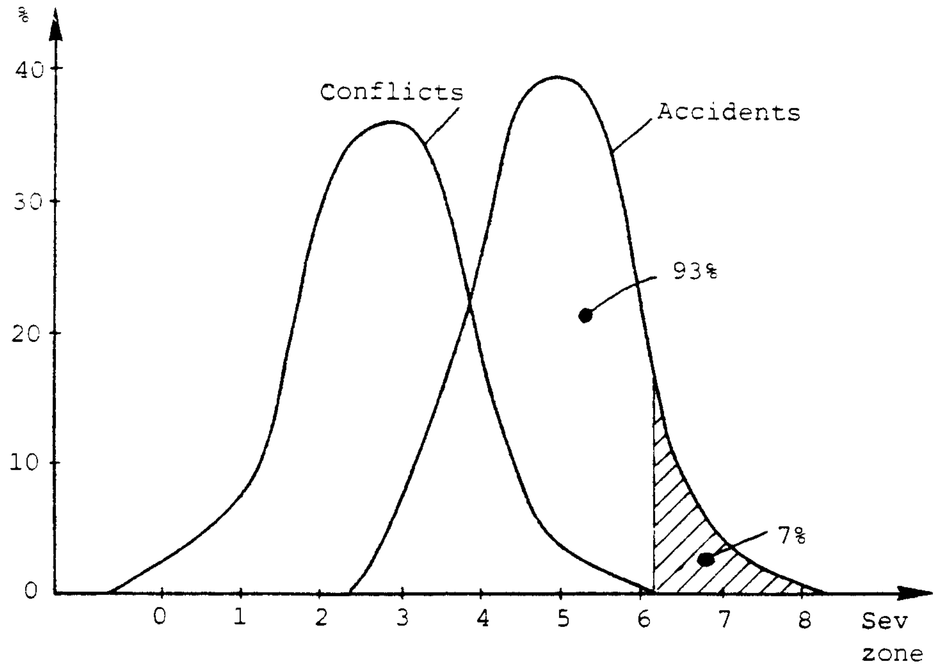


FIGURE 7.25 DISTRIBUTION OF CONFLICTS AND ACCIDENTS WITH REGARD TO SEVERITY ZONES
All accidents and conflicts
Severity definition: ALT.DEF.2

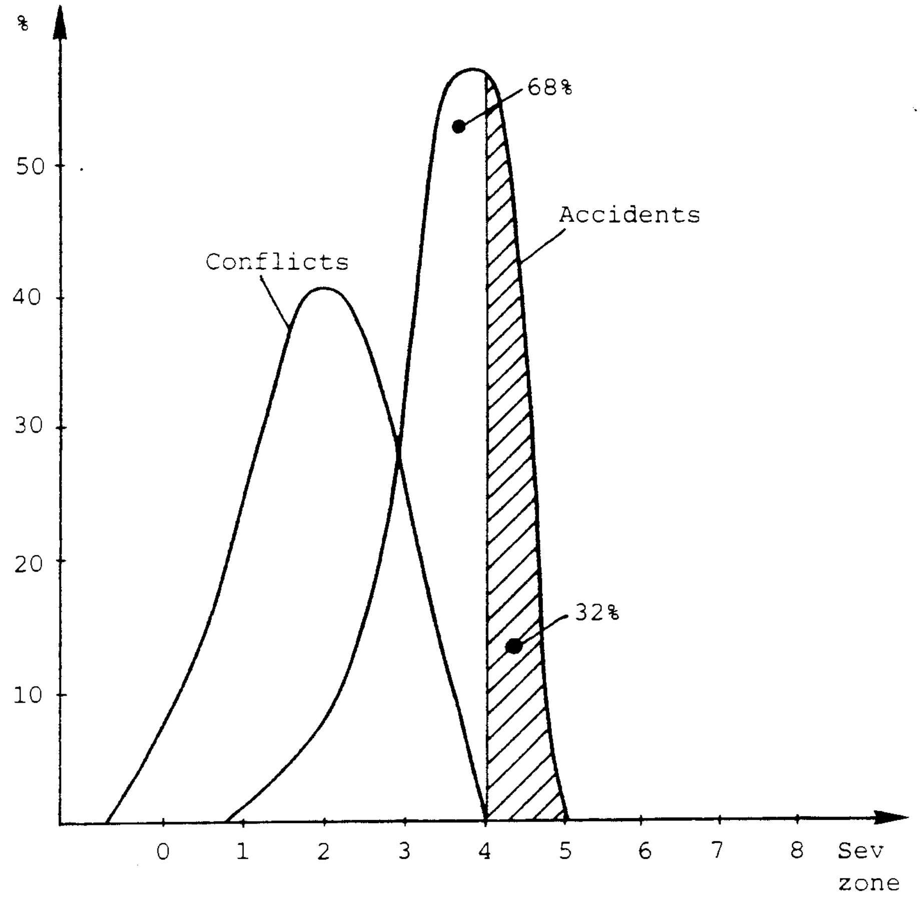


FIGURE 7. 26 DISTRIBUTION OF CONFLICTS AND ACCIDENTS WITH REGARD TO SEVERITY ZONES
All accidents and conflicts
Severity definition: ALT.DEF.3

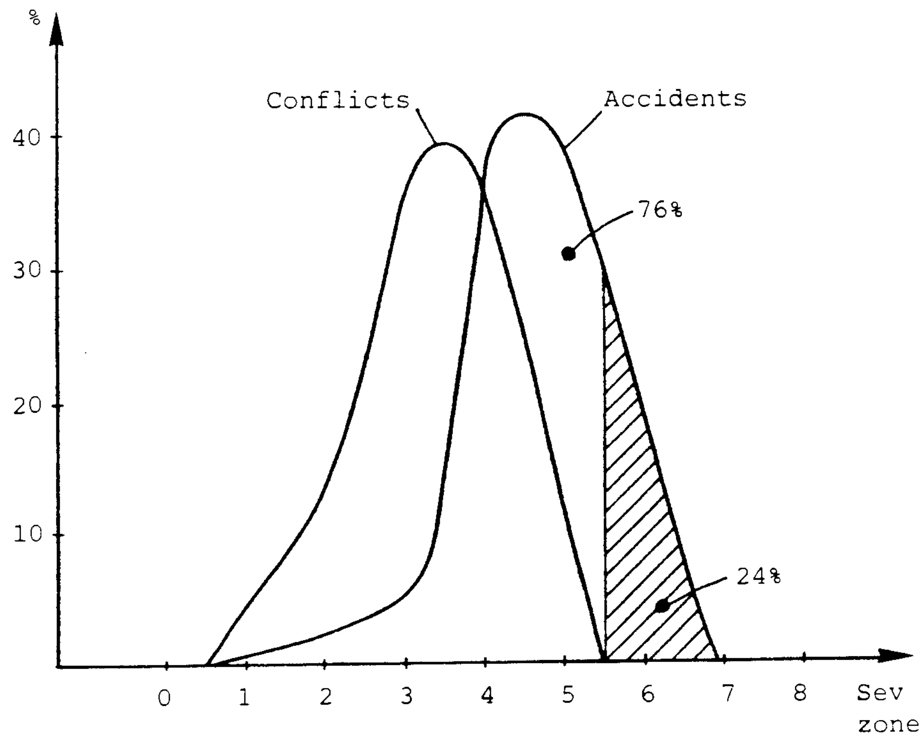


FIGURE 7.27 DISTRIBUTION OF CONFLICTS AND ACCIDENTS WITH REGARD TO SEVERITY ZONES
All accidents and conflicts
Severity definition: ALT.DEF.4 (TA)

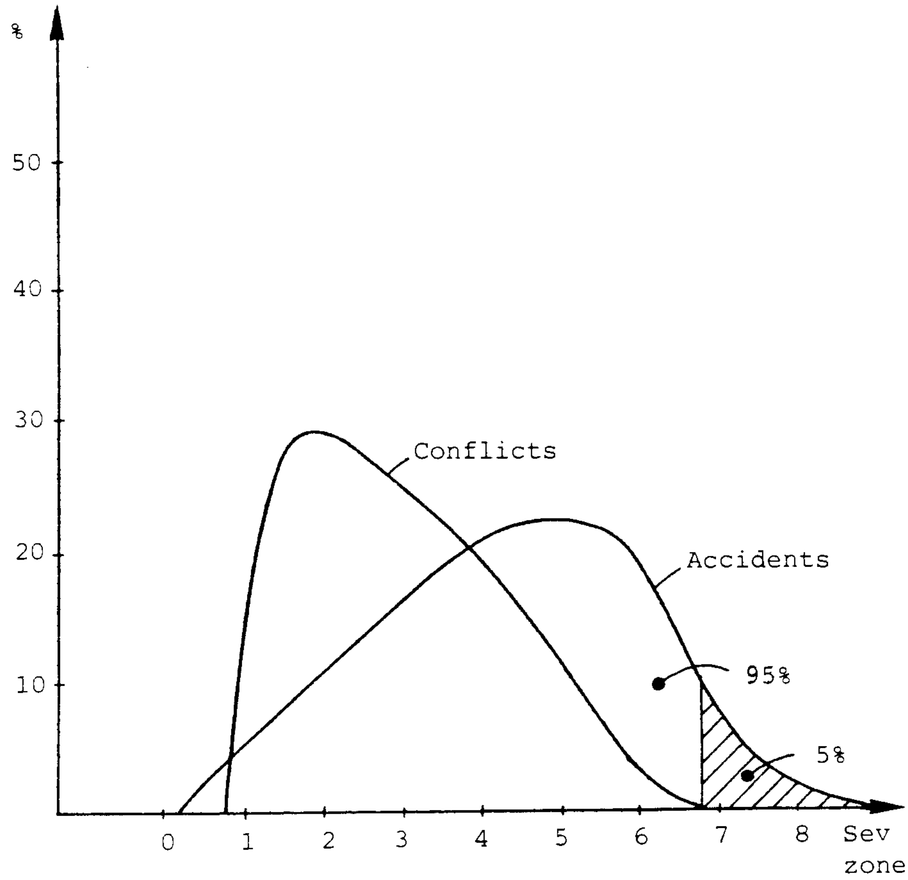


FIGURE 7.28 DISTRIBUTION OF CONFLICTS AND ACCIDENTS WITH REGARD TO SEVERITY ZONES
All accidents and conflicts
Severity definition: ALT:DEF.5 (speed)

The results regarding the "cover" aspect are summarized in table 7.4:

TABLE 7.4 PROPORTION OF ACCIDENTS AND CONFLICTS WITH SIMILAR VALUES FOR TA AND CONFLICTING SPEED
A comparison of the five alternative definitions

Severity definition	Proportions (%) of all accidents where accidents and conflicts have similar values for TA and Conflicting Speed
ALT.DEF.1	89
" 2	93
" 3	68
" 4	76
" 5	95

The main conclusions are:

- ALT.DEF. 5, 2 and 1 have very high proportions of accidents with similar values for accidents and conflicts. All three, therefore, seem to be very appropriate definitions from the "cover" point of view, while ALT.DEF.3 and 4 seem to be less appropriate.

- As can be seen in appendix 7.4, car-car has the highest similar proportions generally, while all the definitions except for ALT.DEF.4 have considerably lower proportions for car-bicycle and car-pedestrian.

None of the definitions come to a complete similarity between accidents and conflicts. The reason for this is that the accidents that are "not covered" by conflicts are very rare events. As accidents, per definition, are conflicts, the two distributions can be combined in order to produce a more reliable estimate of the conflict distribution. It is, then, indicated that in the tail of the distribution where only accidents have occurred in our sample, the frequency of events is extremely low, e.g. one event per 5 000 observation hours (see app. 7.5). Thus, a study would have to be extremely long to make possible a reliable estimate of the tail of the distribution. This has not been possible (for anyone) to carry out yet, but on the other hand this is not of major importance.

The major thing at this stage is, instead, to show that the definition of severity that is going to be used has a reasonably high "cover rate", compared to the other alternative definitions.

4) The relevance of the combined conflict and accident distributions.

By combining the two distributions, one can see whether the accident distribution is actually a part of the conflict distribution. Two criteria have to be fulfilled:

a) There is some kind of "continuity" between the conflict distribution and the accident distribution.

b) The combined distribution between accidents and conflicts should be logical, in the sense that the accidents should cover the most severe part of the combined distribution.

To fulfill the two criteria about continuity and logic, the conflict distribution in our sample should end with its highest values (from a severity point of view) somewhere between the peak and the end of the accident distribution. (see figure 7.29).

If the conflict distribution ends before the peak of the accident distribution, the combined distribution is discontinuous and the events with highest severity are more numerous than events with slightly lower severity.

It seems as if all five definitions are both logical and continous and, therefore, fulfill the criteria.

The following conclusion can be drawn from the comparisons made in this paragraph:

The ALT.DEF.2 seems to be the most relevant definition of severity because it fulfills all the tested criteria more satisfactory than any of the other definitions. This is valid both for the severity scalings as well as for the test of similar proportions between conflicts and accidents.

The other four alternative definitions show a poor performance in at least one of the four comparisons. The ALT DEF.1 seems to be the second best alternative.

It is to be observed that the reliability problem is not considered here. It will, however, be done later on in the report. (See section 7.5). The five definitions are, however, very similar regarding the reliability problem. It is, therefore, without hesitation that ALT.DEF.2 can be selected as the most appropriate definition.

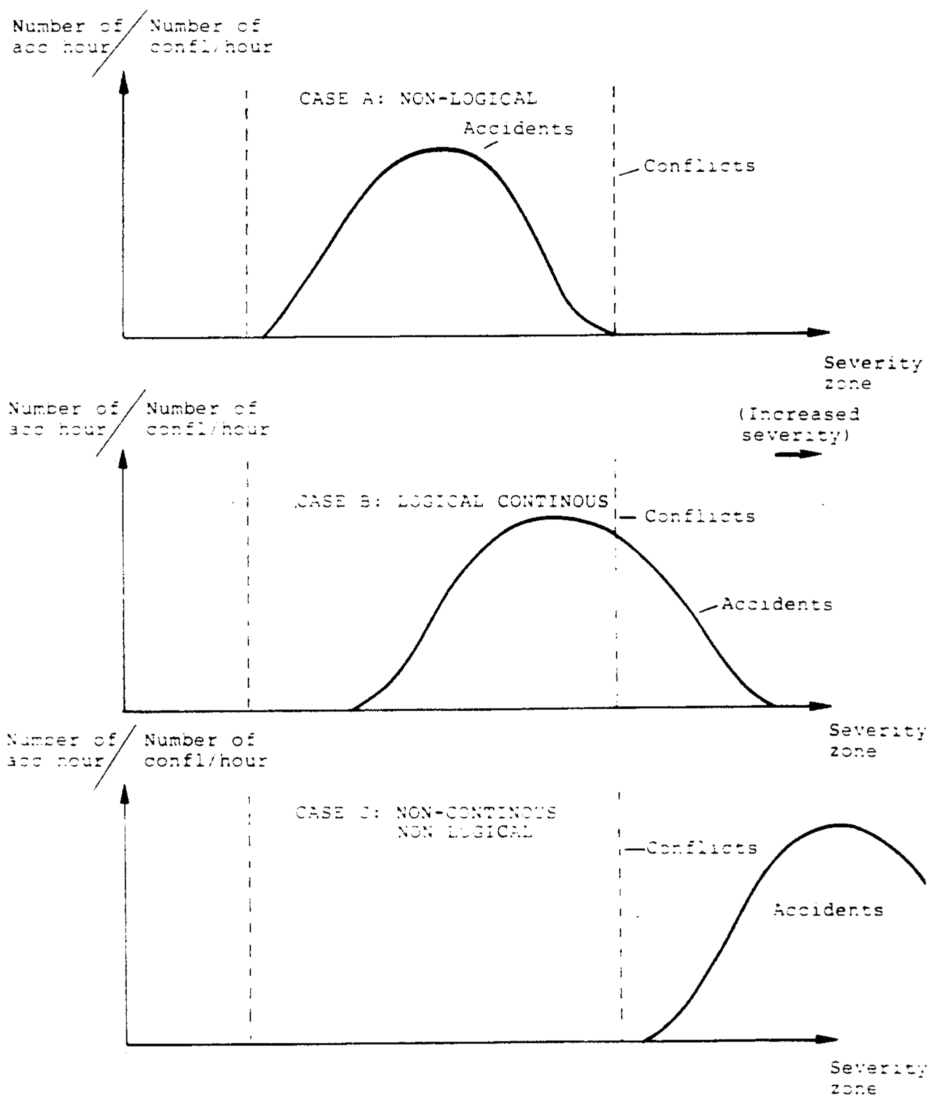


FIGURE 7.29 DIFFERENT RELATIONS BETWEEN CONFLICTS AND ACCIDENT DISTRIBUTIONS.

7.3.6 Test of the uniform severity level for the selected severity definition

The selection of the ALT.DEF.2 as the most appropriate definition of severity was based on a test of a number of criteria. One test remained, however, before the definition was found to fulfill all the criteria in a satisfactory way. The test concerns the hypothesis about uniform severity level within each severity zone, i.e. that the degree of severity is the same as long as the perpendicular distance from a border line between two severity zones is the same.

Due to the limited data volume within each zone the test had to be limited to a comparison of the degree of severity within two halves of each zone. The test is based on a comparison of the accident-to-conflict ratios for the two halves.

The split is first made for accidents using the "TA-Conflicting Speed" graphs, figures 7.6, 7.8 and 7.10, pages 128, 130 and 132. The split is done with a line perpendicular to the border lines between the severity zones, so that half of the accidents are on each side. The same lines are then drawn in the respective graphs for conflicts. (Figures 7.7, 7.9 and 7.11, pages 129, 131 and 133). The number of accidents and conflicts in respective zone are counted and the accident-to-conflict ratios calculated. (See table 7.5, page 157).

On the whole, one can see from the table that the accident-to-conflict ratios are fairly the same if they are compared pair-wise for the two parts. A chi-square test on the number of accidents and conflicts for each pair does not indicate any significant differences except for in 2 cases out of 15 tested (5% level of significance, severity zone 8 for car-car and severity zone 7 for car-pedestrian). These tests of independence, however, give limited information about the actual similarities between the ratio for accidents and conflicts respectively.

Looking at the various ratios we find some clear trends:

- When accidents were split in two equal parts, conflicts for "car-bicycle" and "car-pedestrian" were also split in almost equal parts. For "car-car" there is, however, a considerable difference. The "lower part" has almost twice as many conflicts when the accidents are split in two equal parts. If conflicts instead were split in two equal parts then the number of accidents had been considerably higher in the "upper part".

  Considering the total results one can thus conclude that conflicts and accidents are equally distributed for "car-bicycle" and "car-pedestrian", but not for "car-car". The most possible explanation for these results is that the accident definition used (police-reported injury accidents) for the two first groups is almost equal to all collisions while for "car-car" a lot of damage-only collisions are left out. It is clear that these accidents would have lower Conflicting Speeds, on average, and consequently the accident distributions would be more like the conflict distribution even for "car-car".

The conclusion is that the chosen definition, from this point of view, seems to correspond better with 'all accidents' rather than injury accidents only. This is also in line with the basic theory: The 'TA-Conflicting Speed' based definition of a serious conflict is primarily reflecting the 'risk of a collision'. The risk of a collision leading to an injury accident is then calculated with the help of conversion factors. It is clear, however, that a validation against all accidents would be valuable from a theoretical point of view, so that a better distinction could be made between "risk of collision once in a serious conflict" and "risk of injury once in a collision".

- The pair-wise comparisons of accident-to-conflict ratios show that the ratios are very equal for the two parts in "car-car". For "car-bicycle" and "car-pedestrian" the ratios seem to be displaced approximately one severity zone. (The ratios for the "lower parts" of the data should be increased by one zone).

  The explanation for this displacement is linked to the aforementioned phenomena that accidents with a TA-value that equals zero "should have been given a negative TA-value". (See also section 7.3.3).

  This kind of accidents appear almost only in the "lower parts" of the "car-bicycle" and "car-pedestrian" data This explains, to start with, why there is no displacement in the "car-car" data but only in the other two. If these accidents had been given negative TA-values their define severity would have increased. For quite a few of them the severity zone value most probably had increased, one or perhaps two zones. The change had contributed to an equalization of the ratios for the two parts of data.

The conclusion from this analysis of the split data is, when reservations are made for the limitations in the analysis (too small data volumes that only allowed a split of data in two parts), that the ALT.DEF.2 seems to be highly relevant, even regarding the hypothesis about uniform severity level. This means that the "risk-level" (accident-to-conflict ratios in this case) seems to be the same in different parts of the same severity zone and thus also increasing in a similar way in different parts of the zones.

One way of solving the displacement for "car-bicycle" and "car-pedestrian" ratios would, of course, be to reclassify accidents in the "lower parts" for these two groups of ratios (increasing the severity zone by one). This would change the design of the severity zoning system. The earlier comparisons of the five different alternative definitions of severity (para. 7.3.5) have, however, shown that such a reclassification would not be feasible. Besides, a reclassification due to the "problems" caused by accidents with a TA-value that equals zero would also influence the design of the lower severity zones and, thus, also influence the border between serious and non-serious conflicts. (Dealt with in para.

7.3.9). Such an influence on the lower severity zones would be irrelevant as long as the reclassification is due to accidents with a TA-value that equals zero. As this seems to be the case this gives a second argument not to reclassify accidents in the "lower parts".

TABLE 7.5 ACCIDENT-TO-CONFLICT RATIOS FOR DATA SPLIT IN TWO PARTS

Severity zone	Lower parts of the graphs			Upper parts of the graphs		
	Accid.	Confl.	Accid./confl.	Accid.	Confl.	Accid./confl.
I CAR - CAR						
0	0	2	0	0	6	0
1	0	6	0	0	0	0
2	0	5	0	0	12	0
3	0	30	0	0	16	0
4	0	40	0	0	19	0
5	0	58	0	0	14	0
6	3	50	0.06	0	18	0
7	2	30	0.07	3	19	0.16
8	6	20	0.30	0	22	0
9	10	9	1.11	11	6	1.83
10	15	5	3.00	8	2	4.00
11	7	3	2.33	12	4	3.00
12	10	0	∞	9	0	∞
13	1	0	∞	3	0	∞
14				5	0	∞
15				1	0	∞
16				2	0	∞
Σ	54	258	0.21	54	138	0.39
II CAR - BICYCLE						
0					5	
1	0	1	0		1	
2	0	0	0		9	
3	0	7	0		11	
4	0	9	0		14	
5	5	17	0.29	2	8	0.25
6	7	17	0.41	2	9	0.22
7	10	6	1.67	4	9	0.44
8	18	2	9.00	9	2	4.50
9	10	0	∞	17	1	17.00
10	14	0	∞	12	0	∞
11			-	10	0	∞
12			-	3	0	∞
13			-	2	0	
14			-			
Σ	64	59	0.92	61	69	1.13
III CAR - PEDESTRIAN						
0	0	2	0		3	0
1	0	8	0		6	0
2	0	6	0		5	0
3	0	12	0		21	0
4	0	21	0		27	0
5	1	27	0.04	2	19	0.11
6	0	19	0	1	16	0.06
7	11	17	0.65	1	13	0.08
8	13	6	2.17	2	4	0.50
9	5	0	∞	7	4	1.75
10	7	0	∞	7	1	7.00
11	3	0	∞	9	0	∞
12			-	8	0	∞
13			-	1	0	∞
14			-	1	0	
Σ	40	118	0.34	39	119	0.33

7.3.7 Comparisons of conflicts and accidents with regard to behavioural aspects

In the comparisons of the five alternative definitions of severity in paragraph 7.3.5 general characteristics of conflicts and accidents were used.

In this paragraph whole samples of conflicts and accidents (without any severity classification) will be compared with regard to two behavioural aspects.

These are:

1) Type of evasive manoeuvre

2) Relevant road-user, i.e. the type of road-user in car-bicycle and car-pedestrian events that is used for the calculation of "Time to Accident" and "Conflicting Speed".

The comparisons are based on the same sample of conflicts and accidents as earlier in section 7.3.

We will look at the two aspects separately:

1) Type of evasive manoeuvre

In table 7.6 the results on accidents are shown. The following conclusions can be drawn:

- One third of the accident data is missing because it has not been possible to define whether there has been any evasive action taken or not. Is has not been possible to analyze missing data with regard to any possible bias. The missing data is, however, very equally spread among the different road-user types involved.

- To take no evasive action, before the collision, is very uncommon at car-car accidents, but stands for appr. one fourth of all car-bicycle and car-pedestrian accidents (excl.missing data).

- "Braking" is the far most common type of evasive manoeuvre followed by "braking and swerving" combined, "swerving only" and, last, "accelerating". Acceleration is used in only appr. 2% of the accidents.

TABLE 7.6 PRESENCE AND TYPE OF EVASIVE MANOEUVRE BEFORE COLLISION
Injury accidents in Malmö

Type of road-user involved	No evasive action	Braking	Braking+ swerving	Swerving	Ac-cel.	Missing data (not possible to define	Total
Car-Car	8	63	13	10	2	49	145
Car-Motorcycle	0	14	3	1		6	24
ΣMotor veh only	8	77	16	11	2	54	168
% incl missing data	5	46	9	7	1	32	100
% excl missing data	7	67	14	10	2	-	100
Motor vehicle-Bicycle	33	44	13	10	2	52	154
Motor vehicle-Moped	5	19	9	2	1	21	57
ΣMotor vehicle-Twowheelers	38	63	22	12	3	73	211
% incl missing data	18	30	10	6	1	35	100
% excl missing data	28	46	16	9	2	-	101
Motor vehicle-Pedestrian	19	33	20	4	1	32	109
% incl missing data	17	30	18	4	1	29	99
% excl missing data	25	43	26	5	1	-	100
TOTAL	65	173	58	27	6	159	488
% incl missing data	13	35	12	6	1	33	100
% excl missing data	20	52	18	8	2	-	100

Primarily, these results should be compared with corresponding data for conflicts. Table 7.7 presents this comparison. The number of conflicts and number of accidents for one type of evasive manoeuvre have been compared with the total number of conflicts and accidents. The following significant (5% level) differences were found on the total data-set:

"Swerving only" as well as "braking + swerving" are more common among accidents than among conflicts.

In the case of "braking + swerving", the difference found is only due to a difference in the car-pedestrian ratio. In the "swerving only" case, however, the ratios seem to be very similar for all three types of road-users.

The two findings above indicate that swerving seems to be used to a larger extent in accidents than in conflicts. This may be due to the fact that the road-users in accident situations more often "try everything". Another reason that might be possible is a bias in the accident analysis, namely that road-users in interviews with the police may try to indicate that they tried to avoid the accident, at least by swerving. This kind of bias can not be checked.

The main conclusion, however, is that the agreement is very satisfactory. In the vast majority of relations the similarity is quite convincing; there had to be a change of the classification in only 11% of the cases in order to achieve a complete agreement. On the whole, one must therefore conclude that conflicts from this point of view are very relevant substitutes for accidents.

One remaining question under this heading is whether accidents not covered by conflicts of similar severity, have different characteristics regarding type of avoiding manoeuvre from other accidents. For severity classification the ALT.DEF.2 will be used (see para. 7.3.5). Table 7.8 gives the results of the comparison.

The results show that the differences are very small. For each road-user type and totally, chi-square-tests are made on the "yes/no"-relation for each manoeuvre type compared with the total relation. No significant differences were found (5% significance level).

The results, therefore, indicate that those accidents that were not covered by conflicts in our samples do not have different characteristics regarding avoiding manoeuvres from other accidents. Thus conflicts may well work as a substitute for all accidents from this point of view.

TABLE 7.7 TYPE OF EVASIVE MANOEUVRE IN CONFLICTS AND ACCIDENTS

		Braking	Braking+ swerving	Swerving	Accele- rating	To- tal
Car-Car	No. of conflicts	307	63	20	11	401
	No. of accidents	77	16	11	2	106
	Proport. of confl.(%)	77	16	5	3	101
	Proport. of accid.(%)	73	15	10	2	100
Car-Bic	No. of conflicts	142	41	14	0	197
	No. of accidents	44	13	10	2	69
	Proport. of confl.(%)	72	21	7	0	100
	Proport. of accid.(%)	64	19	14	3	101
Car-Ped	No. of conflicts	220	15	7	6	248
	No. of accidents	37	17	3	1	58
	Proport. of confl.(%)	89	6	3	2	100
	Proport. of accid.(%)	64	29	5	2	100
Total	No. of conflicts	669	119	41	17	846
	No. of accidents	158	46	24	5	233
	Proport. of confl.(%)	79.1	14.1	4.8	2.0	100
	Proport. of accid.(%)	67.8	19.7	10.3	2.1	100

TABLE 7.8 TYPE OF EVASIVE MANOEUVRE IN ACCIDENTS COVERED AND NOT COVERED BY CONFLICTS WITH REGARD TO THE "ALT. DEF.2" SEVERITY DEFINITION.

Type of road-user	Covered by conflicts	Braking	Braking + swerving	Swerving	Accel.	Total
Car-car	Yes	42	8	5	2	57
	No	27	8	6	0	41
Car-Bicycle	Yes	22	10	10	3	45
	No	35	11	2	1	49
Car-Pedestrian	Yes	17	5	2	1	25
	No	22	15	2	0	39
Total	Yes	81	23	17	6	127
	No	84	34	10	1	129
Total	Yes %	64	18	13	5	100
	No %	65	26	8	1	100

2) Relevant road-user

At each conflict in our sample "Time to Accident" and "Conflicting Speed" have been estimated for the road-user that takes evasive action, or if both road-users do this, for the one that produces the least severe conflict (with the new ALT.DEF.2 this has become equal to the plot that comes closest to the border line between serious and non-serious conflicts in a "TA-conflicting speed" - graph. See also section 7.1.2). The road-user that counts in the estimation is defined as the <u>relevant road-user</u>. The same procedure is followed for the accident sample. For accidents with a TA-value of zero, i.e. there was no avoiding action prior to the collision, the relevant road-user is defined as the one that hits the other at the collision. For car-bicycle and car-pedestrian conflicts the ratios of car drivers to bicyclists and car drivers to pedestrians can be calculated and compared with the corresponding ratios for accidents. Table 7.9 shows the result of such a comparison.

TABLE 7.9 RELEVANT ROAD-USER IN CAR-BICYCLE AND CAR-PEDESTRIAN CONFLICTS AND ACCIDENTS

Road-users involved	Relevant[1)] road-user	Conflicts	Accidents	Total
Car-Bicycle	Cyclist	53 (41%)	35 (28%)	80 (36%)
	Car-driver	75 (59%)	90 (72%)	145 (64%)
		128 (100%)	97 (100%)	225 (100%)
Car-Pedestrian	Pedestrian	31 (13%)	7 (9%)	38 (12%)
	Car-driver	206 (87%)	72 (91%)	278 (88%)
		237 (100%)	79 (100%)	316 (100%)

1) Data are collected from figures 7.8 - 7.11, page 130-133.

The number of relevant cyclists compared to the total number of involved road-users in car-bicycle situations, is significantly higher (5% level) in conflicts than in accidents. This is not the case with pedestrians.

We can see from table 7.9 that pedestrians are much less often defined as the relevant road-user than cyclists are. This difference is significant both for conflicts (significance level 0.5%) and for accidents (sign.level 5%).

To conclude and comment:

In both conflicts and accidents, the number of relevant pedestrians in car-pedestrian situations was significantly lower than the relevant number of cyclists in car-cyclist situations.

At the same time the proportion of both relevant cyclists and relevant pedestrians was lower for accidents. This is probably due to the fact that conflicts involving cyclists and pedestrians as relevant road-users are less severe than other conflicts. The number of conflicts per accident is, therefore, higher where the pedestrian or the cyclist are the relevant road-users (see para. 7.3.5). It is, therefore, to be expected that the proportion of relevant cyclists and pedestrians is higher for conflicts.

Even though there is a difference between conflicts and accidents, they discriminated in a similar way between relevant and non-relevant cyclists and pedestrians.

This analysis, therefore, adds some more support to the hypothesis that conflicts and accidents have similar patterns in the last phase of their respective processes.

7.3.8 Time to Accident equals zero

In some of the accidents, there was no avoiding action taken prior to the collisions. "Time to Accident" is then zero.

The fact that there is no avoiding action has been of general concern for researchers in the area.

As I have explained earlier (chapters 3 and 6), TA-values of zero are, in principle, no problem with our technique: those situations represent the end of a scale where events are of graduating closeness in time to an accident. We do not discriminate between conflicts where the time-margin is big (but small enough to be defined as a serious conflict), small or non-existant. I also propose a change of our definition (see also chapter 7), in order to overcome the problem of presupposing an evasive manoeuvre.

Thus, conflicts with a TA-value of zero should not be a problem for us any more. Still, the general interest in this kind of event makes a special analysis warranted.

In car-car accidents, TA equals zero in 7 cases out of 108, corresponding to 6.5%. (From figure 7.6, page 128).

In car-bicycle accidents, the corresponding figures are 37 out of 125 or 30% (from figure 7.8, page 130) and in car-pedestrian accidents 19 out of 79, or 24%. (From figure 7.10, page 132).

In figure 7.30, the proportion of accidents with TA = 0 in each speed interval is shown.

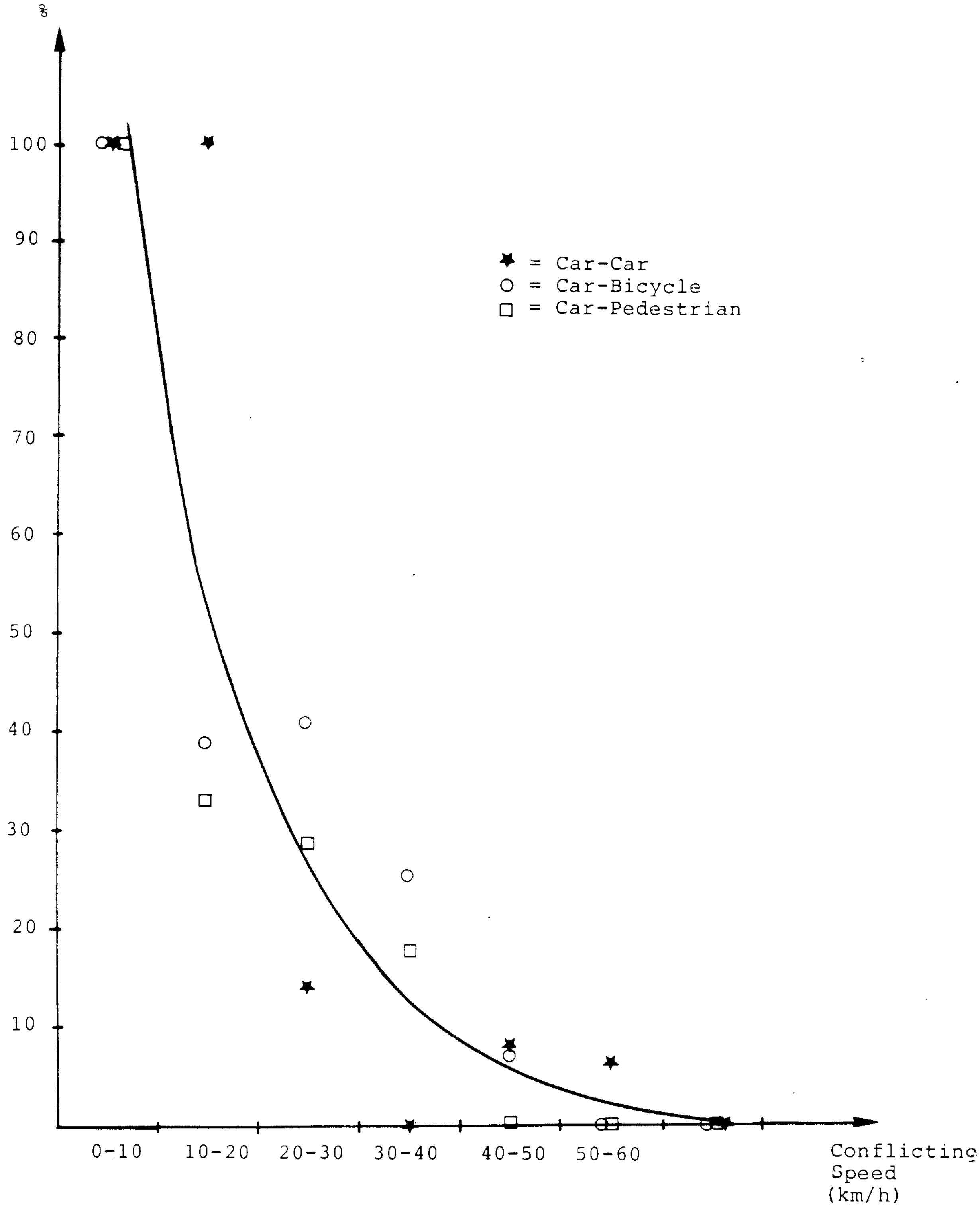


FIGURE 7.30 PROPORTION OF ACCIDENTS WHERE TIME TO ACCIDENT EQUALS ZERO FOR DIFFERENT SPEED INTERVALS.

Figure 7.30 indicates very clearly that the proportion is very dependent on speed: at very low speeds (below 10 km/h) all accidents in the sample have a TA-value of zero. (I have to remind the reader that the sample is "police-reported injury accidents").

At speeds above 50 km/h, there are almost no accidents any more with a TA-value that equals zero.

If one looks at the "TA-conflicting speed" plot for car-car accidents (figure 7.6), one can see that the "Conflicting Speed" is less than 30 km/h in about 4% of the accidents. In car-bicycle accidents, the corresponding figure is 40% and in car-pedestrian accidents 33%.

This difference explains why there are relatively few car-car accidents with a TA-value of zero. It also illustrates the much higher vulnerability of "unprotected" road-users, particularly cyclists and pedestrians.

The speed dependence shown in figure 7.30 is also encouraging in view of the earlier analyses in this section, which emphasizes both a speed and TA-dependant definition of severity: figure 7.30 shows that road-users tend to accept smaller time margins, the lower the speeds are. At very low speeds, the time margin in serious conflicts is very often so small, that there is not time enough to start an evasive action.

7.3.9 The border between serious and non-serious conflicts

Earlier in section 7.3, we were dealing mainly with the severity of conflicts, the border between conflicts and accidents, accidents not covered by conflicts, etc. I also concluded that, from most point of views, the ALT.DEF.2 seemed to be the most appropriate definition of severity.

To complete the picture I should, however, also define a serious conflict, i.e. I should define the border between serious conflicts and non-serious ones.

The most relevant starting point is, then to look at the "TA-conflicting speed" graphs (figures 7.6 - 7.11) and the distributions (appendix 7.4) for ALT.DEF.2, and to see what area is covered by accidents. By including only conflicts that have corresponding accidents with regard to "TA" and "Conflicting Speed", the most relevant definition of a serious conflict will be guaranteed. On the other hand, the tighter the definition we choose, the smaller the number of conflicts there will be to include. The expected number of serious conflicts will be estimated with less accuracy, the smaller the number of conflicts is. Thus, there are contradicting interests.

If we look at the distributions in appendix 7.4 we find that accidents cover an area starting at severity zone 2 for car-bicycle, somewhere between zone 2 and 3 for car-pedestrian, and close to zone 3 for car-car. Even though the starting point varies with the type of road-user involved, it is probably wise, from an observing view-point, to use the same threshold between serious and non-serious conflicts for all road-user types.

The earlier analyses have not indicated any major differences between conflicts of different severity. Due to this and the general interest in collecting as many conflicts as possible, it is natural to select the threshold between severity zone 1 and 2 as the threshold between serious and non-serious conflicts.

This provides the final link in being able to propose a new definition of a serious conflict. The operational definition would then be:

> A SERIOUS CONFLICT IS AN EVENT WHERE THE "TIME TO ACCIDENT" AND "CONFLICTING SPEED" FOR THE RELEVANT ROAD-USER PRODUCES A COMBINED VALUE THAT LIES IN SEVERITY ZONE 2 OR HIGHER FOR THE ALT.DEF.2 OF SEVERITY

7.3.10 Conversion between conflicts and accidents

The proportional distributions of conflicts and accidents per severity zone (app. 7.6), can be used as a starting point for the calculation of ratios between accidents and the sum of accidents and conflicts in absolute numbers.

Then, we also must know the total numbers of conflicts and accidents and the total number of observation hours. The following data is used, obtained within the validation project in Malmö, 1982:

Number of	car-car	accidents:	83
-"-	car-bicycle	"	63
-"-	car-pedestrian	"	56

Number of	car-car	conflicts:	490
-"-	car-bicycle	"	223
-"-	car-pedestrian	"	216

Number of observation hours for conflicts:

109	x	12	+	6	x	6	= 1 344 hours
Number of sites		Obs. hours per site		Nu. of si-tes		Obs. hours per site	

Number of observation hours for accidents:

9	x	240	x	7	x	115	= 1.738.800 hours
hours per day		week-days except saturdays and sundays per year		years		locations	

Tables 7.10-7.12 combine these data with the proportional distributions.

TABLE 7.10 ABSOLUTE NUMBERS OF CONFLICTS AND ACCIDENTS PER SEVERITY ZONE. Car-car

Zone *)	Number of obs. per 1738800 hours Acc.	Confl.	Confl./Acc.	Acc./Co+Acc. Abs.val.	Acc./Co+Acc. Rel. values
1a	0	8241	-	0	
1b	0	28527	-	0	
2a	0	73537	-	0	
2b	0	94457	-	0	
3a	0	115377	-	0	
3b	2.32	109037	47000	2.13×10^{-5}	1 **)
4a	3.07	78608	25600	3.91×10^{-5}	1.8
4b	5.40	67197	12400	8.04×10^{-5}	3.8
5a	14.61	24090	1600	60.61×10^{-5}	28.4
5b	19.17	11411	600	167.71×10^{-5}	78.7
6a	15.36	11411	750	134.43×10^{-5}	63.1
6b	13.86	0	0	1.0	
7a	3.07	0	0	1.0	
7b	3.82	0	0	1.0	
8a	0.75	0	0	1.0	
8b	1.58	0	0	1.0	
All zones	83.01	621893	7491	13.35×10^{-5}	

*) See classification, figure 7.17.
**) Given value 1.

TABLE 7.11 ABSOLUTE NUMBERS OF CONFLICTS AND ACCIDENTS PER SEVERITY ZONE. Car-bicycle

Zone *)	Number of obs. per 1738800 hours Acc.	Confl.	Confl./Acc.	Acc./Co+Acc. Abs.val.	Acc./Co+Acc. Rel. values
1a	0	2308	-	0	
1b	0	22503	-	0	
2a	0	40679	-	0	
2b	0	51931	-	0	
3a	3.53	56259	15900	6.27×10^{-5}	1 **)
3b	4.54	58567	12900	7.75×10^{-5}	1.2
4a	8.57	31447	3670	27.24×10^{-5}	4.3
4b	12.10	11252	930	107.42×10^{-5}	17.1
5a	14.11	2308	160	607.64×10^{-5}	96.9
5b	12.60	0	0	1.0	
6a	5.04	0	0	1.0	
6b	1.51	0	0	1.0	
7a	1.01	0	0	1.0	
7b	0	0	0	1.0	
8a	0	0	0	1.0	
8b	0	0	0	1.0	
All zones	63.01	277254	4400	22.72×10^{-5}	

*) See classification, figure 7.17
**) Given value 1.

TABLE 7.12 ABSOLUTE NUMBERS OF CONFLICTS AND ACCIDENTS PER SEVERITY ZONE. Car-pedestrian

Zone*)	Number of obs. per 1738800 hours Acc.	Confl.	Confl. / Acc.	Acc. / Co+Acc. Abs.val.	Acc. / Co+Acc. Rel. values
1a	0	16488	-	0	
1b	0	12855	-	0	
2a	0	31857	-	0	
2b	0	63715	-	0	
3a	2.13	54213	25500	3.93×10^{-5}	2.2
3b	0.73	41359	56700	1.77×10^{-5}	1*)
4a	9.24	35490	3800	26.03×10^{-5}	14.7
4b	9.91	11737	1200	84.36×10^{-5}	47.7
5a	8.51	4751	560	178.80×10^{-5}	101.0
5b	9.91	1118	110	878.62×10^{-5}	496.4
6a	8.51	0	0	1.0	
6b	5.66	0	0	1.0	
7a	0.73	0	0	1.0	
7b	0.73	0	0	1.0	
8a	0	0	0	1.0	
8b	0	0	0	1.0	
All zones	56.06	273583	4880	20.49×10^{-5}	

*) See classication, figure 7.17
**)Given value 1

The "accidents to conflicts + accidents" ratio, reflects the probability that a conflict of a certain severity leads to a (police-reported) injury accident.

If the severity zones are compared one by one we can see that the ratio differs considerably between the three road-user types. Table 7.13 shows the relations.

The results from table 7.13 indicate the following:

1) The "accidents to conflicts + accidents" ratio increases more with increasing severity zone for car-bicycle and car-pedestrian situations, than for car-car.

2) For most severity zones, the ratio is much higher for car-bicyle and car-pedestrian situations, than for car-car. Thus, car-bicycle and car-pedestrian conflicts do have a higher "accident potential" than car-car conflicts. This result is in line with the original validation results (see chapter 5).

3) The "accidents to conflicts + accidents" ratios vary quite considerably with severity zone.

TABLE 7.13 RELATION BETWEEN "ACCIDENTS TO CONFLICTS + ACCIDENTS" RATIOS FOR DIFFERENT ROAD-USER TYPES.

Severity zone	Car-Car	Car-Bicycle	Car-Pedestrian
2b	-	-	-
3a	-	1 *)	0.6
3b	1 *)	3.6	0.8
4a	1 *)	7.0	6.7
4b	1 *)	13.4	10.5
5a	1 *)	10.0	3.0
5b	1 *)	(596)	5.2
6a	1 *)	(744)	(744)
6b	1 *)		

*) Given the value 1 for comparisons within each zone.

If the average distribution of conflicts over severity zones is the same for every sub-sample of locations manoeuvre types, etc. where conflicts studies may be carried out, then the average results (accident to accident + conflict ratios) can be used. If, however, the distribution varies with any of the factors mentioned above, then a use of different ratios might be useful and contribute to more reliable estimates of "average number of expected accidents".

At the same time, a split of data produces reliability problems because big ratios are linked to small numbers of conflicts.

I have not checked any data with regard to the distribution of conflicts on severity zones for different intersections, manoeuvre types etc. I can not, therefore, indicate whether a split seems to be beneficial due to differences.

Further research will have to be carried out to find these distributions, and to see whether a split of data could produce more reliable accident predictions.

7.4 Calibration of different Traffic Conflict Techniques

7.4.1 Background

The conflict technique was first systematically applied by Perkins & Harris (1968). Since then, a number of countries have developed conflict techniques. The terms and procedures used in different countries are in most cases quite different. Results obtained in different countries were, therefore, difficult to compare, as long as the similarities and differences between the conflict techniques were not known.

This was the main reason why the International Committee on Traffic Conflict Techniques (ICTCT) was formed in 1979. One of its main tasks is to decide objectives, and to plan, design and conduct international studies on the calibration and validation of conflict techniques.

ICTCT decided to carry out a large calibration study in Malmö, Sweden, May-June 1983. The main idea was to carry out simultaneous recording of conflicts with the various techniques, and at the same time collect objective data. This procedure could enable a detailed comparison of the techniques and also make it possible to find out what objective elements that were important for the definition of severity.

Our Swedish technique was participating, and I therefore found it relevant to describe the results here, thus making it possible to put the results in perspective of my own findings (section 7.3) with regard to severity classification of conflicts.

7.4.2 Participating techniques and their definitions

All techniques that were operational at that time were represented in the study. The nine techniques represented were:

- Austria: Kuratorium für Verkehrssicherheit (KfV), Vienna
- Canada: Transport Canada, Ottawa. (Used specially trained Swedish observers)
- Finland: Technical Research Center (VTT), Espoo
- France: Organisme National de Securité Routière (ONSER), Arcueil
- Germany: Technical University, (TU), Braunschweig
- Great Britain: Transport and Road Research Laboratory (TRRL), Crowthorne
- Netherlands: Institute for Perception (IZF-TNO), Soesterberg
- Sweden: Lund Institute of Technology, University of Lund, Lund
- USA: Midwest Research Institute (MRI), Kansas City.

The conflict techniques used by the different teams are described in the report of the preparatory meeting of the study (Asmussen, 1984). Table 7.14 shows the type of definition and severity scaling that was used by each of the teams.

Sweden was testing four different scales and France two. Sweden 1 and 2 belong to the original technique, while Sweden 3 was a purely subjective scale, and Sweden 4 was based on a threshold function of speed. (What is called ALT. DEF. 2 in section 7.3). The two last definitions were tested as part of the on-going redevelopment of the Swedish technique.

Time to Collision (TTC) is in the case of Sweden 1 and Finland, the original threshold for Time to Accident (TA) of 1,5 seconds. The Netherland's technique calculates TTC curves on the basis of quantitative measurements of the positions of road-users in successive frames of video recordings they carry out themselves. From these curves the minimum TTC value is derived. Normally, conflicts with a minimum TTC of 1.5 seconds or less are studied.

TABLE 7.14 CONFLICT DEFINITION AND SEVERITY SCALING USED BY THE TEAMS AT THE MALMÖ STUDY

	Conflict definition			Severity scaling	
	Estimation of Time to Collision (TTC)	Estimation of Post Encroachment Time (PET)	Interpretation of evasive action	Based on proximity to collision (any type)	Based on proximity to injury accident
Sweden 1 Finland	fixed threshold			x	
Sweden 2	fixed threshold				average speed and type of road user
Sweden 4	threshold function of speed			x	
Canada		fixed threshold	(x)	x	
Great Britain France 2			intensity and result		x
France 1 United States Sweden 3			intensity and result	x	
Germany Austria			intensity and result	x	
Netherlands	calculated minimum value			x	

From: Grayson, 1984.

<u>Post Encroachment Time (PET)</u> is the time difference between the moment an "offending" vehicle passes out of the area of potential collision, and the moment of arrival at the potential collision point by the "conflicted" vehicle possessing the right of way. Canada makes a straight estimation of the PET value. The threshold level between serious conflicts and non-serious conflicts is 1,5 seconds. Canada also scores CE-conflicts (close encounters), which form the highest class of severity.

<u>Interpretation of evasive action</u> is made in different ways by the teams. In the British technique, a matrix is used by field observers. The severity rate of the conflict is derived from estimations of "time before possible collision", "severity of the evasive action", "type of evasive action", and "proximity in distance when evasive action ends". France 2 and Sweden 2 use a risk matrix to transform serious conflicts (France 1 and Sweden 1) as predictors of proximity to collision, to values predicting the risk of an injury accident. These transformations are made after the field study.

France 1, USA, Sweden 3, Germany, and Austria, are purely subjective estimates of the severity of the conflicts, based on different scales.

All teams, but the Netherlands', used human observers for ground-level observation.

Except for the conflict counts, the following data was obtained:

1) The Dutch team collected objective data on speeds, distances, etc with a video-based, semi-automatic, technique.

2) Volume counts for the whole period were obtained afterwards through video-recordings.

7.4.3 Study design

The planning of the study design demanded a lot of work due to the differences between the techniques. Quite a few compromises had to be made. Still, the final design was accepted by all teams without much of hesitation.

Bearing in mind that the main objective of the study was to make detailed comparisons of the scoring of different teams, and to compare these with objective data, the main points of the study design were as follows:

- Conflict recording was carried out simultaneously by the eight teams that were using field observers, at three intersections, three days at each.

- The Lund Institute of Technology made video-recordings in order to label conflicts afterwards and to make volume counts.

- The Dutch Institute for Perception (IZF-TNO) made video-recordings in order to collect objective data on a subset of the conflicts recorded by the other teams.

- Comparative analysis of all conflicts was carried out by SWOV, the Netherlands.

- Evaluation of the objective data was carried out by IZF-TNO.

Each team also made a normal safety analysis based on the conflict data they had collected. The results from this part are not included here. For those results as well as for further details of the study, see Grayson (1984).

7.4.4 Data analysis

7.4.4.1 Overall analysis

In total, 973 conflicts were scored by at least one team in the 47 1/2 hours of observation. A subset of 117 conflicts were analysed by IZF-TNO, who computed speed and deceleration of the road-users involved, together with minimum distance, "distance at minimum TTC", the "minimum TTC-value" and the Post Encroachment Time. For detailed information about the IZF-TNO technique, see Van der Horst (1982, 1983).

The main questions to be answered by the comparative analysis were the following:

- what is observed by the conflict teams

- what are the similarities and dissimilarities between the teams with regard to conflict selection and severity rating.

- how are the observations and scores related to objective aspects of the traffic situations that have been observed.

The eight teams scored quite different numbers of conflicts as can be seen in table 7.15.

TABLE 7.15 THE MALMÖ-STUDY: SCORINGS BY THE EIGHT TEAMS.

Teams	Severity score				Sum:	Not	Not	Total
	1	2	3	4	scored	scored	observed	
Austria	168	14	0	0	182	705	86	973
Canada	174	94	36	0	304	668	1	973
Germany	220	22	1	0	243	618	112	973
France 1	136	18	1	1	156	817	-	973
England	338	46	3	0	387	586	-	973
Sweden 1	62	25	6	0	93	880	-	973
Finland	169	51	9	0	229	744	-	973
USA	161	42	2	0	205	768	-	973

From: Grayson, 1984.

Table 7.15 shows that Sweden scored by far the least number of conflicts. The table is, however, somewhat misleading: for instance did both England and Finland score slight conflicts (in the table "SEVERITY SCORE 1") which they normally do not use in safety assessment. This was not the case for Sweden. Thus, if the severity score 1 - conflicts for England and Finland were omitted, then England scored 49 conflicts and Finland scored 60 conflicts, compared to the 93 conflicts scored by Sweden.

In the second stage of the analysis the extent was examined to which the various teams agreed with each other in their judgements about the conflicts they observed and scored. A special form of "principal components analysis" (PRINCALS), was used for this purpose. The analytical technique is described elsewhere (Kraay, 1982) and will not be discussed in detail here.

The findings presented further on in this paragraph are collected from the earlier mentioned report (Grayson, 1984), with exceptions noted.

In short, the PRINCALS programme addresses two fundamental questions at the same time:

1) Are the scores of the teams homogeneous, i.e. do the teams score the severity of conflicts in a similar way, and is there a common severity dimension?

2) What scales are used by the different teams, and how must data by each team be rescaled in order to compare the individual severity scales.

The results of the analysis carried out by SWOV showed clearly that there was one dominant component to which all the teams contributed, and which they all correlated with. This could be interpreted as though all the teams agreed on the same, one-dimensional, severity scale. The PRINCALS analysis maximizes the homogeneity among the teams. Table 7.16 presents the so found "category scores", i.e. the scores on a common severity scale for each severity grade, used by each team.

TABLE 7.16 THE MALMÖ STUDY: CATEGORY SCORES FOR ALL CONFLICTS FROM A ONE-DIMENSIONAL "PRINCALS" ANALYSIS.

	NON SCORED Category	NON OBSERVED score[1)]	SEVERITY GRADE 1 Category score[1)]	2	3	4
AUSTRIA	-0.05	-0.13	0.18	4.77	-	-
CANADA	-0.34	-0.11	-0.22	0.13	2.78	-
GERMANY	-0.14	-0.18	0.17	3.56	13.08	-
FRANCE	-	-0.16	0.36	4.01	9.68	-0.53
ENGLAND	-	-0.16	-0.09	1.98	10.55	-
SWEDEN	-	-0.16	0.82	2.71	3.59	-
FINLAND	-	-0.21	-0.01	1.91	6.34	-
USA	-	-0.15	0.07	2.30	3.58	-
MEAN[2)]	-	-0.16	0.16	2.67	7.09	-

Derived from Grayson (1984)
1) The score on a common severity scale for all the teams.
2) Unweighted

If the severity scales used by each team were relevant, then the category scores should increase with increased severity grade, and the category scores for non-scored and non-observed conflicts should be lower than for severity grade 1 - conflicts. All this when the comparison is within one team.

The criteria above is fulfilled in all cases but two:

1) France, severity grade 4, has the lowest category score This score is, however, based on one observation only.

2) For Canada it seems as if the non-scored conflicts are, in general, more severe than they should be. This implies, that Canada selected conflicts in a different way than the other teams, while once they scored a conflict they used the same severity dimension as the other teams.

Based on the results from the report, I have done a special analysis of the Swedish results:

From a Swedish point of view, the results are in line with what should be expected. One could also see from table 7.16, if severity grades one are compared, that the category scores for Sweden are much higher than for any other team. For severity grade 2, the Swedish category score is the same as the unweighted mean value, while for severity grade 3 the Swedish value is lower than for most other teams. This implies two things:

a) The Swedish threshold between serious and non-serious conflicts is set at a higher common severity level than is the case for all the other teams, except for Finland and England (whose severity grade 1 conflicts are not defined as serious conflicts).

b) Swedish grade 3 conflicts have a lower "common severity" value than all the other teams except Canada. The reason for this is that the Swedish team did not score all conflicts given the highest common severity.

7.4.4.2 Comparison of Swedish and Finnish results

The Finnish technique has its origin in the Swedish one. The main difference at the Malmö-study, as was mentioned earlier, was that the Finnish team scored what they called "potential conflicts", given severity grade 1. These conflicts were not to be scored at all by the Swedish team. In table 7.17 I have made a special comparison of the two teams.

TABLE 7.17 THE MALMÖ STUDY: A COMPARISON OF THE TOTAL SWEDISH AND FINNISH RESULTS.

		SEVERITY GRADE 1	2	3	NON-SCORED
NUMBER OF CONFLICTS SCORED	Sweden	62	25	6	880
	Finland	(169)	51	9	744
CATEGORY SCORES[1] FOR THE SET OF ALL CONFLICTS	Sweden	0.82	2.71	3.59	-0.16
	Finland	-0.01	1.91	6.34	-0.21

1) The score on a common severity scale for all the teams. Derived from: Grayson, 1984.

The comparison in table 7.17 indicates that, if the 169 "potential conflicts" scored by Finland are omitted, Sweden is scoring more conflicts with the lowest severity grade. (It is then supposed that Finland-grade 2 equals Sweden-grade 1 plus the majority of grade 2 conflicts). The "common severity score" is also lower for the Swedish scores - even though the exact value cannot be decided. In case of the highest severity grade, the Finnish scorings have a higher "common severity" value.

In order to get a better understanding of the similarities and differences between the Swedish and Finnish scorings, I have evaluated some basic data from the report about the selected 117 conflicts, i.e. conflicts scored by 4 teams or more.

Appendix 7.7 presents the basic comparison, conflict by conflict. In table 7.18 the 117 conflicts are split with regard to whether none of the two teams, one of them or both, had scored the conflicts. In table 7.19 the Swedish scores are compared with the Finnish and in table 7.20 the Finnish scores are compared with the Swedish.

TABLE 7.18 ICTCT CALIBRATION STUDY IN MALMÖ: SWEDISH AND FINNISH SCORINGS; INDIVIDUALLY AND COMBINED, FOR THE SELECTED SET OF 117 CONFLICTS.

A. Incl. Finland, severity grade 1

Numbers in the common severity scale	Scored by: Sweden only		Finland only		Sweden and Finland		Neither of countries		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%
1- 40*)	2	5	13	33	9	22	16	40	40	100
41- 80	4	10	14	35	18	45	4	10	40	100
81-117	4	11	8	22	20	54	5	13	37	100
Total	10	9	35	30	47	40	25	21	117	100

B. Excl. Finland, severity grade 1

Numbers in the common severity scale	Sweden only No.	%	Finland only No.	%	Sweden and Finland No.	%	Neither of countries No.	%	Total No.	%
1- 40*)	9	22	3	8	2	5	26	65	40	100
41- 80	14	35	7	18	8	20	11	27	40	100
81-117	4	11	8	22	20	54	5	13	37	100
Total	27	23	18	15	30	26	42	36	117	100

*) Lowest common severity.
Derived from: Grayson, 1984

Derived from: Grayson, 1984.

TABLE 7.19 ICTCT CALIBRATION STUDY IN MALMÖ: SWEDISH SCORINGS COMPARED TO FINNISH.

Number in the common severity scale	Scored by Sweden No.	Also scored by Finland (incl sev grade 1) No.	% (of Swedish scores)	Also scored by Finland (excl sev grade 1) No.	% (of Swedish scores)
1- 40*)	11	9	82	2	18
41- 80	22	18	82	8	36
81-117	24	20	83	20	83
Total					

*) Lowest common severity

Derived from: Grayson, 1984.

TABLE 7.20 ICTCT CALIBRATION STUDY IN MALMÖ: FINNISH SCORINGS COMPARED TO SWEDISH.

Numbers in the common severity scale	Scored by Finland (incl sev grade 1) No.	Also scored by Sweden No.	Also scored by Sweden % (of Finnish scores)	Scored by Finland (excl sev grade 1) No.	Also scored by Sweden No.	Also scored by Sweden % (of Finnish scores)
1- 40*)	22	9	41	5	2	40
41- 80	32	18	56	15	8	53
81-117	28	20	71	28	20	71
Total						

*) Lowest common severity

Derived from: Grayson, 1984.

The following conclusions can be drawn from tables 7.18, 7.19 and 7.20.

If Finland severity grade 1 conflicts are included, then the Finnish scores cover more than 80% of the Swedish scores, the same for all three degrees of common severity. If Finland severity grade 1 conflicts are excluded, then the cover is very low at the lowest common severity, but is increasing to the same level when the severity grade 1 conflicts are included. If the two-thirds of the 117 conflicts with the lowest common severity are counted, then less than one third of the "Swedish conflicts" are scored by Finland, while Sweden scores almost half of those conflicts scored by Finland, regardless of whether Finland's severity grade 1 conflicts are included or not.

These results indicate very clearly that Finland is scoring a large portion of the Swedish conflicts with the lowest common severity as "potential conflicts". At the same time, however, they add quite a few "potential conflicts" that are not scored by Sweden. Table 7.18 also shows that the proportion of all conflicts that are scored by both Sweden and Finland is fairly low, even if the Finnish severity grade 1 conflicts are included. The highest proportion is achieved at the highest common severity.

There are obviously two main points that can be concluded from this special comparison between the Swedish and Finnish scorings:

1) Finland seems to have re-classified some of the conflicts that are classified by the Swedes as serious conflicts to "potential conflicts". The Swedes do not score anything like these "potential conflicts". Thus, in the field, a Swedish observer detecting a conflict with low severity has to decide immediately whether to "accept" the conflict as a serious one or not. The Finnish observer, on the other hand, may compromise by "accepting" the same conflict as a "potential conflict". The result may be that a Swedish observer ends up with an over-estimation of serious conflicts with low severity because he is "afraid of loosing some information". The Finnish observer may end up with an under-estimation of serious conflicts because uncertainty about conflicts with low severity can always be resolved by classifying border cases as "potential conflicts". ("I have at least recorded the conflict").

2) The general agreement between the two teams is low, with less than 50% of all conflicts in common. Particularly, it seems as if the Swedish team is scoring less conflicts with highest severity on the common severity scale.

Further investigations should try and find out to what extent the indicated differences between the Swedish and the Finnish scorings are due to differences in detection, and to what extent they are due to differences in the interpretation of severity in conflicts. Specially designed studies focused on these problems would probably be very informative for both the Swedish and the Finnish teams.

7.4.4.3 Interrelation between all the teams

Further on in the report from the Malmö study, the interrelation between the teams was calculated. (See table 7.21).

TABLE 7.21 THE MALMÖ STUDY: CORRELATIONS BETWEEN THE CONFLICT SCORES OF THE TEAMS FOR THE SET OF ALL CONFLICTS AFTER SUBSTITUTION OF THE CLASSIFICATIONS BY THE CATEGORY SCORES.

TEAMS	AUS	CAN	GER	FRA	ENG	SWE	FIN
CANADA	.26						
GERMANY	.52	.24					
FRANCE	.21	.37	.29				
ENGLAND	.21	.31	.52	.49			
SWEDEN	.22	.30	.23	.38	.30		
FINLAND	.36	.32	.40	.48	.53	.42	
USA	.32	.15	.36	.11	.31	.20	.35

From: Grayson (1984).

Sweden correlates best with Finland, while Finland correlates best with England, and Sweden as number three. This confirms that the Swedish and Finnish techniques are associated, even though the correlation "could have been better" compared to the correlation with other teams. This general finding is, however, much in line with my special comparison of the Swedish and Finnish scorings.

The fact that the Finnish team includes "potential conflicts" probably explains why Finland correlates better with England and France than with Sweden.

The PRINCALS analysis was carried out of both the total set and the selected set of 117 conflicts. The two conclusions were similar, which implies that serious conflicts are not treated differently than other conflicts, they are just assigned a higher score on the average. The conflicts in the selected set were of above average severity, and all the severe conflicts were present in the selected set.

One important conclusion of the PRINCALS analysis is that the variation in scoring was derived mainly from differences in the detection of incidents as conflicts rather than in the evaluation of severity. Observers seem to have more difficulties with the detection than with the severity rating of conflicts.

7.4.4.4 Comparison of subjective scores and objective measures

The first step in this analysis was to compare the PRINCALS scores (the "common severity scores") with the minimum TTC values as computed by IZF-TNO. The results are plotted in figure 7.31.

The plot shows that there is a relation. The correlation is r = - 0.46. We can also see that a high severity score always corresponds with a low TTC. The opposite is not always true, however, i.e. conflicts with a low-minimum TTC are not always severe conflicts regarding the "common severity scale". This analysis does not show, however, what other criteria are used to evaluate severity.

In a second step these other relations were investigated as well. Altogether there were ten parameters used for description of conflicts. (See table 7.22).

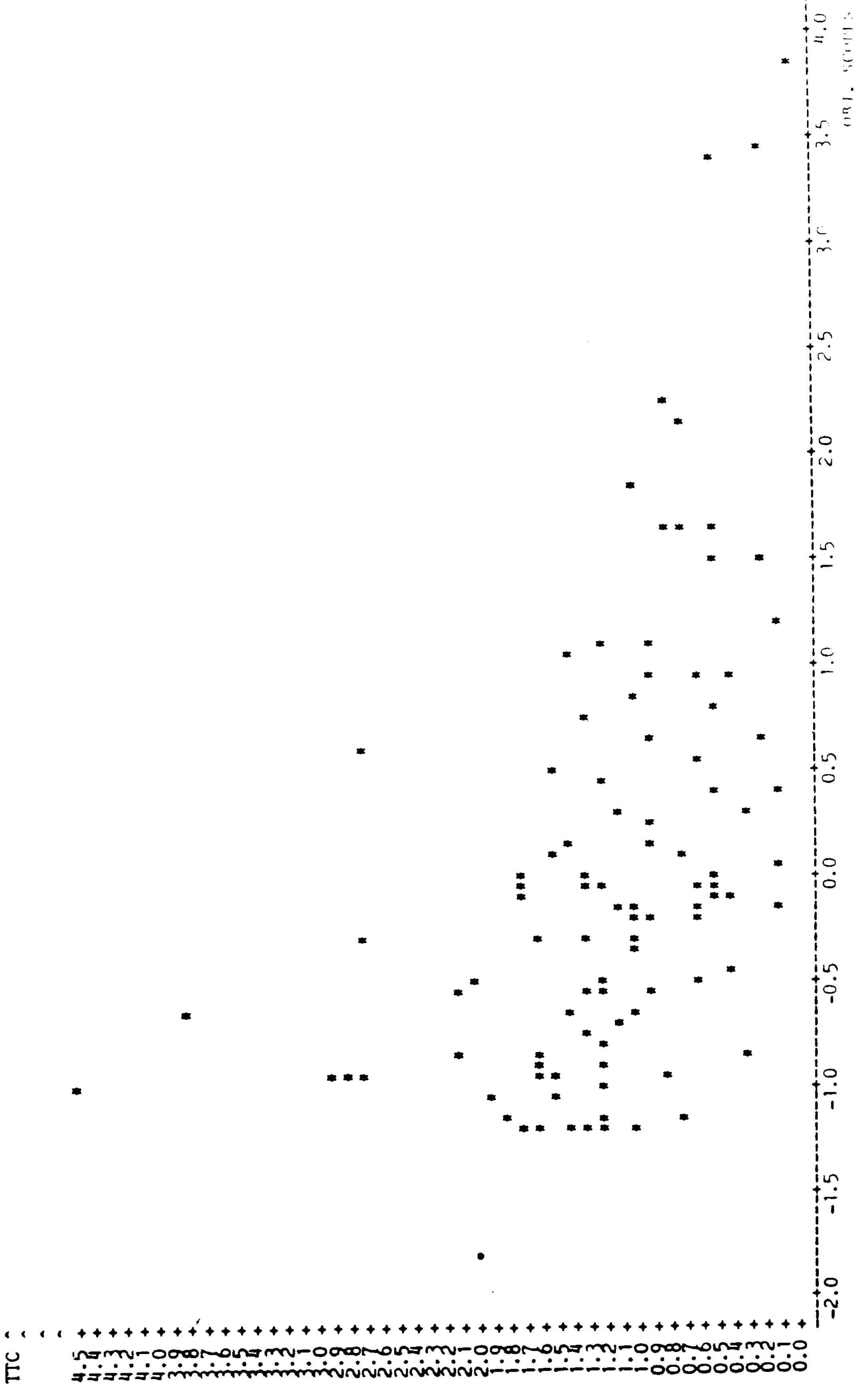


FIGURE 7.31 THE MALMÖ STUDY: PLOT OF THE TTC VALUES AGAINST THE SCORES ON THE COMMON SEVERITY SCALE
The selected set of 117 conflicts.
From: Grayson, 1984.

TABLE 7.22 THE MALMÖ STUDY: EXPLANATION OF PARAMETERS, USED FOR DESCRIPTION OF CONFLICTS.

- Road-user 1:	Road-user with right of way. In car-following situations, the first one.
- Road-user 2:	Other road-user involved in interaction.
- V1:	Initial speed of road-user 1 (m/s), as measured in the beginning of the quantitative analysis of the interaction.
- V2:	Idem for road-user 2.
- A1:	Maximum acceleration, road-user 1 (m/s^2) preceding or during the interaction (mean value during one second around the peak).
- A2:	Idem for road-user 2.
- MDIS:	Minimum distance between road-users (m), as measured between two nearest points of both road-users before, during or after the interaction.
- MTTC:	Minimum time to collision value (s). For the used time to collision concept, see a.o. Van der Horst (1982).
- DTTC:	Distance between road-users (m) at the moment the minimum time to collision value occurs
- PET:	Post encroachment time (s) after the definition of Cooper (1983).

From: Grayson, 1984.

It was found that "Minimum Time to Collision" (MTTC) was the most important factor in explaining the common severity scale.

The second most important variable is "Minimum distance", although this variable does not add much to the description of severity made by MTTC alone. "Conflict type" is adding more to this description and "Minimum distance" and "conflict type" together predict the severity score as well as MTTC alone.

As far as conflict type is concerned, pedestrian conflicts were regarded as most severe, while conflicts among cars and lorries were regarded as least severe. Conflicts involving bicyclists are in between the two other.

If "Conflict type" and "Manoeuvre type" are related to the teams' scores the right-angle and left-turn conflicts are distinguished from the rear-end, weave, and merge manoeuvres and regarded as more severe.

speeds and accelerations, do not, in this study, correlate with severity. This may be caused by the diversity of the conflicts that were analyzed. Some preliminary analyses with more homogeneous subsets of conflicts showed that, in these subsets, both aspects are much more important. The subsets, however, were too small to produce conclusive answers.

In an analysis where the scores of all teams were related to MTTC and PET, it was found that the Finnish and U.S. teams correlate highest with MTTC. The Swedish team, however, correlated less with MTTC than was expected.

7.4.5 Comments to the calibration results

The results were both encouraging and discouraging from the Swedish teams' point of view.

It was expected beforehand, that "Minimum Time To Collison" (MTTC) and the Swedish "Time to Accident" (TA) were highly associated. In this field study, however, the correlation between the Swedish scores and MTTC seemed to be low. One explanation is, of course, that objective TTC is not compared with objective TA, but with estimations of TA. Thus, reliability problems may partly explain the low correlation. Still, it does not seem to be relevant that the U.S. team is more closely associated with MTTC than the Swedish team, as the U.S. team does not have MTTC (or TA) included in their operationalized definition of severity of conflicts, while Sweden has. Besides the Sweden 1-definition was based on "Time to Accident" only!

There has to be a more detailed analysis of the relation between TA and TTC in order to find the actual relationship between the two variables. One such effort is presented in the next section.

The results from the analysis of objective data versus subjective scores were quite encouraging from a Swedish point of view. The findings in the calibration study coincide very much with the conclusions drawn from the developmental work carried out at our Department:

1) The "Minimum Time to Collision" (MTTC) was found to be the most important factor in explaining the common severity scale. Even though the correlation between MTTC and the Swedish "Time to Accident" (TA) was not very strong in this study, they are quite associated in theory as they both deal with the time-margin to an accident.

   The aforementioned comparisons between MTTC and TA, that will be presented in next section, will give a more detailed description of the relation between the two measures than what was given in the report from the calibration study.

   It must also be mentioned here that an "objective TA" was not tested in the calibration study, and its importance compared to TTC can, therefore, not be estimated.

Finally, I want to stress that "conflict severity" in the calibration study relates to the common severity scale derived from the scores of the eight teams. It does not relate directly to any measure of accident risk or injury risk. This is important to keep in mind, as Sweden is one of the few teams that have studied this relation on a large scale.

2) The second most important factor in the comparison of objective data with subjective scores was "Minimum distance" (MDIS). This measure is rather similar to MTTC, as both describe the minimum marginal.

We do not include "Minimum distance" in our definition of a serious conflict. The new generation of definitions that is introduced, represented, for instance, by the ALT DEF 2 (see section 7.3), includes, however, the distance to the collision point at the moment when evasive action is started. This measure is also combined with the approach speed of the road-user. This combined measure is associated with the MDIS-measure, and I therefore think that we do consider the "Minimum distance" in a proper way. The main exception is when there is snow or ice on the road surface, but these conditions are excluded, generally.

3) The third most important factor was "Conflict type" (CT). This factor was already introduced in our original technique. In chapter 5, the original risk matrix was presented that transforms serious conflicts into "police-reported injury accidents". One of two factors that were included in this original risk matrix was CT, split into "car-car" and "car-bicycle plus car-pedestrian". The last two groups could not be split, due to insufficient data volumes. The risk matrix very clearly indicates the same thing as the calibration study, namely that "car-car" conflicts are much less severe than "car-bicycle" and "car-pedestrian" conflicts (in our case, though, measured as "accident to conflict"-ratios).

4) The fourth factor, although of less importance than the others in the calibration study, was the manoeuvre type. Specifically, right-angle conflicts and left-turners versus oncoming vehicles were found to be more severe than rear end, weaving and merge conflicts. This is exactly in line with what Linderholm (1981) found when he reanalyzed the original Swedish validation data. (See also para 6.3).

On the whole it can be claimed that the Swedish technique is very much in line with the major findings at the calibration study in Malmö. This is encouraging as it indicates that the basic structure of the Swedish technique, i.e. definitions and recording procedure, seems alright and needs only small modifications from here on.

7.5 A comparison of Swedish observers' estimations and objective data

7.5.1 Introduction

The calibration study in Malmö, as reported in section 7.4, gave an excellent opportunity to compare the recordings of the Swedish observers with objective data, evaluated with the semi-automatique technique developed by IZF-TNO in the Netherlands.

The evaluation of data from each conflict is quite time-consuming, and the Dutch team had to analyze a sub-set of the 973 conflicts, scored in total by the teams. This sub-set could be split in two parts:

- Conflicts scored by four teams or more (111), plus conflicts given a high severity score by one team (6). Altogether 117 conflicts.

- All conflicts scored by three teams, during the three days study at one of the three intersections. Altogether 33 conflicts.

Ideally, a complete test of the Swedish scorings should be based on an analysis of all events during the whole nine days of study that were scored by the Swedish team, or should have been scored.

The 973 conflicts as such, must be considered as a sample that is very close to an ideal one. There are three main reasons why I claim that:

a) First, the calibration study showed that Minimum Time to Collision was the most important variable in explaining the common severity scale derived from the scorings of all eight teams. I therefore claim that the teams were searching for conflicts that were quite similar to the "Time to Accident", based conflicts that were to be scored by the Swedes.

b) Second, all the other teams scored many more conflicts than Sweden, i.e. they included less severe conflicts.

c) Third, the observation of eight teams made it very unlikely that any events that might be of interest went unrecorded.

The sub-set of the 973 conflicts that were analyzed by the Dutch team was a very reasonable compromise, even with my specific aims:

1) The 117 conflicts scored by four or more teams were of particular interest to analyze, as they were considered to be the most important ones that were recorded in the calibration study.

2) The 33 conflicts scored by three teams gave a good extra cover for three days of all conflicts that also

might include some that were to be scored by the Swedish team. Those conflicts that were omitted in this analysis, i.e. conflicts scored by one or two teams, were almost generally considerably less severe (on the common severity scale) than conflicts scored by the Swedish team. They should, therefore, be of less interest for this comparative exercise.

7.5.2 Analyzing technique

For the complete sub-set of conflicts mentioned earlier the Dutch team provided me with all available data, thus enabling my own comparisons.

The Dutch analyzing technique, developed at IZF - TNO, can briefly be described as follows: (For further information see Van der Horst, 1981, 1982).

In successive video frames, the positions of some easily identifiable points on the road-user are selected. Coordinates for these points are evaluated by positioning of electronic cross-hairs. One such point may, for instance, be the touch of a wheel on the ground. By transformation rules, based on at least four reference points, x and y, positions of the video plane can be translated into positions on the plane of the street. Van der Horst has chosen a sample of four observations per second as being a reasonable compromise between accuracy and time consumption for evaluation.

One of the parameters in Van der Horst's analysis, and the most important for me, is the Time To Collision (TTC). Input data are momental speeds and distances to the collision point.

The following information, provided by Van der Horst, was used in my comparisons:

- Speed-graphs of the two road-users involved
- Time To Collision (TTC-graph).

The measures were taken continously, every 0.24 seconds, starting some seconds in advance of the conflicts.

Figure 7.32 presents a typical set of graphs when braking of a car was the avoiding manoeuvre.

The conflict, as shown by the graphs in figure 7.32, can be split into the following sub-events:

Time 1: The actual calculating of TTC starts.

Time 1-2: Road-user 1 is approaching with even speed.
Road-user 2 is accelerating.
TTC is approaching zero seconds somewhat faster than running time.

Time 2: Road-user 2 starts braking.
The TTC-curve is changing its inclination.
At this time the Swedish observer should estimate the "Time to Accident", thus equal to TTC at this moment. Thus "Time to Accident" in this example 1.0 seconds.

Time 3: Road-user 1 also starts braking
Road-user 2 continues to brake
TTC reaches its minimum
(≈ 0.8 seconds).

Time 3-4: Both road-users continue to brake
TTC is slowly starting to increase again.

Time 4: One of the road-users leaves the collision area
TTC turns to infinity, instantaneously.

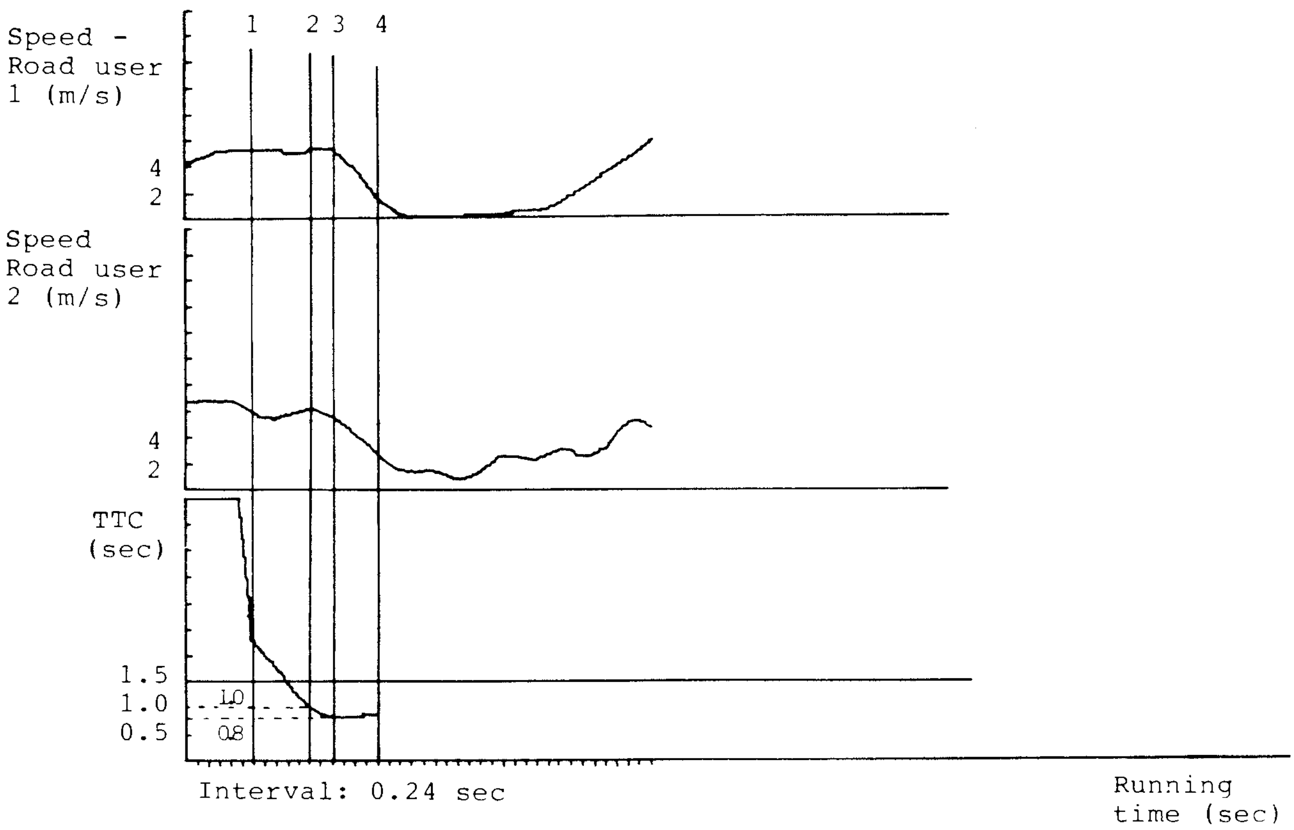


FIGURE 7.32 TYPICAL SET OF GRAPHS REPRESENTING ONE CONFLICT
car-car, avoiding manoeuvre: braking

In most conflicts, the speed-graphs and TTC-graph combined gave a clear picture of when the evasive manoeuvre was taken and, consequently, what the objective TA-value was. On some rare occasions, however, the graphs were difficult to interpret. This was mainly linked with swerving as the evasive maneuver. Figure 7.33 gives an example of this kind of conflict.

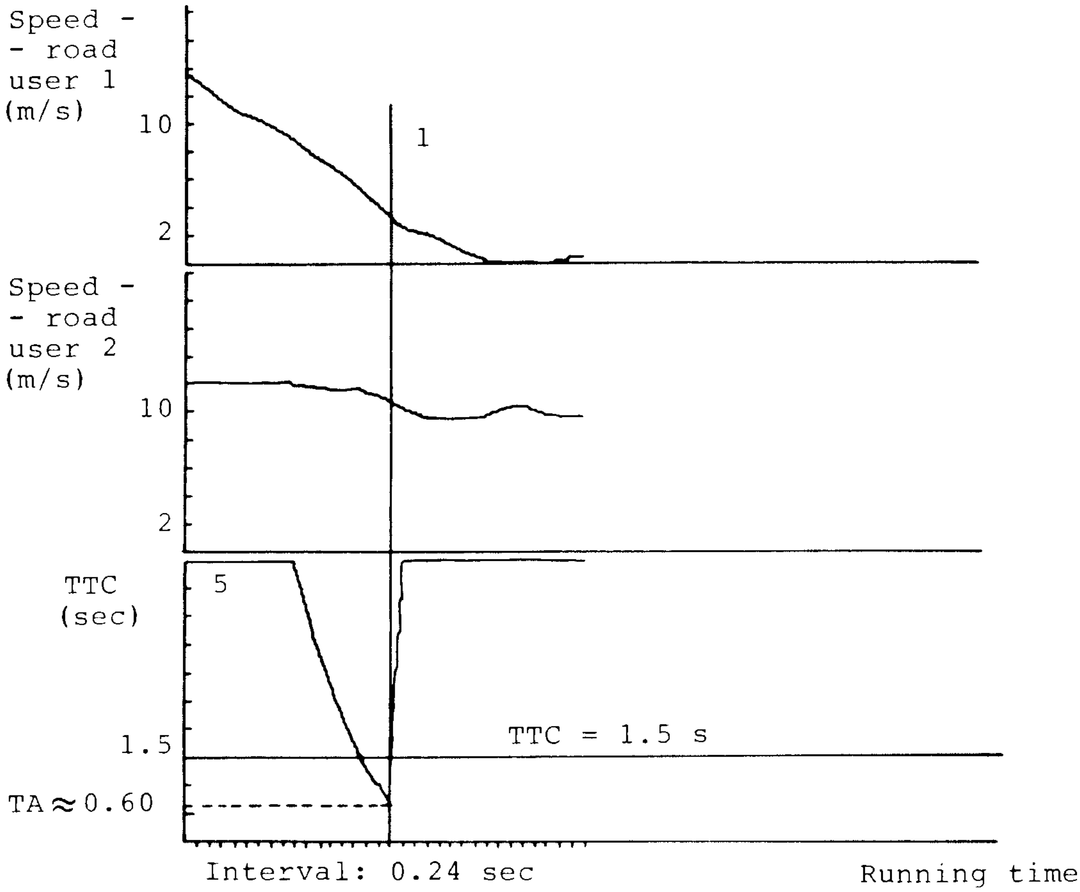


FIGURE 7.33 SPEED GRAPHS AND TIME TO COLLISION GRAPH IN A CONFLICT WHERE SWERVING IS THE AVOIDING ACTION

In this case, there are no distinct changes either in the speed-graphs or in the TTC-graph until the moment TTC goes towards infinity. The reason is the following: the swerving maneuver is started without any change of the speed. From the moment the swerving has started, the direction of travel is changed so quickly, that the collision course is almost instantaneously changed to a (near) miss situation in stead. As was mentioned earlier, there are 0.24 seconds between each calculation in the graphs. In most cases, one such interval will give ample time for the necessary change of direction of travel. The moment for the start of the swerving manoeuvre is, therefore, in these cases approximated with the moment the TTC-curve goes towards inifinity, in figure 7.33 at Time 1. Time to Accident ≈ 0.6 sec.

To overcome interpretative problems as far as possible, all conflicts are also checked on video-tapings from the study.

All the information combined made the evaluation of the graphs reliable. Specifically, it was noted that the basic elements in the Swedish operational definition of a serious conflict are that the evasive manoeuvre is clearly visible, and that there is a sudden and harsh change of speed and/or direction. If this is transferred to the graphs, it means that there should also be a visible change in either the speed-graphs or in the TTC-graph - unless swerving was the only evasive manoeuvre. This latter was, however, the case in only 2 out of 55 conflicts scored by the Swedish team within the selected set of 117 conflicts.

Two types of comparisons between objective data and the Swedish scorings were made:

1) The cover rate by the Swedish observers, i.e. the extent to which conflicts are scored or not, in relation to whether they should be scored or not.

2) The scoring ability by the Swedish observers, i.e. how accurate they were able to estimate Time to Accident and road-user speed at the start of the evasive action (conflicting speed). This analysis was based on conflicts scored by the Swedish observers and three other teams or more. (A sub-set of the 117 conflicts).

7.5.3 Cover rate by Swedish observers

The Swedish team used four different definitions in the Malmö study (see also para 7.4). The comparisons that follow are based on one of these, namely the original definition ($TA \leq 1.5$ s).

Table 7.23 presents the summarized results of the two studies where the cover rate was calculated. The detailed results are shown in appendices 7.8 and 7.9.

TABLE 7.23 SCORINGS OF THE SWEDISH TEAM COMPARED WITH THE OBJECTIVE EVALUATION.

Sample	Objective evaluation To be scored (TA≤1.5s)	Objective evaluation Not to be scored (TA>1.5s)	Swedish scorings Scored	Swedish scorings Not scored	Swedish scorings Not scored but should be scored ("missing rate")	Swedish scorings Scored but should not be scored
Scored by*) three teams three days of obs.	19	14	12	21	7 (37%)	0 (0%)
Scored by**) four teams or more the whole study	57	50	51	56	11 (19%)	6 (12%)

*) Partly a sub-sample of the other.
**) Ten conflicts out of the 117 in the second sample were omitted due to insufficient information from the graphs.

The "missing rates", for the two samples, i.e. the proportions of conflicts that were not scored but should have been were tested for independence using a chisquare test. The hypothesis of independence was not rejected (5%-level), i.e. it cannot be claimed that the two missing rates were different.

If the two samples are combined, the missing rate is 16/62, corresponding to 26%. (As some of the conflicts belong to both samples, these figures can not be derived from table 7.23 but only from app. 7.8 and 7.9). This rate is somewhat higher than what was found in earlier studies (see chapter 5).

One important question is whether the missed conflicts are biased in any way. Table 7.24 presents the Time to Accident for missed and not missed conflicts.

TABLE 7.24 TIME TO ACCIDENT FOR MISSED AND NOT MISSED CONFLICTS BY THE SWEDISH TEAM.

Sample	Average Time to Accident Missed conflicts by the Swedish team	 Not missed conflicts
Scored by three teams, three days of obs	1.07 (7)[1)]	1.04 (12)
Scored by four teams or more, whole study	1.01(11)	1.02 (45)

1) Number of conflicts.

Table 7.24 shows that the average Time to Accident is very similar for missed and not missed conflicts. The missed conflicts do not seem to be biased from this point of view, but simply a random sample of the conflicts that should have been scored.

This means that the missed conflicts are not particularly slight, and this can therefore not explain why conflicts are missed.

One condition that might influence the proportion of misses (i.e. not scored when it should have been and vice versa), is the traffic volumes. One might think that heavy traffic would increase the difficulty in recording conflicts so that the proportion of misses increased. This was checked and the result is presented in table 7.25

TABLE 7.25 MISSES BY THE SWEDISH TEAM AT PEAK HOURS AND NONPEAK HOURS.
Sample: Conflicts scored by four or more teams during the whole study.

	Correct, i.e. scored by the Swedish team and should have been scored	Misses Scored by the Swedish team but should not have been scored	 Not scored by the Swedish team but should have been scored	Misses total
Peak hours 11.30-13.00 15.30-18.00	28	2	7	9
Non-peak hours	29	4	4	8

The total proportion of misses indicated by table 7.25 is very similar for peak hours and non-peak hours. The proportion of conflicts not scored is, however, bigger for the peak hours. The numbers are too small, however, to produce a significant difference. The conclusion is that the study did not indicate that the total proportion of misses seems to increase during peak hours. The question whether the observers actually missed more conflicts during peak hours needs, however, to be examined in a bigger study.

In the sample of conflicts scored by four or more teams there were 50 conflicts that were not supposed to be recorded by the Swedish team. Six of these (12%) were still recorded. It is, however, encouraging to find out that the Swedish observers scored only a small part of these conflicts, even though they were considered as being serious by at least four other teams. This indicates again that the observers discriminated well, with regard to the 1.5 seconds criterion.

Besides these 6 "extra" conflicts stand for a small proportion in addition to the correctly scored conflicts. As long as these "extra" conflicts are not extremely biased regarding any important variable, they will cause very little disturbance to the results. The number of "extra" conflicts in this study is too small to allow any statistical test of the bias. A check, however, revealed that the conflicts scored when they should not were similarly distributed, regarding involved road-user types, as the conflicts not scored when they should have been. The bias, from this point of view, therefore does not seem to be extremely big.

7.5.4 The observer's ability to score Time to Accident

In the sample of 107 conflicts (those 107 conflicts out of the 117 conflicts, scored by four teams or more), these 57 conflicts scored by the Swedish team formed the basis for a comparison of estimated TA and objectively measured TA.

Seven conflicts had to be omitted in the comparisons, four of them because information was missing in the graphs and three because there were no TTC on the graphs. It is not known wether these three events were near-misses where one or both of the road-users reacted because "it was so close". In that case those conflicts should be included regarding my proposed extension of our definition (see para. 6.1.6). As TTC-graphs were missing because there was no collision course, I had to leave them out from my analysis.

App. 7.10 gives the objectively computed TA-value (TA_{obj}) as was shown in para 7.5.1 and the estimated TA-values (TA_{est}).

In figure 7.34 the TA_{est} and TA_{obj} are plotted.

Figure 7.34 shows that the difference between estimated and objectively measured TA-values is fairly small, in most cases. The average size of the difference (absolute values) is 0.28 seconds. In almost half of the conflicts the difference is less than $\pm$ 0.2 seconds, and in 82% of the cases the difference is less than $\pm$ 0.4 seconds.

One can also see from figure 7.34 that the difference is positive and negative almost equally often. On the whole, the estimated TA-values are not very biased. The average difference is only 0.05 seconds.

If the regression line for the estimated TA-values is compared with the line $TA_{est} = TA_{obj}$ (see figure 7.34), one finds that the inclination of the regression line is significantly different (5%-level) from 1. (The inclination of the line $TA_{est} = TA_{obj}$.

Even though there is a significant difference figure 7.34 indicates that the main reason for the differences found, is a small tendency that observers under-estimate high, objectively measured, TA-values and overestimate low values.

It is also interesting to see whether any specific type of conflict produces any particular difficulties for the observer. The conflicts are therefore split into road-user type involved, and (partly) into manoeuvre type. Figure 7.35 presents the regression lines for the split data. (Values are derived from app. 7.10.

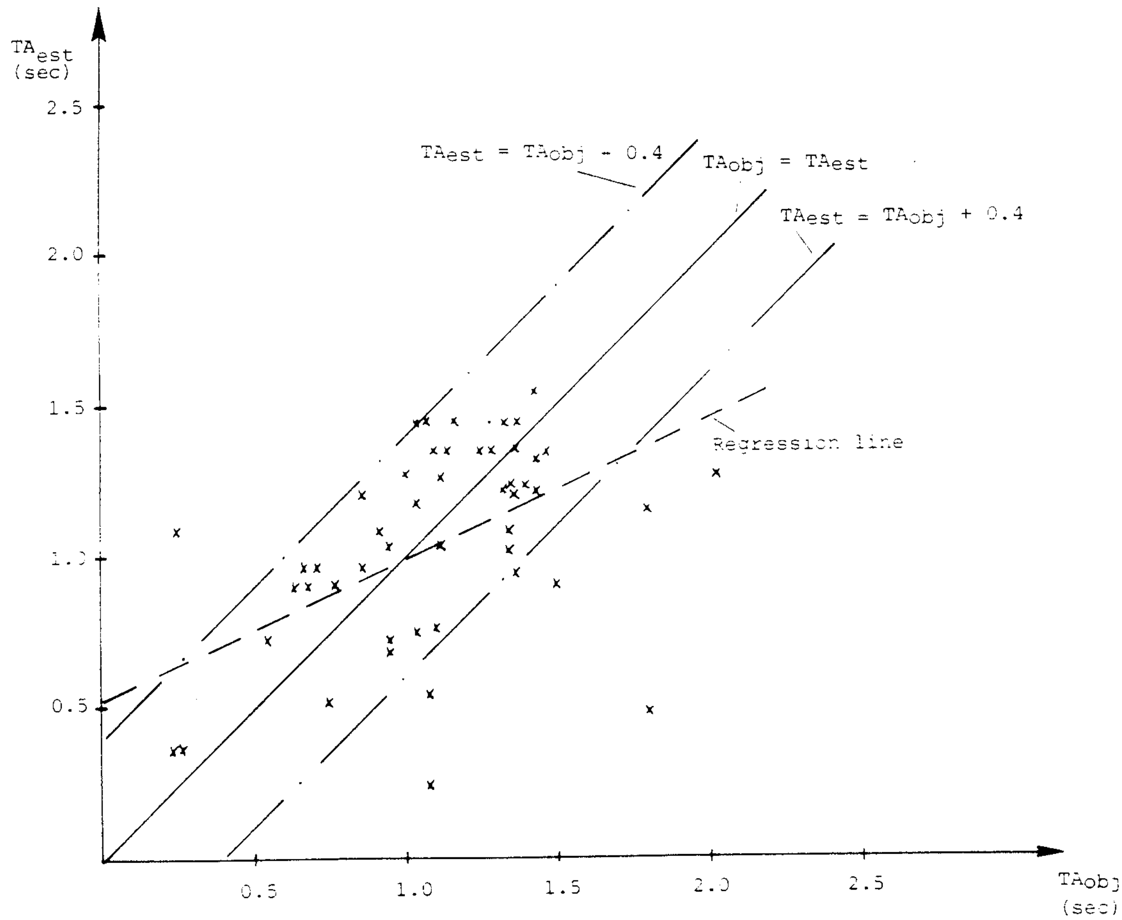


FIGURE 7.34 THE RELATION BETWEEN ESTIMATED TIME TO ACCIDENT (TA_{EST}) AND OBJECTIVELY MEASURED (TA_{OBJ}) Conflicts scored by Sweden within the sample of 117 conflicts.

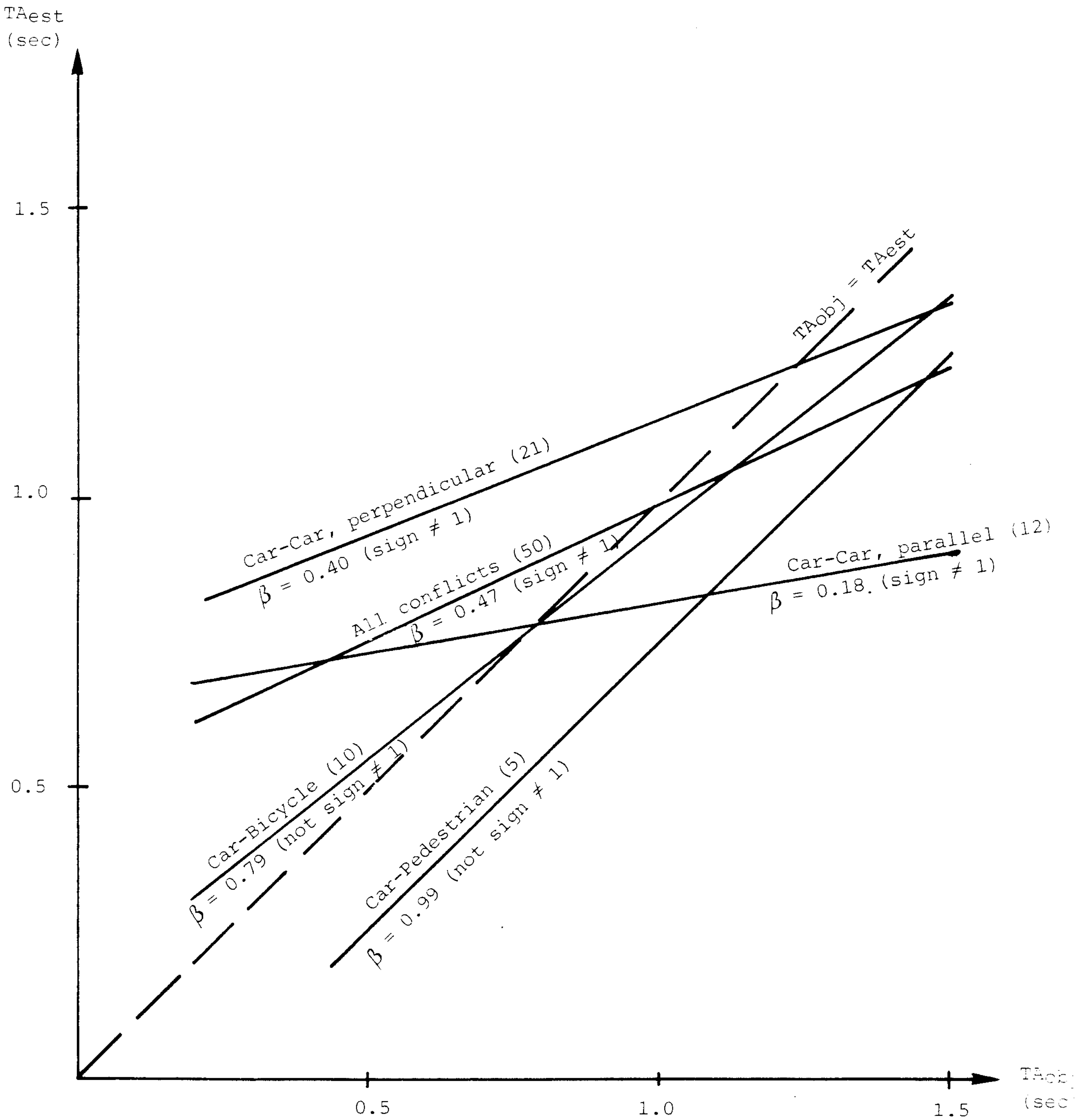


FIGURE 7.35 REGRESSION LINES FOR THE RELATION BETWEEN ESTIMATED TIME TO ACCIDENT (TA_{est}) AND OBJECTIVELY MEASURED (TA_{obj}), TOTALLY AND SPLIT INTO DIFFERENT TYPES OF ROAD-USERS AND MANOEUVRES.

Figure 7.35 indicates that car-car conflicts generally seem to be more difficult to estimate than other types. Car-car conflicts of rear-end and weaving type seem to be the most difficult ones to estimate. This is very much in line with the observers' opinion, i.e. the TA-values are very difficult to estimate when the collision point is hard to detect, as in the rear-end case when both cars are moving in the same direction. The TA-values in weaving conflicts are difficult to estimate, partly for the same reason as above, and partly because the actual distance between the two cars is often very small.

It must, however, also be noticed that the objectively measured TA-values may have a systematic error in case of the rear-end conflicts. The assumption is based on the following facts:

- As was mentioned earlier, the semi-automatic technique, developed by IZF-TNO in the Netherlands, produces a distance to the collision point by using the <u>momental</u> speed of the vehicles. If the leading vehicle is decelerating in the moment the TA-value is supposed to be estimated by the human observer on the ground, which is most often the case, then the IZF-TNO-technique produces a "distance to the collision point" which is longer than it would have been if there was a collision. The estimates in the field, on the other hand, should be based on the actual speed characteristics of the leading vehicle. The semi-automatic technique should, due to this, produce higher values than the observer estimations. This also seem to be the case if one compares the average values for the seven rear-end conflicts. The sample is, however, much too small to allow any definite conclusions to be drawn. It is, therefore, not possible to state to what extent there is a bias in the semi-automatic computation in this case compared to a bias in the observer estimations.

  The observers' estimations of TA in car-bicycle and car-pedestrian conflicts seem to be much less biased than for car-car. This is also in line with observers' opinion. The numbers analyzed are, however, too small to allow any definite conclusions to be drawn.

  The general question as to whether the recordings are biased with regard to the severity of conflicts is analyzed in figure 7.36. The new proposal for a severity definition, earlier referred to as ALT.DEF.2 (See section 7.2 and 7.3), forms the basis for an individual comparison of the estimated and objective values for each conflict. The results are summarized in table 7.26.

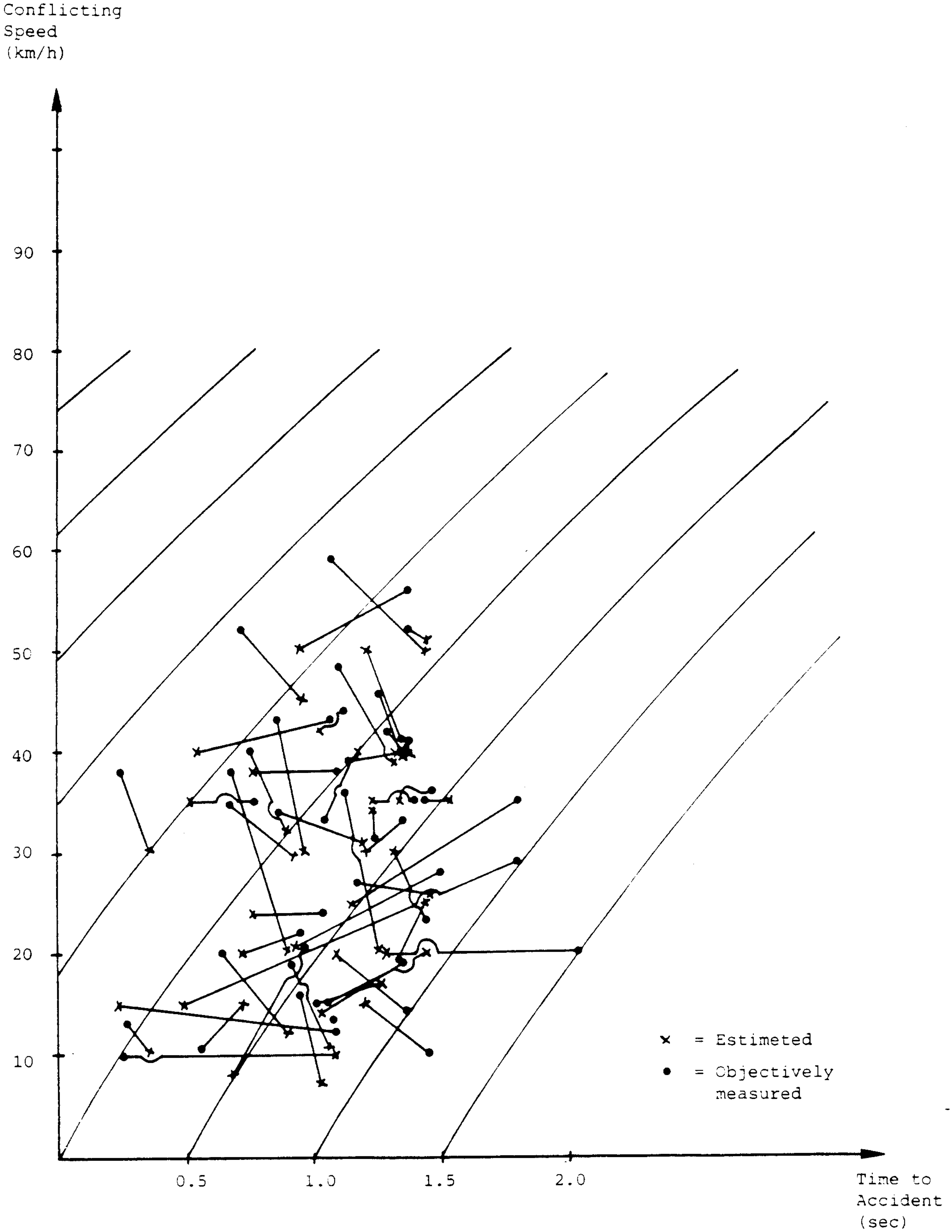


FIGURE 7.36 A COMPARISON OF THE SEVERITY OF ESTIMATED AND OBJECTIVELY MEASURED CONFLICTS
Severity based on the ALT.DEF.2

TABLE 7.26 THE DIFFERENCE IN SEVERITY CLASSIFICATION OF CONFLICTS BETWEEN ESTIMATED AND OBJECTIVELY MEASURED VALUES
A summary of figure 7.36

	Difference between estimated and objectively measured severity values for each conflict				
	- 1 class	± 0 class	+ 1 class	+ 2 class	ΣΣ@
Number of conflicts	17	22	10	1	50
Number of conflicts x classdiff	-17	0	+10	+2	-5

The results indicate that the difference in severity classification is very small between estimated and objective values:

- Almost half of the conflicts were given the same severity class by the field observer, as was obtained via the objective evaluation.
- The net change of severity is very small - "one tenth of a severity class in underestimation" on average for each conflict.
- Only in 1 out of 50 conflicts was the difference bigger than one severity class.

7.5.5 The observer's ability to score Conflicting Speed

In appendix 7.10, the estimated and objectively measured conflicting speeds are listed. In this case, the comparison is based on 53 conflicts where comparable data were obtained.

In figure 7.37, the estimated Conflicting Speeds are plotted against the objectively measured Conflicting Speeds. The inclination of the regression line is tested against the inclination of the line "Estimated speeds = Objectively measured". No significant (5%-level) difference was found. Figure 7.37 also shows clearly that the differences are small:

On average, there is an underestimation by 3.0 km/h. In 32 conflicts the speed is underestimated, in 13 it is overestimated while the estimated speed is equal to the objectively measured one in 8 cases. In 48 out of 53 conflicts (91%) the difference is smaller than 10 km/h. In 28 out of 53 conflicts (53%) the difference is smaller than 5 km/h.

The underestimation of speeds seems to be about the same at different, objectively measured, speeds.

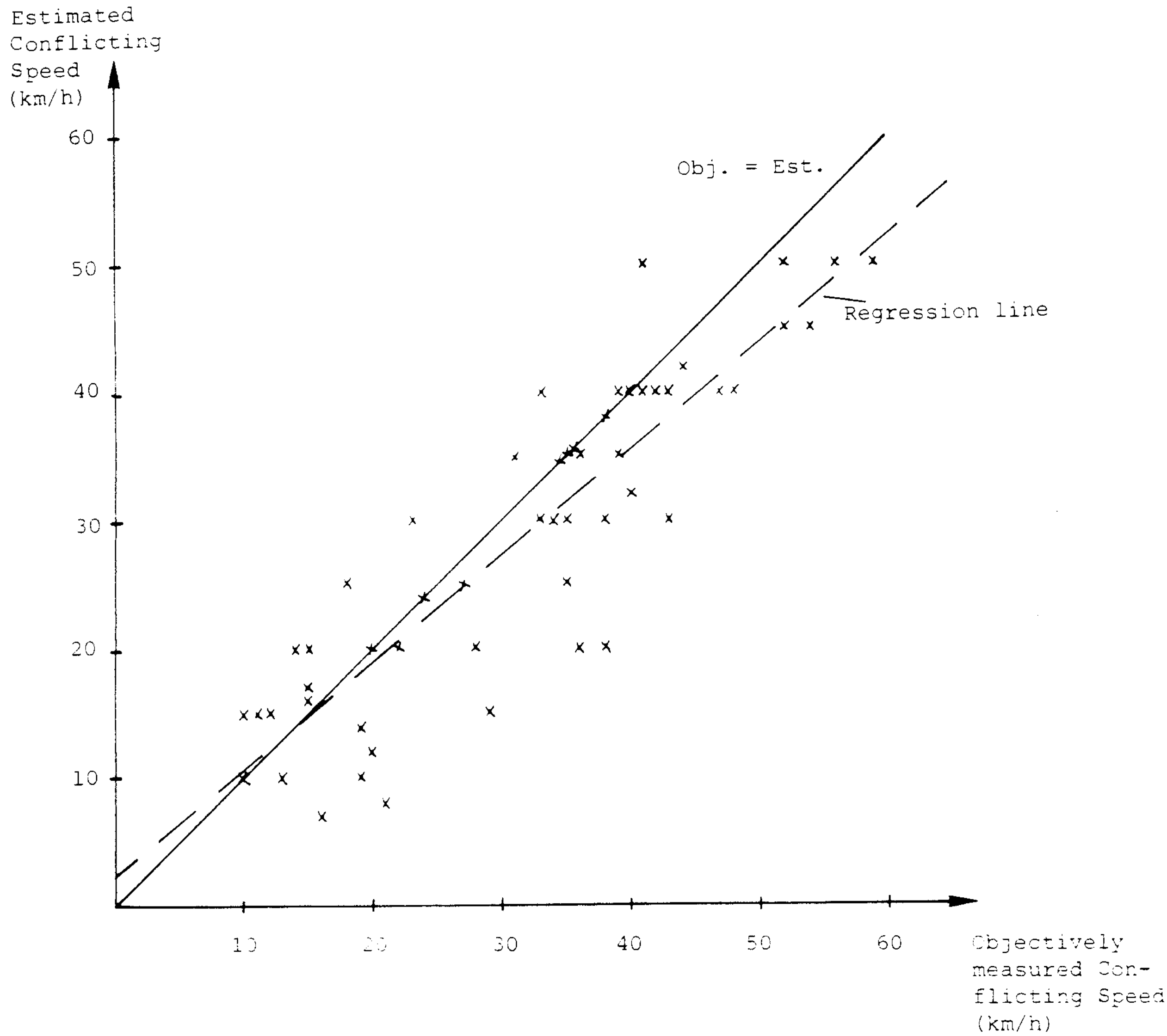


FIGURE 7.37 THE RELATION BETWEEN ESTIMATED AND OBJECTIVELY MEASURED CONFLICTING SPEEDS
Conflicts scored by Sweden within the sample of 117 conflicts

7.5.6 A comparison of Time to Accident (TA) and Minimum Time To Collision (MTTC)

There is a general interest in finding out to what extent TA and MTTC are correlated. It is also interesting to see whether objectively measured TA (TA_{obj}) and estimated TA (TA_{est}) correlate differently with MTTC.

The graphs used in para 7.5.3 to evaluate TA_{obj} can be used to evaluate the objectively measured MTTC as well. Appendix 7.11 presents the above mentioned values for the sample of conflicts scored by Sweden, plus at least three more teams in the Malmö-study.

In figure 7.38 the estimated TA-values (TA_{est}) are plotted against the MTTC-values, and in figure 7.39 the objectively measured TA-values (TA_{obj}) are plotted against the MTTC-values.

The results show that the correlation is higher for TA_{obj} versus MTTC than for TA_{est} versus MTTC. One important reason for this is that, in the latter case, the difference between the two measures is, par definition, restricted to one side, while this is obviously not true for the first relation.

One can therefore conclude that the relations are not very clear for all conflicts together.

The question remains, however, as to whether a split of the conflicts might produce more distinct relationships. The conflicts are, therefore, split with regard to conflict type, manoeuvre type and Conflicting Speed, and related to the difference between objectively measured TA and MTTC. The results are shown in figure 7.40. It can be clearly seen in the graph that there are no distinct relationships. A linear regression analysis for each of the three conflict types/ /manoeuvre types also produced low correlations. The highest value is for car-car, right angle + left turning conflicts. ($r = 0.37$).

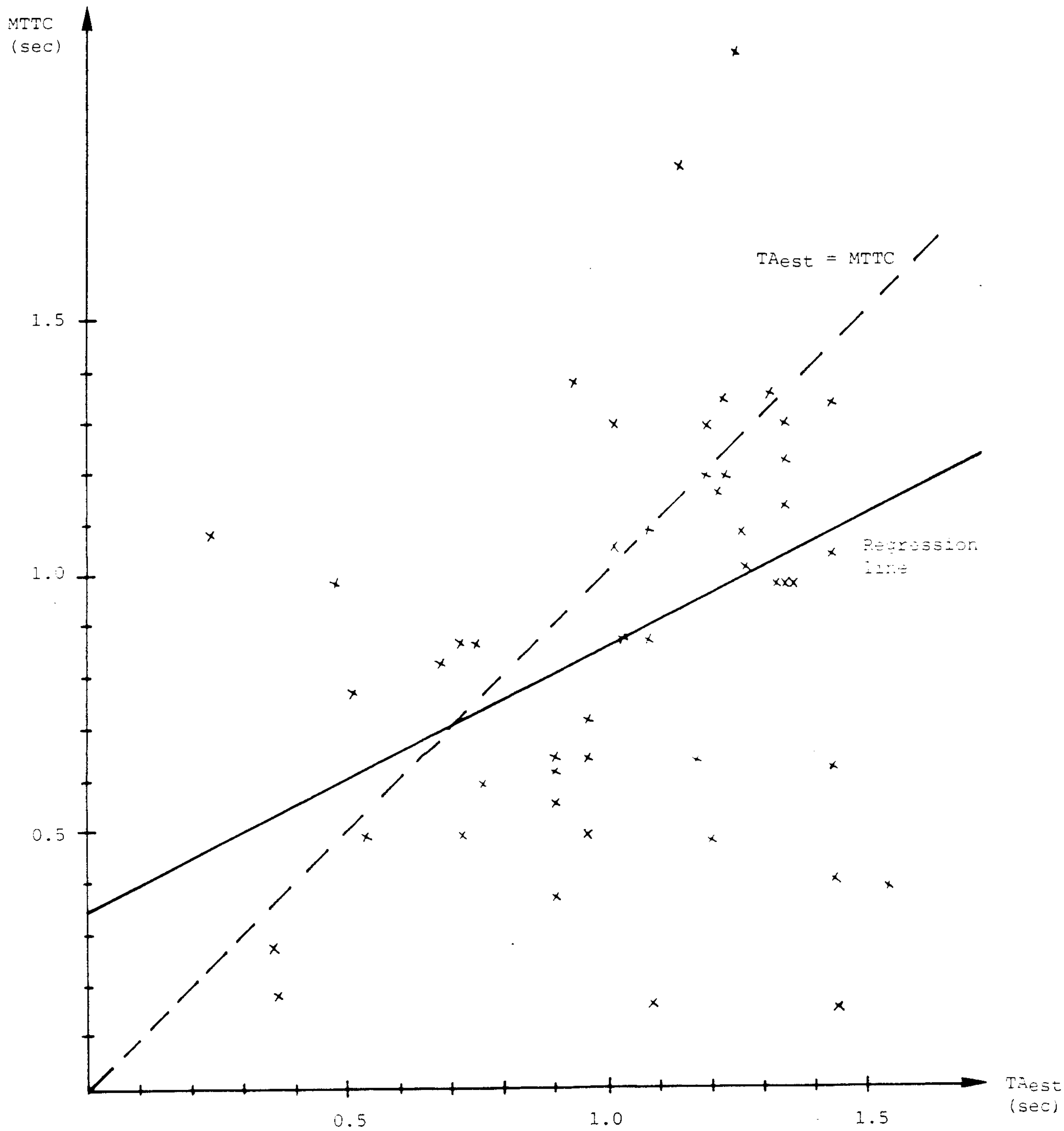


FIGURE 7.38 ESTIMATED TIME TO ACCIDENT (TA_{est}) VERSUS OBJECTIVELY MEASURED MINIMUM TIME TO COLLISION (MTTC).

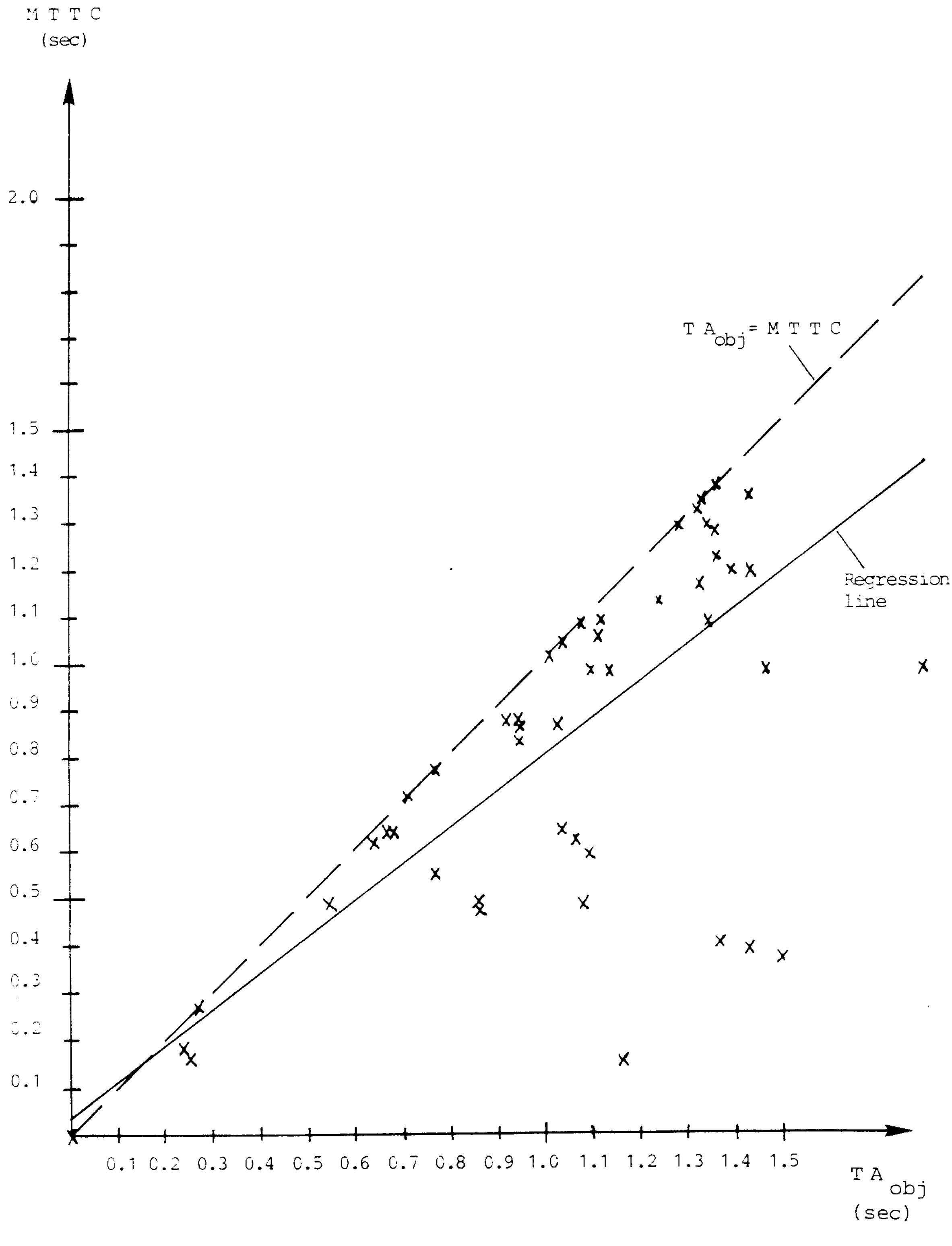


FIGURE 7.39 OBJECTIVELY MEASURED TIME TO ACCIDENT (TA_{obj}) VERSUS OBJECTIVELY MEASURED MINIMUM TIME TO COLLISION (MTTC)

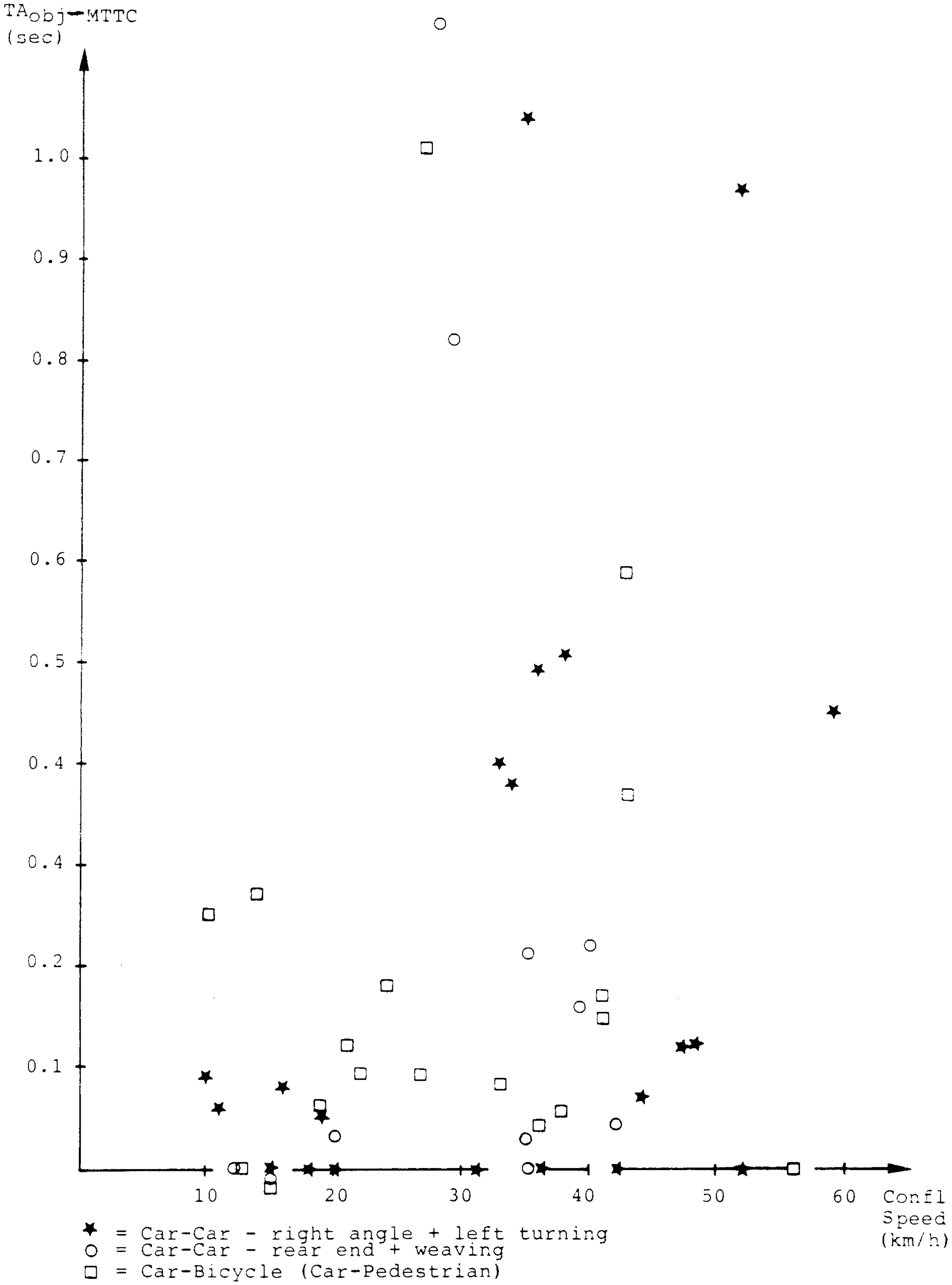


FIGURE 7.40 THE RELATION BETWEEN THE DIFFERENCES IN OBJECTIVELY MEASURED TIME TO ACCIDENT AND MINIMUM TTC AND ROAD-USER SPEED.

7.5.7 Comments

The reliability problem has two aspects:

1) The detection of the conflict
2) The scoring of the conflict.

A conflict that should be scored and was not, would be due to the fact that the observer did not detect the conflict, or that he did detect it but rejected it because his estimation of the TA value was above the threshold, 1.5 seconds.

A conflict that is scored when it should not have been, is done because the observer estimated the TA value incorrectly.

The combined detection rate for the two samples in the analysis described in this section was 26%. This is fairly in line with the results obtained in earlier reliability studies (chapter 4).

Two questions are important:

1a) Are the misses biased in some way?

1b) Do the "extra" conflicts (scored by the observer but should not) cause any problem?

Question 1a) can be answered with a no! There are no indications that the missed conflicts are different with regard to TA or conflict type, than the other conflicts. There is, however, an unverified indication that the detection rate is lower at peak hour traffic. This aspect must be studied further in order to gain a better knowledge of the optimal number of field observers that should be used in different traffic volumes.

Question 1b) can also be answered with a no. Primarily becau-se the proportion of "extra" conflicts seems to be quite small, in the analysis described in this section around 10%, and in the earlier reliability studies (chapter 4) around 5%. Besides, the "extra" conflicts do not seem to be very biased, at least with regard to the variable "road-user involved".

On the whole, one must conclude that the comparison (described in this section), between our observer's recordings and the objective evaluation, has shown that the detection of conflicts is carried out very well by the observers.

Regarding the second aspect, the scoring of the conflicts, one must also conclude that the observers seem to be able to do this in a very reliable way. On average there was almost no difference between estimated and objectively measured conflicts, either regarding Time to Accident, Conflicting Speed or severity of the conflicts.

The observers do not seem to be biased, but only produce a small, random, error in the scoring. Included in the judgement that the observers do the scoring in a reliable way, is also the fact that they discriminated well between serious and non-serious conflicts with regard to their definition (in spite of the fact that these non-serious conflicts were scored as serious conflicts by at least four other teams). (Quite another question is whether these conflicts should be included in the Swedish definition for validity reasons. This, however, could only be evaluated through some kind of joint international validation study, where different definitions of serious conflicts were validated against accidents and compared).

The findings above indicate that the main reason for misses seems to be poor observation. Two objective reasons for this are overloading of the observer (too much traffic) or difficulties for the observer to see certain manoeuvres. The first problem could partly be solved by further training of the observers, and shortening of the length of observation periods. The second problem could partly be solved by circulating the observer(s), so that "all parts of a location are covered in a similar way.

In the German technique developed at the Technische Universität in Braunsschweig (Erke 1979), the observers circulate with regard to a pre-made plan. When circulation is executed, the observers have a short brake as well, to allow them to recover mentally and physically.

The comparison of Time to Accident (TA) and Minimum Time To Collision (MTTC), shows that the difference between the two measures does not correlate with any known variable. This indicates that the two measures individually produce different severity rating of the same conflicts. Comparative validation efforts are needed in order to gain further knowledge about advantages and disadvantages with the two measures, as individual variables, or combined with each other.

8 PERCEPTION OF RISK IN CONFLICTS

8.1 Introduction

The road-users' perceived level of risk is a fundamental issue in research dealing with risk theories of any kind. Questions concerning the perceived level of risk under different circumstances and what the consequencies are with regard to the behaviour performed by a road-user, have been of great importance and will be so even in the future.

In this chapter I will give a contribution to this research by presenting findings we have achieved regarding the perceived level of risk for road-users who have been involved in conflicts.

The results will be used for three purposes here:

1) In chapter 3 it is hypothesized that serious conflicts can be characterized as break-downs in the interaction between two road-users, i.e. at least one of them would not like to be involved in the creation of a similar event deliberately. (Para 3.3.1). The results presented in section 8.3 can be used to study the above mentioned hypothesis.

2) It is of general interest to see how road-users act upon their risk concept and how this coincides with how we and other researchers have tried to incorporate the concept in our definitions of conflicts and conflict severity.

3) Theories concerning road-users perception of risk and its implications on their behaviour may be an important factor in understanding the role of human behaviour in accident causation.

In this connection the "theory of risk homeostasis" presented by Wilde (1982) has raised my interest. Knowledge regarding road-users' perception of risk in conflicts ma be able to be used in the further discussion and verification, or rejection, of theories like the one presented by Wilde.

In order to be able to discuss this matter I will, therefore, start by making a short presentation of Wilde's theory.

8.2 Theory of risk homeostasis by Wilde

Wilde's general idea behind his theory of risk homeostasis is, that a person who is for instance, driving a car is acting in a way that may be understood as a homeo-statically controlled self-regulation process. At any moment of time the instantaneously perceived level of risk is compared with the level of risk the individual wishes to take, and decisions to alter on-going behaviour will be made wherever these two levels are discrepant. Whether the avoiding behaviour will have the desired result of re-establishing equilibrium between the target level and the perceived level of risk, depends upon the individual's perceptual, decisional and executional skills.

Wilde is presenting a task analysis model of driver behaviour. (See figure 8.1).

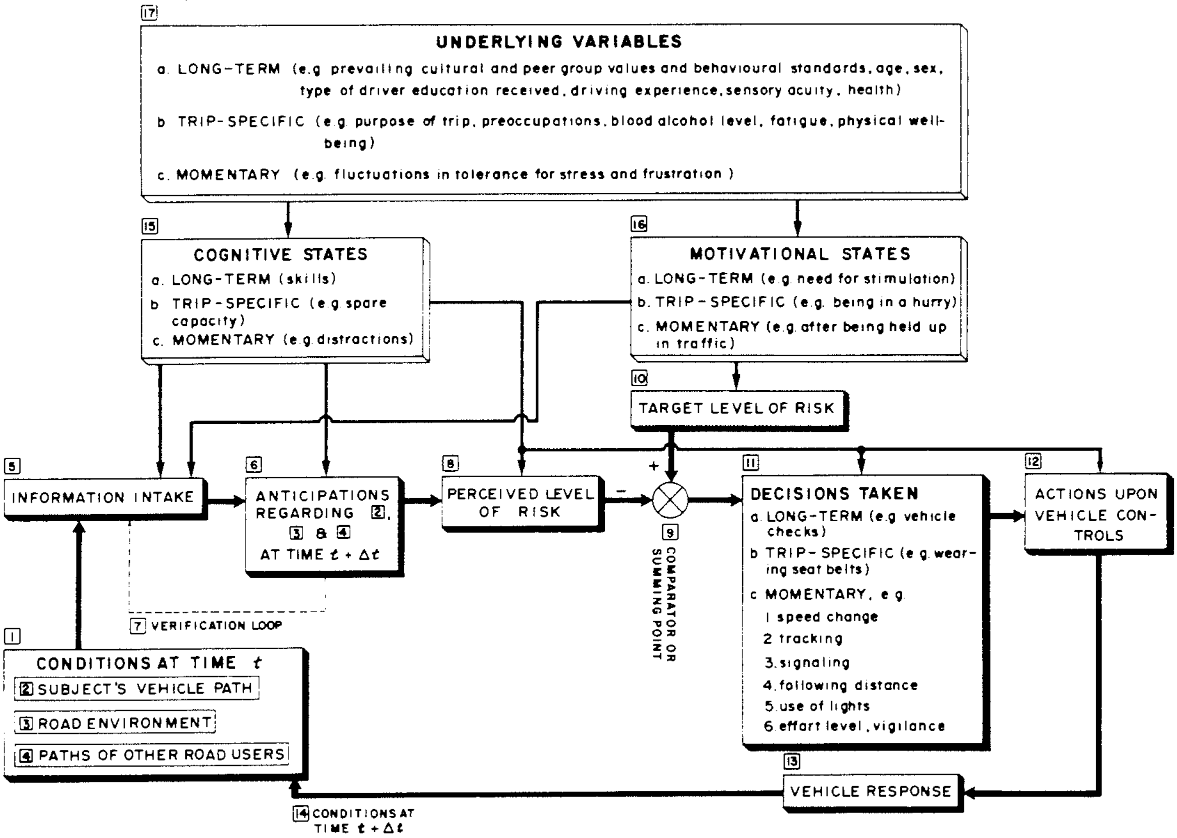


FIGURE 8.1 A SIMPLIFIED TASK ANALYSIS MODEL OF DRIVER BEHAVIOUR.
From: Wilde, 1982

Figure 8.1 deals with decisions that influence driver behaviour for a very short period of time, like a couple of seconds. Figure 8.2 below, which is a simplification of figure 8.1, sums across individual driver's or other road user's and it extends the time frame from a few seconds to a year or so. The skills (box 15 in Figure 8.1) have been subdivided into perceptual, decisional and executional (vehicle handling) skills (boxes 4, 2 and 3 in Figure 8.2).

Wilde argues that the skill factors as well as extraneous interventions provide a greater opportunity, but not a greater desire for safety. They do, at most, have a temporary effect upon the level of subjective and objective risk. The only factor that appears to determine the long-term level of subjective and objective risk is <u>the target level of risk</u>, which, in turn, is dependant upon the individual's evaluation of the costs and benefits of various action alternatives. This is the situation, Wilde claims, that provides a potential opportunity for external intervention for the purpose of reducing accident rates.

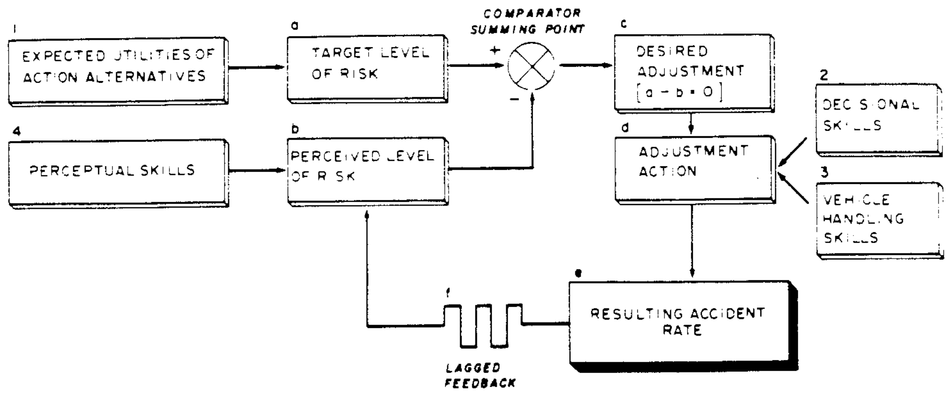


FIGURE 8.2 HOMEOSTATIC MODEL RELATING ACCIDENT RATE TO DRIVER BEHAVIOUR.
From: Wilde, 1982

The theory proposed by Wilde was earlier called the "Theory of Risk Compensation" but is now called the "Theory of Risk Homeostatis". According to the theory, fluctuation in the perceived accident rate is followed by adjustment actions that tend to stabilize the average accident rate over time.

In order to be able to come to a perceived level of risk and be able to compare this with the target level of risk, the road-user has to come up with some kind of estimation of the accident likelihood in different situations. Generally, Wilde says, the road-users are not explicitly informed of these likelihoods based on accident statistics as collected and analyzed by government agencies. Instead, they must distill risk estimates from their own day-to-day experience. This includes the number and intensity of emotional (i.e. anxiety provoking) events that occur to them on the streets and roads, events experienced as close calls or near-accidents, and the accidents they see either happening or the results after these occurred. Figure 8.3 describes the adjusted model, when drivers are receiving feed-back through personal experience, rather than from recorded accident frequencies.

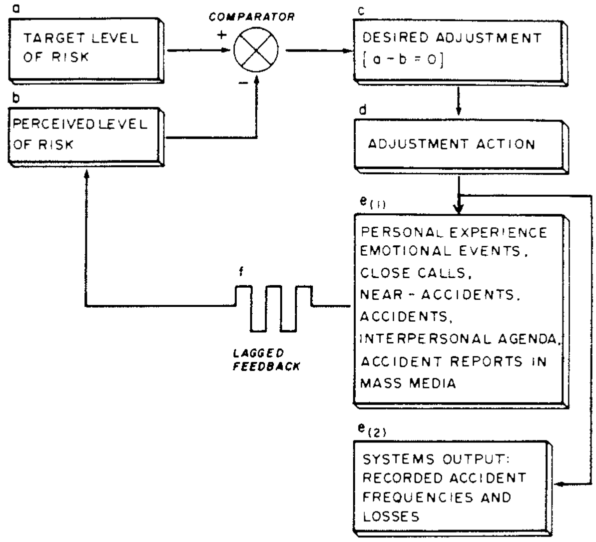


FIGURE 8.3 MODEL ADJUSTMENT TO ACCOUNT FOR DRIVERS RECEIVING FEEDBACK THROUGH PERSONAL EXPERIENCE e(1) RATHER THAN FROM SYSTEMS OUTPUT e(2). From: Wilde, 1982

I do not want to make any general statements with regard to Wilde's theory. There are, however, some aspects that I want to focus on, all more or less of interest in the perspective of the empirical findings I will present in next section:

1) There is no doubt that almost any safety-related countermeasure, of any kind, "modifies" road-user behaviour in some way. This "modification" may be due to many different factors, one of which is the perceived level of risk. The main point that I want to stress, however, is that this "modification" changes the risk level in a way that was not anticipated. Quite often this results in a "net" improvement of risk that is smaller than expected.

   The use of studded tyres is one example: Carlsson (1979) found in a study that vehicle drivers that had cars with studded tires drove faster than drivers without studded tires. One conclusion of the study was that the higher speeds by drivers with studded tires made the "net"-improvement smaller than originally anticipated.

2) The role played by the perceived level of risk is of great interest: How do for instance, road-users operationalize their perceived level of risk? What cues do they use to evaluate this risk level?

3) How does a change of the actual risk change the road-users' behaviour and how does this in turn influence the actual risk?

4) What role is played or could be played by conflicts in this context?

8.3 The perceived risk among road-users involved in conflicts

8.3.1 Introduction

The results presented in this section were achieved in a larger project dealing with the safety of unprotected road-users on arterial streets (Hydén, Ståhl, 1979, Hydén, 1981).

The main questions that I will deal with in this presentation are:

- Do road-users react specifically to events classified as serious conflicts compared to other events, i.e. can it be claimed that road-users do not deliberately get involved in such conflicts.
- What cues are road-users using in their operationalization of risk perception?

8.3.2 Technique used

The technique that was developed, and used in all six studies presented here, had the following design:

1. A conflict observer was installed at an intersection. Conflicts, serious as well as non-serious ones, were recorded.

2. Four policemen were located adjacent to the intersections closest to the one studied, one in each exiting direction. Immediately after a conflict was recorded the policemen were asked by the observer, via wireless communication to stop those vehicles that were involved in the conflict. Interviewers were always on hand at the intersection and they went straight to the locations where vehicles were stopped. Pedestrians were stopped by the interviewers themselves.

3. The interview was started as soon after the conflict occurred as possible. Normally, this was within 1-2 minutes after the occurrence of the conflict.

4. The first two questions were the only ones relevant to this presentation. They dealt with the attention paid by those involved in the conflict. The first question was: "Did anything particular happen when you passed that last intersection?" (The interviewer was given information about the conflict by the observer). The answer was immediately checked: if the answer was correct, i.e. if the correct conflict was mentioned, the interview continued with the second question. If the correct conflict was not addressed then the interviewer asked (specifically for each conflict), for example, "Didn't you see the pedestrian that you were forced to brake for?"

The second question was: "What is your assessment of a situation like the one you were involved in?" Three alternatives were mentioned:

- Could easily have ended up as an injury accident (EA)
- Could possibly have ended up as an injury accident (PO)
- Could hardly have ended up as an injury accident (HA)

5. All conflicts were recorded on video; afterwards four experienced conflict observers scored the conflicts from video, independently. The mean estimated values on Time to Accident and Conflicting Speed were then used as the objective values.

The idea behind the first of the two questions was to find out whether the conflict had caused any reaction at all among those involved. There are so many events occurring during a trip that all but the most "spectacular" ones have to be sorted out immediately. An event that is still remembered 1-2 minutes after the occurrence must, therefore, have produced a significant increase in the average "arousal" level.

The second question, that deals directly with the perceived risk, is phrased as it is because our serious conflicts are validated against (police-reported) injury accidents.

The answers to both questions were related to the following three factors:

1) Time to Accident (TA)
2) Conflicting speeds (CS)
3) Type of road-user.

At the time of these studies, 1977-79, the "new generation" definitions of severity were not developed. TA and CS are, therefore not combined in these studies in a way that enables me to test the results against any "new generation" definition.

8.3.3 The selected intersections

Altogether six intersections were selected. They were all four-way intersections and located in urban areas with a speed limit of 50 km/h, all on intersecting streets. Table 8.1 gives the characteristics of the intersections.

TABLE 8.1 INTERSECTION CHARACTERISTICS
Interviews with road-users involved in conflicts.

Intersection #	City	Type of regulation	Number of lanes	Priority rule
I	Malmö	Non-signalized	2 x 1	Give way
II	Malmö	-"-	2 x 2	Give way
III	Malmö	-"-	2 x 3	Right-hand priority
IV	Malmö	-"-	2 x 2	Right-hand priority
V	Göteborg	-"-	2 x 2	Give way
VI	Västerås	-"-	2 x 2	Give way

8.3.4 Missing data

In the first two studies, (Malmö I, Malmö II) the missing data was checked.

Table 8.2 shows that the missing interviews range from 20% to 31%. The results are fairly equal for the two intersections, with a somewhat larger proportion of missed interviews among the non-serious conflicts. The proportion of missed conflicts seems to be rather equally distributed among the three types of road-users. The two main differences are:

- Car drivers in car-car conflicts generally have a higher proportion of missed conflicts. This is not the case with car-drivers in other types of conflicts.

- Pedestrians have a significantly higher proportion of missed non-serious conflicts.

There were two main reasons for missed interviews:

- Cars or bicyclists were not stopped either because radio-communcation did not work, or the policeman could not fulfill his task due to the traffic situation. These misses represents 25% of the total.

- Road-users were stopped but they did not want to be interviewed. In the majority of these cases time-restraints were said to be the main reason (75% of the missing interviews).

In the first case there is no reason to believe that the missing interviews are biased.

In the second case, however, there is a risk that the missing interviews are biased, primarily with regard to the fact that these road-users said they were in a hurry. It is not possible, however, to state the character of the bias with regard to questions about perceived severity that we will analyze here. Still, these missing interviews only represent between 15% and a bit more than 20%.

TABLE 8.2 THE NUMBER OF INTERVIEWS AND MISSED INTERVIEWS
Interviews with road-users involved in conflicts
Malmö I + II

INTERSECTION: MALMÖ I

		Car-Pedestrian		Car-Bicyclist		Car-Car	Total
		Car-driver	Ped	Car-driver	Bic.		
Serious conflicts	The potential number of interviews	17	17	9	9	18	70
	The actual number of interviews	14	14	9	8	11	56
	Missing interviews, No.	3	3	0	1	7	14
	%	18	18	0	11	39	20
Non serious conflicts	The potential number of interviews	11	11	15	15	20	72
	The actual number of interviews	10	4	12	14	14	54
	Missing interviews, No.	1	7	3	1	6	18
	%	9	63	20	6	30	25

INTERSECTION: MALMÖ II

		Car-driver	Ped	Car-driver	Bic.	Car-Car	Total
Serious conflicts	The potential number of interviews	10	10	6	6	18	50
	The actual number of interviews	9	9	5	4	13	40
	Missing interviews, No.	1	1	1	2	5	10
	%	10	10	17	33	28	20
Non serious conflicts	The potential number of interviews	8	8	2	2	12	32
	The actual number of interviews	7	4	2	0	9	22
	Missing interviews, No.	1	4	0	2	3	10
	%	12	50	0	100	25	31

8.3.5 Results

The first part deals with the road-users' notice of conflicts, i.e. the answers to the first of the two questions. The results regarding the relation between the notice of conflicts and their Time to Accident value is presented in table 8.3.

TABLE 8.3 ROAD-USERS' NOTICE OF CONFLICTS COMPARED WITH THEIR TIME TO ACCIDENT VALUE

Intersection location	$TA \leq 1.0$ sec			$1.0\ s < TA \leq 1.5\ s$			$1.5\ s < TA \leq 2.0\ s$		
	Correct*	Yes*	No*	Correct*	Yes*	No*	Correct*	Yes*	No*
Malmö #	22	4	2	39	20	5	14	15	8
I + II %	79	14	7	61	31	8	38	41	21
Malmö #	23	0	1	17	10	12	6	5	3
III %	96	0	4	44	26	30	43	36	21
Malmö #	11	2	4	13	12	5	4	6	6
IV %	65	12	23	43	40	17	25	37	37
Göteborg #	11	1	2	15	3	3	2	0	1
%	79	7	14	71	14	14	67	0	33
Västerås #	10	2	1	16	5	1	1	1	0
%	77	15	8	73	23	4	50	50	0
TOTAL #	77	9	10	100	50	26	27	27	18
%	80	10	10	57	28	15	38	38	24

*) Correct; The road-user was referring to the correct conflict at once

Yes; The road-user remembered the conflict when being reminded

No; The road-user did not remember the conflict when being reminded.

The proportion of correct answers increases significantly with increasing severity, as measured by Time to Accident. Serious conflicts (TA ≤ 1,5 s) have a higher proportion of correct answers (0.5%-level), than non-serious conflicts. These proportions are fairly similar in the five studies. No statistically significant differences were found between the studies.

The second question dealt directly with the risk perceived by road-users involved in conflicts. The answers to this question, related to the Time to Accident of the conflicts, are summarized in table 8.4. Even in this case the answers are distinctly related to the TA-values, i.e. the lower the TA-values are the higher the proportion of answers "EAsily". The relationship is somewhat less clear than for the first question. Still, the proportion of answers "EAsily" is significantly (1%-level) higher for serious conflicts than for non-serious ones.

TABLE 8.4 ROAD-USERS' PERCEIVED RISK IN CONFLICTS RELATED TO TIME TO ACCIDENT VALUES.

Intersection location	TA≤ 1.0 s			1.0 s<TA≤1.5 s			1.5 s<TA≤2.0 s		
	EA*	PO*	HA*	EA	PO	HA	EA	PO	HA
Malmö #	6	6	15	10	9	45	2	10	25
I + II %	22	22	56	16	14	70	5	27	68
Malmö #	5	4	17	5	3	41	0	4	10
III %	19	15	65	10	6	84	0	29	71
Malmö #	8	1	8	4	6	17	1	3	13
IV %	47	6	47	15	22	63	6	18	76
Göteborg #	4	4	7	4	1	16	1	0	2
%	27	27	47	19	5	76	33	0	67
Västerås #	4	1	7	2	6	14	0	0	2
%	33	8	58	9	27	64	0	0	100
TOTAL #	27	16	54	25	25	133	4	17	52
%	28	16	56	14	14	72	6	23	71

* EA; Could EAsily ended up as an injury accident

PO; Could POssibly ended up as an injury accident

HA; Could HArdly ended up as an injury accident.

The influence of Conflicting Speed has only been studied for the I + II in Malmö. In Appendix 8.1,2 the detailed results are presented. Table 8.5 summarizes the results with regard to road-users' notice of conflicts. The table indicates small differences in the proportions between Conflicting Speed below and above 30 km/h. None of the differences are statistically significant.

TABLE 8.5 THE PROPORTION OF ROAD-USERS THAT REMEMBERED THE CONFLICT AT ONCE, RELATED TO CONFLICTING SPEED
Malmö I + II

	Serious conflicts (TA ≤ 1.5 sec)		Non-serious conflict (TA > 1.5 sec)		Total	
Conflicting Speed	>30km/h	≤30km/h	>30km/h	≤30km/h	>30km/h	≤30km/h
Proportion of road-users remembering the conflict at once	30/52[1)] 58 %	31/40 78 %	12/33 36 %	12/42 29 %	42/85 49 %	43/82 52 %

*) Remembering/Total

Table 8.6 summarizes the results of appendix 8.2 with regard to the perceived risk of road-users.

TABLE 8.6 THE PROPORTION OF ROAD-USERS THAT ANSWERED THAT THE CONFLICT COULD "EASILY" HAVE LED TO AN INJURY ACCIDENT, RELATED TO CONFLICTING SPEED
Malmö I + II

	Serious conflicts (TA ≤ 1.5 sec)		Non-serious conflict (TA > 1.5 sec)		Total	
Conflicting Speed	>30km/h	≤30km/h	>30km/h	≤30km/h	>30km/h	≤30km/h
Proportion of answers "easily"	9/44[1)] 20 %	7/38 18 %	3/21 14 %	4/31 13 %	12/65 18 %	11/69 16 %

1) Easily/Total

Again, the differences between the two Conflicting Speed intervals are very small and without any statistical significance.

For the Malmö (I + II) I have also split the data regarding perceived risk for road-user type involved. (Appendix 8.3). The results are summarized in table 8.7.

TABLE 8.7 THE PROPORTION OF ROAD-USERS THAT ANSWERED THAT THE CONFLICT COULD "EASILY" HAVE LED TO AN INJURY ACCIDENT, RELATED TO TYPE OF ROAD-USER Malmö I + II

		Serious conflicts (TA ≤ 1.5 sec)	Non-serious conflicts (TA > 1.5 sec)	Total
Unprotected road-users in conflict with protected road-users	Numb Proportions	9/29 [1)] 31 %	1/9 11 %	10/38 26 %
Protected road-users in conflict with unprotected road-users	Numb Proportions	4/33 12 %	1/13 8 %	5/46 11 %
Protected road-users in conflict with protected road-users	Numb Proportions	3/29 10 %	0/15 0 %	3/44 7 %

*) Easily/Total

The table indicates that unprotected road-users, tend to perceive a higher risk than the protected road-users, particularly in serious conflicts. The difference is statistically significant (the ratios between answers "easily" and other are compared) for serious conflicts and for the total, in both cases, however, only on the 10%-level.

Protected road-users seem to perceive the same risk in conflicts with unprotected road-users as in conflicts with other protected road-users.

In the studies in Malmö, IV, in Västerås and Göteborg, the first interview on the street was followed up, immediately afterwards with a video-session where the road-user was asked to comment on a couple of issues while watching the conflict.

In the beginning of each session the conflict was shown a couple of times so as to give the road-user the opportunity to get used to the media. In this context one of the questions was of particular interest: the direct question of perceived risk that was put forward at the on-road session was repeated at the video-session.

The results are summarized in table 8.8.

TABLE 8.8 PERCEIVED RISK BEFORE AND AFTER WATCHED THE CONFLICT ON VIDEO
Malmö IV, Göteborg, Västerås

		After the video-showing			
	Perceived risk	Easily	Possibly	Hardly	Sum
Before the video showing	Easily	15	3	4	22
	Possibly	2	10	5	17
	Hardly	2	10	37	49
	Sum	19	23	46	88

The missing interviews were numerous at these video-sessions. Only 88 out of 234 road-users (38%) agreed to participate. This was mainly due to the fact that it was considerably more time-consuming and inconvient because road-users had to walk to a van that was parked close to the location. Still, I think that these specific results give some indications of how road-users react when they are able to see all the details of the conflict repeatedly.

In total, 62 out of the 88 road-users (70%) kept their original opinion. Fourteen (16%) thought that the conflict was more severe and 12 (14%) thought it was less severe after having watched the conflict on video. Only in 6 cases (7%) did the road-user change opinion more than one step.

8.3.6 Conclusions

The results indicate clearly that road-users reacted much more strongly to serious conflicts than to non-serious ones, both regarding their notice of them and the perceived risk.

If one takes into account all the encounters that a road-user continously experiences in urban traffic, it is quite obvious that each individual encounter is kept in mind only for a very short period of time. In order to stay in the short-term memory of the road-user, an event must bear some odd characteristics. It is reasonable to presume that conflicts are remembered because an accident was close.

The results show that Time to Accident is strongly correlated to the perceived risk. At low Time to Accident values, most road-users seem to still remember the conflict 1-2 minutes after it occurred, while at high values rather few remembered it.

The answers to the direct question about perceived risk also revealed a distinct relation to Time to Accident. The interpretation of these answers, however, is not simple. The answer may, for instance, (except for the part concerning the "pure" perceived risk in the conflict), also reflect attitudes towards other road-users, road-user types, the specific road-user they conflicted with, or the attitudes to traffic safety in general. The interpretation has, unfortunately, not been possible to check afterwards.

Conflicts of different severity reflect, as was shown in section 7.3, different likelihoods of an injury accident. These likelihoods are very small, and not possible at all to derive empirically for the road-users. Still they tend to discriminate surprisingly well with regard to the Time to Accident criterion.

On the other hand conflicting Speed does not seem to correlate at all with the perceived risk. This might be due to one or both of the following facts:

- Conflicting Speed is "just" the speed when one of the road users starts an evasive action and not, for instance, the speeds when the road-users are closest to each other.

- Conflicting Speed only says something about the speed of the relevant road-user, and not about the speed of the other road-user involved in the conflict.

Unfortunately, data were not classified in a way that enabled me to test the new definition of a serious conflict, based on the ALT.DEF2 (see section 7.3). Such a test might have given a better perspective on the Conflicting Speed aspect than was the case.

The results discussed above may be used to test the hypothesis concerning "serious conflicts as being break-downs in the interaction between two road-users, i.e. at least one of the road-users would not deliberately get involved in a similar conflict".

Neither of the two questions that were put to the road-users involved in conflicts directly reflect the hypothesis. Indirectly they do, however. The question concerning road-users' notice of conflicts indicates to what degree the road-users were mentally stressed by the conflict and, indirectly, to what degree they would not like to get involved deliberately in a similar conflict. The question directly concerned with the perceived risk in conflicts indicates more clearly the extent to which road-users would avoid getting involved in a similar conflict. Especially when they answered that the conflict could "EAsily" have ended up as an injury accident, is it reasonable to suppose that they would <u>not</u> deliberately like to get involved in a similar conflict.

The following comments may now be made with regard to the hypothesis mentioned above:

- If one looks at serious and non-serious conflicts as a whole, the hypothesis seems to be verified to a fairly large extent. Serious conflicts, in our sample, produced significantly more answers that indicated a "mental stress" among the road-users. If the results are extrapolated one can see that the proportion of road-users that spontaneously recognized the right conflict and said that it could "Easily" have ended up as an injury accident was approaching 0% when the TA-value is approaching 2.5-3.0 sec, while the proportions would approach 100% when the TA-value is approaching 0 seconds. This means that if all conflicts within this TA-range are included, then there is a considerable difference between the average serious conflict and the average non-serious conflict. Regarding the spontaneous recognition of the conflict the serious conflicts would range between 60% and 100% while the non-serious conflicts would range between 0% and 40%. Regarding the answers to the question concerning the perceived risk in conflicts, the proportion that answered "EAsily" would range from 14% to 100% for serious conflicts, and from 0% to 6% for non-serious conflicts.
  To conclude: there is a very distinct difference between serious and non-serious conflicts with regard to the road-users' reaction to the conflicts. On the other hand, it is difficult to claim, based on the results presented, that "there is <u>always</u> at least one road-user in serious conflicts that does not want to get involved in a similar conflict deliberately", and that "there are <u>no</u> such road-users in non-serious conflicts".

- The last two statements above postulate that there is a discrete changeover from serious conflicts to non-serious ones, i.e. that there exists a distinct threshold at TA = 1.5 seconds with regard to how the road-users react to the conflict.

  Such a threshold does not exist, however. The changeovers seem to be continous to its nature. This implies that the critical value of 1.5 seconds does not seem to be a threshold value. From this point of view it would, therefore, seem to be alright if the value had been somewhat higher or lower.

  Unfortunately the test of the threshold could not be made on the new definition, ALT.DEF.2 (see section 7.3). That could have introduced the speed aspect in a more relevant way than was the case now.

To summarize the discussion above, the main conclusions with regard to the hypothesis are:

o **It looks as if the hypothesis is verified to a large extent, i.e. most serious conflicts seem to create such a high level of "arousal" among the involved road-users that they would not like to get involved in a similar conflict deliberately.**

o **Most non-serious conflicts do not seem to create the same high level of "arousal". At the same time it seems clear that this level of "arousal" is continous with Time to Accident, even in the area where Time to Accident equals**

1.5 seconds. Even though there is no distinct threshold value, the chosen border between serious and non-serious conflicts (TA = 1.5 sec) still seems to be approximately of the right size, from the point of view of road-user' reactions.

Interview studies, focusing more specifically on the aspect of "deliberate involvement in conflicts", would provide us with more in-depth knowledge. For instance, the threshold between serious and non-serious conflicts could then be better defined regarding road-users' reactions and related to aspects of validation against accidents.

The break-down into road-user types, indicates that unprotected road-users perceive a higher risk than protected ones.

Risk is, however, somewhat ambiguous here: the car driver might think of the risk for himself personally, not for the pedestrian (at least subconsciously, while driving). There are also, however, some other possible explanations for the differences found:

- An unprotected road-user does feel more vulnerable.

- An unprotected road-user is "closer to the scene", not insulated in a cabin as the protected road-user.

- The protected road-user is most often the one that takes the evasive action. This might give him a better understanding of the potential need for avoiding an accident. At the same time this might create a feeling of frustration for the unprotected road-user.

It is not possible from these studies to find out what factor contributes most to the found difference between how different road-user types perceive risk. This knowledge may, however, be of interest in the whole process of trying to understand the motives behind the behaviour of road-users.

The main conclusion from the video-session regarding perceived risk is that a great majority kept their original opinion, and when the opinion was changed, it was done equally often in both ways. It, therefore, seems as if road-users had a "realistic" view of the perceived risk in the field.

A comparison of the results presented in this section with the findings from the calibration study in Malmö, where the results of eight teams were combined, (see also section 7.4) draws attention to some interesting points:

- The most important factor, when discriminating conflicts with regard to severity, was found to be Time to Collision (TTC) in the calibration study in Malmö. This measure is closely related to Time to Accident, which seems to be the most discriminating factor among road-users themselves.

- The second most important factor in the calibration study in Malmö was both "type of road-user" and "speed". Even the road-users themselves seemed to discriminate with regard to "type of road-user" involved although in a more limited way. "Speed", however, was not found to influence the perceived risk in our own study. One reason might be that "speed in the Malmo-study meant the speed of the road-users during "the whole" conflict, while "speed" in our study meant the Conflicting Speed, i.e. the speed of one of the road-users in the moment the evasive action is started.

On the whole, however, the comparison with the results from the calibration study in Malmö shows that there is a good deal of consensus between road-users' perception of risk in conflicts and the way in which eight different conflict techniques operationalize severity of conflicts. This indicates to me that road-users once involved in conflicts have a very realistic view of the risks involved. The only-draw back in our own study is that we restricted the control group to "non-serious" conflicts, based on our definition. An enlarged control group may have revealed some other types of events that were ranked high with regard to perceived risk.

8.4 Discussion related to Wilde's theory

Our studies focused entirely on the perceived risk once road-users get involved in conflicts. This is, on the other hand, according to Wilde, one of the main factors that contributes to the perceived level of risk that each road-user is ending up with. This perceived level of risk, again according to Wilde, is then compared to the target level of risk. To improve safety, Wilde claims, one has to change the road-users' target level of risk.

Now the interesting thing is that the target level of risk, in my opinion, must be based on similar grounds as the perceived level of risk, otherwise they can never be compared. This means that one of the main elements contributing to the target level of risk is emotional events, such as close-calls or near-accidents. A reasonable hypothesis, then, is that the target level of risk is operationalized by the road-user in limiting the number and intensity of emotional events to a certain maximum level. The problem, however, is that the road-user can not relate this maximum level of emotional events to a certain accident risk. The road-user has no reliable or valid technique to transform his emotional events into a likelihood of an accident. Besides, one might assume that the road-user probably operates with a target level of risk that is so low that he will not be involved in an accident during his "lifetime". This is obviously false, most probably because he under-estimates the accident-potential of the emotional events that he gets involved in.

One very obvious countermeasure, therefore, would be to influence on the road-users' way of interpreting close-calls or near-accidents. The results I have shown in section 8.3

indicate that such an approach is theoretically possible: the major criterion to be fulfilled is that road-users are able to detect the near-accidents. Our results show that road-users are able to detect conflicts based on our definition and also that they seem to be very sensitive to the severity of the conflicts. Consequently, the potential seems high regarding the possibility of teaching the road-users to select conflicts with a certain minimum level of severity. (The reliability probably does not have to be very high). Our reliability tests of observers (see also chapter 4) show that observers, no matter what formal skills they had, were able to record conflicts reliably. The countermeasure then would be, according to Wilde's vocabulary, a "motivational intervention" that teaches the road-users to conceptualize conflicts, and that the accident potential of a certain conflict is higher than "what they think". I will not go into detail either as to how this could be achieved or in what way, e.g. through general information campaigns, through driver schools or any other way.

9 CONCLUSIONS AND COMMENTS

In this chapter I will summarize the findings I have presented. I will also try to define the present status of the Swedish Traffic Conflicts Technique. I have chosen to go through the main topics one by one.

I. Definitions

An accident has been defined in the same way in all validity studies that we have been carrying out thus far. The definition is based on police-reported injury accidents. This is, of course, not completely satisfying but the reason why we have done it, namely to keep the reporting rate as high as possible and still include as many accidents as possible, is still justifiable with regard to the lack of better sources. It is, however, a well-known fact that today in Sweden the police-statistics only cover a small part of all injury accidents. Linderholm and Olsson (1987) have, for instance, shown that only one out of ten injury accidents to children were known by the police. The main part of the missing accidents was, however, "single bicycle" accidents, "bicycle-bicycle" and "bicycle-pedestrian" accidents. None of these types have been included in our validity studies yet, which makes the police-statistics more suitable for us.

Still, it is a fact that there is quite a large proportion of accidents that are of potential interest for our studies that we have no information about, (especially if damage-only accidents are included, which they should be of course).

No matter what source of information is used, however, it still seems to be both difficult and time/resource-consuming to get an acceptable estimation of all accidents that occur. In the somewhat longer run, it may be possible to collect accident data from the field, through some kind of video-based technique for automatic image processing. If such a technique could be combined with the collection of conflict-data, it would open up for improved validation studies using more reliable (accident- and conflict-) data.

The definitions of severity and of a serious conflict are critical. These definitions must be based on a theory that connects serious conflicts with accidents. If such a theory does not exist there is an obvious risk that efforts to link serious conflicts to accidents, either through a product or process validation, will fail. The conflicts would then only reflect some kind of disturbance or exposure measure. Consequently, the conflicts could not work as a complement to accidents and the usefulness of such a technique would be very limited. Our technique is based on a theory about serious conflicts being the last link in a chain of elementary events with increasing severity. The serious conflicts are characterized by a break-down in the interaction between two road-users. At least one of the road-users does not deliberately want to get involved in a similar conflict. Some of the serious conflicts are so severe that they lead to collisions.

This theory is fairly well verified, through interviews with road-users involved in conflicts and through the different validation studies.

It seems clear to me that the new definition of severity (ALT.DEF.2) built on a relation between Time to Accident and Conflicting Speed, (see sections 7.2 and 7.3) and the new definition of a serious conflict, are both a great improvement from a theoretical point of view. This is also confirmed in the process validation (section 7.3) where the new definition of severity was compared with four others, one of which was the old definition based on Time to Accident only.

The new definition fulfilled all the important criteria, e.g. a logic severity classification of accidents and conflicts and a considerable overlap between conflicts and accidents. The fulfillment of the criteria was much more complete with the new definition, compared to the other four.

The question of further changes, modifications or additions to the definition of a serious conflict must, at present, be looked upon with great hesitation. As I have mentioned in chapter 6, there are some smaller modifications that might be feasible. With the accident and conflict data that is available today or could be available through the conventional data sources, it is very doubtful, however, whether it is possible to detect an actual improvement that is not very big. From a theoretical point of view no such big improvements can be anticipated, and changes or modifications should, therefore, be given low priority at present.

I do think that our technique, given collision course and a "simple" TA-Conflicting Speed relation as a basis, covers all the important types of conflicts. There does not seem to be any specific type of accident that is not covered by our definition. It was, for instance, shown in section 7.3 that the majority of accidents were preceded by an evasive manoeuvre. When this was not the case (TA = 0) there was simply enough not ample time to start an evasive manoeuvre. The analysis in section 7.3 showed that serious conflicts with TA = 0 were not biased in any particular way. They just formed a natural part of the "Time to Accident - Conflicting Speed" graphs.

II Reliability

I have presented quite a few different results all indicating that our observers record serious conflicts in a very reliable way. The new reliability test (section 7.6), where our observers' estimations were compared with an objective evaluation of Time to Accident and Conflicting Speed, was a very strong confirmation of earlier results. The fact that the proportion of missed conflicts was only a bit more than 20% is very encouraging as well as the fact that only 5-10%

'extra' scorings were made. There is, for instance, no individual accident information system that comes close to such a reliability. The high reliability is confirmed by the excellent scoring ability: in almost half of all conflicts the difference between observers' estimations and objectively evaluated TA-values was less than $\pm$ 0.2 seconds (two tenths of a second), and in a bit less than 80% of all conflicts the difference was less than $\pm$ 0.4 seconds. It can be concluded without hesitation that well-trained observers produce very reliable results. The reliability is so high that it will probably be a long time before a semi-automatic or fully automatic technique is developed that is cost-benefical compared with written records made by human observers.

The only remaining potential risk with human observers is that they may loose attention and motivation in the long run. It has only been possible to study the reliability of observers indirectly, through comparisons of day-to-day counts of conflicts using different observers. (Chapter 4). These studies indicated no major biases. On the other hand, they were no perfect tests of the long-term, individual, performance because the observers knew that there would be a follow-up.

I have not seen a perfect test of this type anywhere else and I can, therefore, not indicate what importance the long-term attention and motivation may have. It might be worthwhile to try and design such a study.

III Validity

The first validation study (chapter 5) produced some promising results. Some of the preconditions as well as some of the methodological considerations did, in the long run, not seem to be perfectly wise. One consequence was, for instance, that the actual variance in the accident-to-conflict ratios was not calculated. This, in turn, made it difficult to study the homogeneity between the three data-sets that were compared (Malmö - 50 intersections, Malmö - 15 and Stockholm - 50, see section 5.5).

Besides, the quality of the ratios was not studied, i.e. estimates for the "product" (expected number of accidents) were not produced via conflict counts and compared with accident counts. The latter comparison is now being carried out in the on-going product validation project in our Department as I have mentioned earlier. This on-going project is also based on new methods of validation and the results will hopefully give better indications with regard to the usefulness of conflicts for prediction of the average number of accidents. At the same time it must be pointed out that our technique has been used in this context for appr. 10 years with obvious benefits, some of it demonstrated in chapter 5. Besides, evaluating the "product" is not the only aim of our technique. Evaluating the "process" is also a very important aim, particularly to study the behaviours and events leading up to the accidents in order to identify causes that could be transformed into countermeasures. Both for this second aim and for the first, I think that my new approach to validation (section 7.3) is of great importance. By comparing the last phases of accidents and serious conflicts, I managed to optimize the severity definition (within the limits data set).

I also managed to show the very striking similarities between accidents and conflicts when the Time to Accident - and Conflicting Speed - based severity definition was used. The overlap was big, and there were very strong indications that accidents and serious conflicts were following a similar process in their last parts. The only obvious difference was that accidents "went one step further" than serious conflicts, i.e. that there was a collision.

As I mentioned before, the severity definition worked, both for accidents and conflicts. This means, for instance, that the results indicated that the accident-to-conflict ratio increased with increased, defined, severity. The results also indicated that the outcome of a collision was more severe the higher the defined severity was. Due to inaccuracy in the accident information and too few accidents and conflicts, it was not possible to produce any new conversion factors between serious conflicts and accidents based on these results. The approach as such is, however, very promising according to my point of view. A process validation, similar to the one I have presented in section 7.3, based primarily on a split among road-user types, manoeuvre types and severity classes would probably produce more accurate and competitive conversion factors, presumed more accurate accident information and a considerable increase in the size of accident and conflict data (where available).

The latter is, however one general problem that all researchers have had to live with thus far. Accident information systems have always had built in inaccuracies of different kinds, and the more sophisticated the information that is warranted (as in my process validation), the more severe the inaccuracies.

Another general problem so far seems to be that the recording of conflicts is always a very time- and resource-consuming procedure.

The conclusion is, therefore, that there must be new approaches both on the accident side and on the conflict side in order to overcome the general problems that exist today. My opinion is that semi-automatic and fully-automatic video-based techniques for image-processing, will solve the problems on the conflict side and perhaps the accident side in the long run. Regarding the high reliability of human observers demonstrated in this report, a video-based technique through which a sample of events could be <u>selected</u> (not evaluated in detail), including the serious conflicts, could be a very useful tool. Human observers could then evaluate the events in a second step. Such a technique would enable the collection of sufficient numbers of serious conflicts with an acceptable degree of reliability.

Regarding the process validation of conflicts, my presentation in section 7.3 represents only a start, even though an important one. Included in the notion "process validation" is also everything that lies ahead of that last part of the process that I have been able to study. It includes everything that can describe the events/behaviours that precede the conflict/accident and the causes (in the widest possible sense) that can "explain" the conflict/accident and give guidance in selecting countermeasures.

A validation of this kind, of course, presupposes much more accurate and detailed information than is available to day. A video based technique for image-processing, seems, again, to be by far the most promising way to obtain, at least parts, of this information.

IV The use of the Traffic Conflicts Technique (TCT)

This topic has not been dealt with to any great extent in the report. Still, I want to make a few comments:

- We have, in the Department, demonstrated the usefulness of the technique in quite a few research projects. They have primarily focused on the relationship between physical design, regulations as well as other traffic engineering variables and safety. There are other areas, for instance, within the social sciences, where the technique has been used.

  Thanks to the TCT we have identified severe safety problems connected with the design of bicycle facilities at intersections. (Linderholm, 1984, HB SÄKTRA, 1987).

The existence of these problems were verified <u>later on</u> through accident analysis both in Sweden and in Denmark. Due to this, a project was initiated on the Nordic level in order to find the causes of the identified safety problems. The TCT will play one of the important roles in this project.

The TCT has also been used at our Department for before and after studies in order to follow up the effects of different countermeasures. Some of these are presented in the end of chapter 5. The results show that, thanks to the TCT, it has been possible to obtain an early estimation of the safety effects.

These kinds of follow-up studies have, for instance, made it possible to introduce speed-reducing countermeasures, particularly speed humps, on an experimental basis. The quick follow-up made it possible to check for any draw-backs in the countermeasures before these draw-backs caused any accidents.

In general, one must therefore conclude that the use of TCT in our research has produced valuable results that have increased the general level of knowledge about the relationship between traffic engineering measures and safety.

The general interest in use of the TCT is growing steadily internationally - The International Committee on Traffic Conflict Techniques (ICTCT) that was formed in 1979, is now coordinating the common interests of almost 20 countries. The international calibration study in Malmö, 1983, was the first major activity organized by ICTCT. (Presented in section 7.4).

The Swedish TCT has also been used individually in studies abroad. The major project in connection with this was a Dutch contract where the general aim was to compare different ways of reorganizing and redesigning residential areas. Our task was to study the safety aspect at the borders between residential areas and surrounding arterial streets. (Traffic Safety Group, 1983).

Regarding the use of TCT for research it has become more and more obvious, not only for us but for other researchers, that the TCT must be placed in a wider perspective, i.e. the TCT must be looked upon and used as one of many tools in the evaluation of safety. This is common sense today but it has not been regarded so by many researchers, particularly those who have not been directly involved in research in this area. The development of a TCT is such a big effort in itself, that big resources and mental efforts have been focused on the developmental work. The TCT is now well established and carefully examined in quite a few countries, and it has therefore become optional to put more efforts into it's development and instead use integrated evaluation techniques with the TCT as one tool.

I must, in this connection, mention a large research project that is going on in the Department. The main aim is to develop and test a "total" traffic safety program for a Swedish municipality (Växjö, appr. 70 000 inhabitants). "Total" stands for the integration of all kinds of countermeasures, e.g. information campaigns, enforcement, education, physical and planning measures, etc. One secondary aim of the project is to develop an evaluation technique for use by other municipalities. For this purpose all possible information is collected, such as accident information from the police, hospitals and insurance companies, interviews with children, conflict and behavioural data, exposure data, environmental data, etc. All these sources will be compared with regard to their potential use in different phases of the evaluation procedure.

This project will provide an excellent opportunity for finding out what role the TCT can play in connection with safety evaluation on a local level.

The use of the Swedish TCT for practical applications has been fairly extensive over the years, but it is only the city of Göteborg that has implemented the technique on a larger scale within its own organization. In all other cases the technique has been used for specific tasks. A routine-based implementation has not been found to be cost-effective.

The Swedish National Road Administration has trained conflict observers at all their regional offices. Still the use has been limited.

The reasons for a limited implementation of the technique can, of course, be many. One of the most important ones, I think, is that it demands fairly extensive human resources to carry out a study. Funds and resources have to be reallocated to a new area that has not previously demanded any resources. This creates problems within the organizations.

The relatively high costs for a conflict study is a problem with all sorts of applications. As I mentioned before, it is a problem in the validation of TCT:s and it is also a problem in the implementation of the technique for practical safety work.

The results presented in this report have demonstrated the fact that all methodological topics of importance, such as definitions, reliability, and validity, can be kept well under control. Due to limited funds and high costs for the collection of data, the data-files have, however, been limited in size. Larger files would make it possible to improve the accuracy in the conversion factors between serious conflicts and accidents.

To conclude: The need for more cost-effective conflict-recording techniques seems to be the major remaining hindrance for our TCT becoming generally available and attractive for use, in research and in other areas of application.

REFERENCES

BRÜDE, U and LARSSON, J, (1982). Regressionseffekt. Några empiriska exempel baserade på olyckor i vägkorsningar. Statens Väg- och Trafikinstitut, rapport nr 240, Linköping.

CARLSSON, G, (1979). Åtgärder mot snö- och ishalka; Problemanalys, kunskapsöversikt och behov av FoU. Statens Väg- och Trafikinstitut, rapport nr 182, Linköping.

ERKE, H and ZIMOLONG, B and GSTALTER, H, (1979). Feststellung und Bewertung von gefährlichen Konfliktsituationen im Innerortsverkehr. FP 7615/2. Institut für Psychologie, Abteilung für angewandte Psychologie. Braunschweig.

GRAYSON, G ed (1984). The Malmö Study; A Calibration of Traffic Conflict Techniques. Institute for Road Safety Research SWOV, Leidschendam.

GÅRDER, P, (1982). Konfliktstudier i landsvägskorsningar. Bulletin 42. Institutionen för Trafikteknik, LTH, Lund.

GÅRDER, P and HYDÉN, C, (1978). Allgåfas i signalreglerade korsningar. Bulletin 26. Institutionen för Trafikteknik, LTH.

HAUER, E, (1978). Traffic Conflict surveys: Some study design considerations. TRRL Report SR 352. Transport and Road Research Laboratory, Crowthorne, Berkshire.

HAUER, E, (1986). On the Estimation of the Expected Number of Accidents. Accident Analysis & Prevention. Vol. 18, No.1, pp1-12.

HAUER, E and GÅRDER, P, (1986). Research into the Validity of the Traffic Conflicts Technique. Accident Analysis & Prevention. Vol 18, No. 6, pp471-481.

HAYWARD, J C, (1972). Near Miss Determination through Use of a Scale of Danger. Traffic Records. Highway Research Record. No. 384, pp24-34, Highway Research Board, Washington D.C.

HB SÄKTRA, (1983). Effekten av olika driftformer i en friliggande gång- och cykelsignal, Bjärred.

HB SÄKTRA, (1986). Konflikter mellan bilister och cyklister i signalreglerade korsningar. Studier i två korsningar i Köpenhamn, en med och en utan "cykelsti", Bjärred.

HYDÉN, C, (1977). A Traffic-Conflicts Technique for Determining Risk. Bulletin 15 B, Institutionen för Trafikteknik, LTH, Lund.

HYDÉN, C, (1981). Oskyddade trafikanters säkerhet på stomgator. Rapport nr 7024. Institutionen för Trafikteknik, LTH, Lund.

HYDÉN, C and STÅHL, A, (1979). Åtgärder i trafikmiljön för att öka oskyddade trafikanters säkerhet på stomgator. Rapport nr 7018. Institutionen för Trafikteknik, LTH, Lund.

KRAAY, J H, ed (1982). Proceedings of the Third International Workshop on Traffic Conflicts Techniques, organized by the International Committee on Traffic Conflicts Techniques, ICTCT. R-82-27. Institute for Road Safety Research SWOV, Leidschendam.

LINDERHOLM, L, (1981). Vidareutveckling av konflikttekniken för riskbestämning i trafiken. Rapport nr 7025. Institutionen för Trafikteknik, LTH, Lund.

LINDERHOLM, L, (1984). Signalreglerade korsningars funktion och olycksrisk för oskyddade trafikanter. Delrapport I. Cyklister. Bulletin 55. Institutionen för Trafikteknik, LTH, Lund.

LINDERHOLM, L and OLSSON, B, (1987). Trafikolycksfall bland grundskoleelever - studieobjekt Växjö kommun. Bulletin 69. Institutionen för Trafikteknik, LTH, Lund.

MALMÖ GATUKONTOR, Trafikavdelningen, (1985). Trafikolyckor i Malmö, 1984.

PERKINS, S R and HARRIS, J I, (1968). Traffic conflict characteristics: Accident potential at intersections. Highway Research Record. 225, pp35-43, Highway Research Board, Washington D.C.

PLANFOR, (1972). Metod för erfarenhetsåterföring avseende trafiksäkerhet vid trafikreglering av stadskärnor. Utvecklingsstudier före och efter trafikregleringen i Lunds stadskärna 1971. PLANFOR. Meddelande nr 41. Institutionen för Trafikteknik, LTH.

PLANFOR, (1973). Trafiksäkerhet i Uppsala stadskärna. PLANFOR. Meddelande nr 57. Institutionen för Trafikteknik, LTH.

ROBBINS, H, (1980). Some estimation problems for the compound Poisson distribution. Asymptotic Theory of Statistical Tests and Estimation. pp251-257. Academic, New York. In: Hauer (1986).

SPICER, B R, (1971). A pilot study of traffic conflicts at a rural dual carriageway intersection. RRL report LR410. Road Research Laboratory, Crowthorne, Berkshire.

SPICER, B R, (1972). A traffic conflict study at an intersection on the Andoversford by-pass. TRRL Report LR 520. Transport and Road Research Laboratory, Crowthorne, Berkshire.

SPICER, B R, (1973). A study of traffic conflicts at six intersections. TRRL Report LR 551. Transport and Road Research Laboratory, Crowthorne, Berkshire.

TRAFFIC SAFETY GROUP (1983). An evaluation study of the replanning and redesigning of urban areas. Bulletin 56. Department of Traffic Planning and Engineering, Lund Institute of Technology, Lund.

TRK, (1978). TRK:s haverikommission; Redogörelse för en försöksverksamhet. TRK Rapport nr 1. Försäkringsbranschens Trafiksäkerhetskommitté, Stockholm.

VAN DER HORST, A R A (1982). The analysis of traffic behaviour by video. In: KRAAY (1982).

VAN DER HORST, A R A and RIEMERSMA, J B J, (1981). Registration of Traffic Conflicts: Methodology and practical implications. Report nr. IZF1981 C-22, Institute for perception TNO, Soesterberg, The Netherlands.

VEJDATALABORATORIET, (1982). EMMA-rapport 3. Signalregulering av fodgaengereffekter. Sikkerhedsmaessig effekt. Rapport 29. Vejdatalaboratoriet, Vejdirektoratet, Herlev, Danmark.

VÄGVERKET, (1983). Dokumentation av färdtekniska grundvärden och linjeföring. TU 1983:4. Vägverket, Borlänge.

VÄGVERKET, (1985). Friliggande gång- och cykelsignaler. Försök med olika driftformer. TU 160. Vägverket, Borlänge.

WILDE, G, (1982). The theory of Risk Homeostasis: Implications for Safety and Health. Risk Analysis. Vol. 2, No 4, pp209-225.

FIRST TEST OF OBSERVER RELIABILITY

CONFLICT SITUATION NO	TIME OF DAY	KIND OF ROAD USER INVOLVED[1)]	SERIOUS CONFLICT ACCORDING TO EVALUATION OF VIDEO-TAPES[2)]	SERIOUS CONFLICT ACCORDING TO THE OBSERVER'S RECORDING[2)]				
				A	E	H	J	M
1	16.08	C - B	1	1	1	2	1	-
2	16.11	C - P	3	3	3	3	3	-
3	16.17	C - C	-	-	1	-	-	-
4	16.20	C - P	3	3	3	3	3	3
5	16.30	C - P	4	4	4	4	4	4
6	16.54	C - C	-	-	3	-	-	-
7	16.55	C - B	1	-	-	1	1	1
8	17.01	C - M	1	1	1	1	1	1
9	17.03	C - C	4	4	4	4	2	4
10	17.35	C - C	2	2	2	1	2	2
Total:			8	7	9	8	8	6

1) KIND OF ROAD USER INVOLVED:
C = Car driver
B = Bicyclist
P = Pedestrian
M = Moped driver

2) The figures concern the degree of seriousness in four classes of the serious conflicts (see section 4.2).

Location: No 13 in Malmö, Amiralsgatan - Spånehusvägen. Wednesday, 1974-06-06, 16.00 - 18.00

SECOND TEST OF OBSERVER RELIABILITY

CONFLICT SITUATION	TIME OF DAY	KIND OF ROAD USER INVOLVED 1)	SERIOUS CONFLICT ACCORDING TO EVALUATION OF VIDEO-TAPES 2)	SERIOUS CONFLICT ACCORDING TO THE OBSERVER'S RECORDING 2)						
				L	H	M	T	P	J	R
1	12.32	C - C	2	1	2	2	-	2	2	1
2	12.40	C - C	1	1	-	1	1	1	2	1
3	12.47	C - P	-	-	-	1	-	-	-	-
4	16.15	C - C	-	-	1	-	-	-	-	-
5	16.44	C - P	1	1	-	-	1	1	1	1
6	16.57	C - C	2	1	3	1	1	1	2	1
7	18.07	C - C	2	1	1	-	1	2	2	2
Total:			5	5	4	4	4	5	5	5

1) KIND OF ROAD USER INVOLVED:
C = Car driver
B = Bicyclist
P = Pedestrian
M = Moped driver

2) The figures concern the degree of seriousness in four classes of the serious conflicts (see section 4.2)

Location: No 5 in Malmö, Studentgatan - St Nygatan, Tuesday, 1976-06-03, 11.35 - 13.00 and 15.55 - 18.15.

ACCIDENTS AND CONFLICTS PER TRAFFIC CLASS, KIND OF ROAD USER AND PERIOD OF OBSERVATION
Malmö - 50 intersections, 1974

Traffic class	Kind of road-user	Time period 1)	Number of accidents	Obs. time accid. (min)	Number of accidents per min	Number of conflicts	Obs. time conflicts (min)	Number of conflicts per min	Number of accidents per minute/Number of conflicts per min
1	car-ped	1	14	4.13×10^{7}	3.40×10^{-7}	39	6.23×10^{3}	6.26×10^{-3}	5.4×10^{-5}
2	-"-	1	6	0.842 "	7.13 "	16	1.37 "	11.7 "	6.1 "
3	-"-	1	40	1.68 "	23.8 "	10	2.35 "	4.26 "	56.0 "
4	-"-	1	7	0.842 "	8.31 "	1	1.37 "	0.73 "	114.2 "
1	-"-	2	13	1.47 "	8.84 "	35	5.19 "	6.74 "	13.1 "
2	-"-	2	6	0.301 "	19.9 "	8	1.21 "	6.61 "	30.2 "
3	-"-	2	32	0.601 "	53.2 "	9	1.99 "	4.52 "	117.1 "
4	-"-	2	8	0.301 "	26.6 "	0	1.21 "	0 "	-
1	car-bicycle	1	7	4.13 "	1.70 "	11	6.23 "	1.76 "	9.6 "
2	-"-	1	7	0.842 "	8.31 "	4	1.37 "	2.92 "	28.6 "
3	-"-	1	5	1.68 "	2.98 "	8	2.35 "	3.40 "	8.7 "
4	-"-	1	7	0.842 "	8.31 "	4	1.37 "	2.92 "	28.6 "
1	-"-	2	6	1.47 "	4.08 "	9	5.19 "	1.73 "	23.5 "
2	-"-	2	2	0.301 "	6.64 "	4	1.21 "	3.30 "	20.1 "
3	-"-	2	13	0.601 "	21.6 "	11	1.99 "	5.53 "	39.1 "
4	-"-	2	5	0.301 "	16.6 "	2	1.21 "	1.65 "	100.6 "
1	car-car	1	4	4.13 "	0.97 "	31	6.23 "	4.98 "	1.9 "
2	-"-	1	3	0.842 "	3.56 "	5	1.37 "	3.65 "	9.8 "
3	-"-	1	6	1.68 "	3.57 "	25	2.35 "	10.6 "	3.3 "
4	-"-	1	10	0.842 "	11.9 "	12	1.37 "	8.76 "	13.6 "
1	-"-	2	1	1.47 "	0.68 "	35	5.19 "	6.74 "	1.0 "
2	-"-	2	0	0.301 "	0 "	8	1.21 "	6.61 "	0 "
3	-"-	2	9	0.601 "	15.0 "	28	1.99 "	14.1 "	10.6 "
4	-"-	2	3	0.301 "	9.97 "	20	1.21 "	16.5 "	6.9 "

1) Time period 1: 09.00-16.00, time period 2: 16.00 - 18.30

ACCIDENTS AND CONFLICTS PER TRAFFIC CLASS, KIND OF ROAD USER AND PERIOD OF OBSERVATION
Malmö - 50 intersections, 1975

Traffic class	Kind of road-user	Time period[1]	Number of accidents	Obs. time accidents (min)	Number of accidents per min	Number of conflicts	Obs. time conflicts (min)	Number of conflicts per min	Number of accidents per minute/Number of conflicts per min 1975	1974
1	car-ped	1	14	3.67x10^{7}	3.81x10^{-7}	36	8.36x10^{3}	4.30x10^{-3}	8.7x10^{-5}	5.4x10^{-5}
2	-"-	1	6	0.842 "	7.13 "	17	2.00 "	8.50 "	8.4 "	6.1 "
3	-"-	1	31	1.38 "	22.5 "	16	3.19 "	5.01 "	44.9 "	56.0 "
4	-"-	1	7	0.842 "	8.31 "	0	2.00 "	0 "	-	114.2 "
1	-"-	2	12	1.31 "	9.16 "	46	7.13 "	6.45 "	14.2 "	13.1 "
2	-"-	2	6	0.301 "	19.9 "	16	1.75 "	9.14 "	21.8 "	30.2 "
3	-"-	2	22	0.491 "	44.8 "	13	2.86 "	4.55 "	98.6 "	117.1 "
4	-"-	2	8	0.301 "	26.6 "	3	1.75 "	1.71 "	154.8 "	-
1	car-bicycle	1	6	3.67 "	1.63 "	11	8.36 "	1.32 "	12.4 "	9.6 "
2	-"-	1	7	0.842 "	8.31 "	5	2.00 "	2.50 "	33.3 "	28.6 "
3	-"-	1	2	1.38 "	1.45 "	3	3.19 "	0.94 "	15.5 "	8.7 "
4	-"-	1	7	0.842 "	8.31 "	4	2.00 "	2.00 "	41.6 "	28.6 "
1	-"-	2	5	1.31 "	3.82 "	22	7.13 "	3.08 "	12.4 "	23.5 "
2	-"-	2	2	0.301 "	6.64 "	6	1.75 "	3.43 "	19.3 "	20.1 "
3	-"-	2	10	0.491 "	20.4 "	5	2.86 "	1.75 "	116.6 "	39.1 "
4	-"-	2	5	0.301 "	16.6 "	2	1.75 "	1.14 "	145.1 "	100.6 "
1	car-car	1	4	3.67 "	1.09 "	53	8.36 "	6.34 "	1.7 "	1.9 "
2	-"-	1	3	0.842 "	3.56 "	7	2.00 "	3.50 "	10.2 "	9.8 "
3	-"-	1	5	1.38 "	3.62 "	23	3.19 "	7.21 "	5.0 "	3.3 "
4	-"-	1	10	0.842 "	11.9 "	17	2.00 "	8.50 "	14.0 "	13.6 "
1	-"-	2	1	1.31 "	0.763 "	72	7.13 "	10.1 "	0.8 "	1.0 "
2	-"-	2	0	0.301 "	0 "	5	1.75 "	2.86 "	0 "	0 "
3	-"-	2	7	0.491 "	14.3 "	49	2.86 "	17.1 "	8.3 "	10.6 "
4	-"-	2	3	0.301 "	9.97 "	33	1.75 "	18.9 "	5.3 "	6.9 "

1) Time period 1: 09.00-16.00, time period 2: 16.00-18.30

TEST OF PROBABILITY IN THE MERGING OF THE TWELVE ELEMENTS INTO FOUR CELLS
Malmö - 50 intersections

Cell 1

$p^* = 0.037$

x=5 y=191 N=2 a=0.012

$\Lambda^*_i = 189.000$

Ratio=0.026 F=0.227 OK

x=3 y=25 N=2 a=0.012

$\Lambda^*_i = 27.000$

Ratio=0.12 F=0.959 OK

Cell 2

$p^* = 0.135$

x=15 y=125 N=2 a=0.012

$\Lambda^*_i = 123.319$

Ratio=0.12 F=0.343 OK

x=13 y=82 N=2 a=0.012

$\Lambda^*_i = 83.680$

Ratio=0.158 F=0.709 OK

$$p^* = \frac{\Sigma x_i}{\Sigma y_i}$$

x = Recorded number of accidents

y = Observed number of conflicts

N = Number of elements in the cell

a = test value (5 %-level)

$$\Lambda^*_i = \frac{x_i + y_i}{p^* + 1}$$

$$\text{Ratio} = \frac{x}{y}$$

F = Distribution function

Cell 3

$p^* = 0.214$

x=13 y=53 N=4 a=0.006

$\Lambda^*_i = 54.364$

Ratio = 0.245 F=0.682 OK

x=27 Y=156 N=4 a=0.006

$\Lambda^*_i = 150.736$

Ratio=0.173 F = 0.153 OK

x=9 y=19 N=4 a=0.006

$\Lambda^*_i = 23.063$

Ratio=0.473 F = 0.967 OK

x=12 y=57 N=4 a=0.006

$\Lambda^*_i = 56.035$

Ratio=0.210 F = 0.495 OK

Cell 4

$p^* = 1.285$

x=18 y=27 N=4 a=0.006

$\Lambda^*_i = 19.687$

Ratio=0.666 F = 0.017 OK

x=72 y=48 N=4 a=0.006

$\Lambda^*_i = 52.5$

Ratio=1.5 F=0.800 OK

x=12 y=12 N=4 a=0.006

$\Lambda^*_i = 10.5$

Ratio=1 F=0.304 OK

x=15 y=4 N=4 a=0.006

$\Lambda^*_i = 8.312$

Ratio=3.75 F=0.976 OK

NUMBER OF ACCIDENTS AND CONFLICTS AND RESPECTIVE TIMES OF OBSERVATION
Malmö - 15 intersections

Number of accidents

Traffic class	Car-Car	Bicycle-Car	Pedestrian-Car	Obs. time (min)
1	4	5	3	106.997×10^5
2	0	2	8	63.524×10^5
3	3	2	4	47.554×10^5
4	11	11	5	63.524×10^5

Number of conflicts

Traffic class	Car-Car	Bicycle-Car	Pedestrian-Car	Obs. time (min)
1	63	13	29	4 860
2	10	6	13	3 240
3	38	5	1	2 160
4	30	5	4	3 240

TEST OF PROBABILITY IN THE MERGING OF THE TWELVE ELEMENTS INTO FOUR CELLS
Malmö - 15 intersections

Cell 1

$p^* = 0.054$

$x = 4 \quad y = 63 \quad N = 2 \quad a = 0.012$

$\Lambda_i^* = 63.519$

Ratio = 0.063 F = 0.643 OK

$x = 0 \quad y = 10 \quad N = 2 \quad a = 0.012$

$\Lambda_i^* = 9.480$

Ratio = 0 F = 0.594 OK

Cell 2

$p^* = 0.205$

$x = 3 \quad Y = 38 \quad N = 2 \quad a = 0.012$

$\Lambda_i^* = 34$

Ratio = 0.078 F = 0.042 OK

$x = 11 \quad y = 30 \quad N = 2 \quad a = 012$

$\Lambda_i^* = 34$

Ratio = 0.0366 F = 0.943 OK

$$p^* = \frac{\Sigma x_i}{\Sigma y_i}$$

y = Observed number of conflicts

N = Number of elements in the cell

a = Test value (5 % level)

x = Recorded number of accidents

$$\Lambda_i^* = \frac{x_i + y_i}{p^* + 1}$$

$$\text{Ratio} = \frac{x}{y}$$

F = distribution function

Cell 3

$p^* = 0.295$

$x = 5 \quad y = 13 \quad N = 4 \quad a = 6.370E-03$

$\Lambda_i^* = 13.898$

Ratio = 0.384 F = 0.694 OK

$x = 3 \quad y = 29 \quad N = 4 \quad a = 6.370E-03$

$\Lambda_i^* = 24.708$

Ratio = 0.103 F = 0.028 OK

$x = 2 \quad y = 6 \quad N = 4 \quad a = 6.370E-03$

$\Lambda_i^* = 6.177$

Ratio = 0.0333 F = 0.624 OK

$x = 8 \quad y = 13 \quad N = 4 \quad a = 6.370-03$

$\Lambda_i^* = 16.215$

Ratio = 0.615 F = 0.938 OK

Cell 4

$p^* = 1.466$

$x = 2 \quad y = 5 \quad N = 4 \quad a = 6.370E-03$

$\Lambda_i^* = 2.837$

Ratio = 0.4 F = 0.824 OK

$x = 4 \quad y = 1 \quad N = 4 \quad a = 6.370E-03$

$\Lambda_i^* = 2.027$

Ratio = 4 F = 0.0824 OK

$x = 11 \quad y = 5 \quad N = 4 \quad a = 6.370E-03$

$\Lambda_i^* = 6.486$

Ratio = 2.2 F = 0.772 OK

$x = 5 \quad y = 4 \quad N = 4 \quad a = 6.370E-03$

$\Lambda_i^* = 3.648$

Ratio = 1.25 F = 0.415 OK

NUMBER OF ACCIDENTS AND CONFLICTS AND RESPECTIVE TIMES OF OBSERVATION
Stockholm - 50 intersections

Number of accidents

Traffic class	Car-Car	Bicycle-Car	Pedestrian-Car	Obs. time (min)
1	5	3	1	283.589×10^5
2	1	1	21	216.309×10^5
3	39	4	19	222.820×10^5
4	35	4	33	216.309×10^5

Number of conflicts

Traffic class	Car-car	Bicycle-Car	Pedestrian-Car	Obs. time (min)
1	89	5	37	11 580
2	30	13	62	8 710
3	182	9	25	9 105
4	119	4	20	8 710

TEST OF PROBABILITY IN THE MERGING OF THE TWELVE ELEMENTS INTO FOUR CELLS
Stockholm - 50 intersections

Cell 1

$p^* = 0.050$

$x_* = 5$ $y = 89$ $N = 2$ $a = 0.013$
$\Lambda_i = 89.488$
Ratio = 0.056 F = 0.614 OK

$x = 1$ $y = 30$ $N = 2$ $a = 0.013$
$\Lambda_i^* = 29.512$
Ratio = 0.033 F = 0.390 OK

Cell 2

$p^* = 0.246$

$x = 39$ $y = 182$ $N = 2$ $a = 0.013$
$\Lambda_i^* = 177.389$
Ratio = 0.214 F = 0.218 OK

$x = 35$ $y = 119$ $N = 2$ $a = 0.013$
$\Lambda_i^* = 123.611$
Ratio = 0.294 F = 0.823 OK

$$p^* = \frac{\Sigma x_i}{\Sigma y_i}$$

x = Recorded number of accidents

Y = Observed number of conflicts

N = Number of elements in the cell

a = test value (5 % -level)

$$\Lambda_i^* = \frac{x_i + y_i}{p^* + 1}$$

$$\text{Ratio} = \frac{x}{y}$$

F = Distribution function

Cell 3

$p^* = 0.222$

$x_* = 3$ $y = 5$ $N = 4$ $a = 6{,}371 \times 10^{-3}$
$\Lambda_i = 6.545$
Ratio = 0.6 F = 0,907 OK

$x = 1$ $y = 37$ $N = 4$ $a = 6.371 \times 10^{-3}$
$\Lambda_i^* = 6{,}545$
Ratio = 0.027 F = 2.14×10^{-3} TOO SMALL

$x = 1$ $y = 13$ $N = 4$ $a = 6.371 \times 10^{-3}$
$\Lambda_i^* = 11.455$
Ratio = 0.077 F = 0.151 OK

$x = 21$ $y = 62$ $N = 4$ $a = 6.371 \times 10^{-3}$
$\Lambda_i^* = 67.909$
Ratio = 0.339 F = 0. 947

Cell 4

$p^* = 1{,}034$

$x = 4$ $y = 9$ $N = 4$ $a = 6.371 \times 10^{-3}$
$\Lambda_i^* = 6.390$
Ratio = 0.444 F = 0.088 OK

$x = 19$ $y = 25$ $N = 4$ $a = 6.371 \times 10^{-3}$
$\Lambda_i^* = 21.627$
Ratio = 0,76 F = 0,159 OK

$x = 4$ $y = 4$ $N = 4$ $a = 6{,}371 \times 10^{-3}$
$\Lambda_i^* = 3.932$
Ratio = 1 F = 0,553 OK

$x = 33$ $y = 20$ $N = 4$ $a = 6.371 \times 10^{-3}$
$\Lambda_i^* = 26.051$
Ratio = 1.65 F = 0.951 OK

NUMBER OF ACCIDENTS AND CONFLICTS PER SEVERITY ZONE AND SEVERITY DEFINITION

SEVERITY DEF.	ZONE	NUMBER CAR-CAR Acc1)	Confl2)	CAR-BIC Acc	Confl	CAR-PED Acc	Confl
	0		(12)		(5)		(6)
ALT. DEF. 1	1a	0	14	0	6	0	18
	1b	0	38	1	14	0	32
	2a	0	58	0	21	1	37
	2b	1	91	5	34	2	67
	3a	3	66	7	24	1	29
	3b	6	70	20	20	8	34
	4a	17	26	32	4	24	12
	4b	34	17	35	0	17	2
	5a	22	4	17	0	17	0
	5b	17	0	8	0	7	0
	6a	7	0	0	0	2	0
	6b	1	0	0	0	0	0
	Σ	108	396	125	128	79	237
ALT.	0		(8)		(5)		(5)
DEF. 2	1a	0	5	0	1	0	14
	1b	0	18	0	10	0	11
	2a	0	46	0	18	0	33
	2b	0	59	0	23	0	48
	3a	0	72	7	25	3	46
	3b	3	68	9	26	1	35
	4a	4	49	17	14	13	30
	4b	7	42	24	5	14	10
	5a	19	15	28	1	12	4
	5b	25	7	25	0	14	1
	6a	20	7	10	0	12	0
	6b	18	0	3	0	8	0
	7a	4	0	2	0	1	0
	7b	5	0	0	0	1	0
	8a	1	0	0	0	0	0
	8b	2	0	0	0	0	0
	Σ	108	396	125	128	79	237

1) Police-reported accidents, all intersections in the city of Malmö, 1978 - 1980.

2) Conflicts recorded at 107 intersections in the city of Malmö. 2 days per intersection.

SEVERITY DEF.	ZONE	NUMBER CAR-CAR Acc[1)]	Confl[2)]	CAR-BIC Acc	Confl	CAR-PED Acc	Confl
	0		(30)		(10)		(17)
ALT	1a	0	30	1	12	0	28
DEF 3	1b	1	59	0	18	2	43
	2a	1	71	3	28	2	45
	2b	6	87	10	25	2	52
	3a	13	74	19	31	5	33
	3b	20	33	22	4	19	19
	4a	40	11	39	0	32	0
	4b	21	1	31	0	16	0
	5a	6	0	0	0	1	0
	5b	0	0	0	0	0	0
	Σ	108	396	125	128	79	237
ALT	1a	0	12	0	0	0	0
DEF 4	1b	0	6	1	5	0	7
	2a	1	37	0	10	0	26
	2b	1	10	1	7	4	14
	3a	1	69	3	19	1	45
	3b	5	69	5	24	0	41
	4a	18	84	12	21	6	35
	4b	31	66	24	27	14	47
	5a	34	40	30	14	22	21
	5b	10	3	12	1	13	1
	6	7	0	37	0	19	0
	Σ	108	396	125	128	79	237
ALT	1a	0	5	2	2	6	28
DEF 5	1b	0	31	5	18	4	13
	2a	1	45	10	31	2	27
	2b	0	54	16	29	4	37
	3a	2	41	13	10	2	34
	3b	5	53	14	12	12	36
	4a	9	48	22	8	6	16
	4b	6	49	10	6	11	19
	5a	18	26	9	2	9	12
	5b	20	28	5	9	8	12
	6a	25	8	14	1	8	2
	6b	6	7	4	0	4	1
	7a	8	0	0	0	0	0
	7b	1	1	0	0	1	0
	8a	4	0	0	0	1	0
	8b	1	0	1	0	1	0
	9a	1	0	0	0	0	0
	9b	1	0	0	0	0	0
	Σ	108	396	125	128	79	237

1) Police-reported accidents, all intersections in the city of Malmö, 1978 - 1980.

2) Conflicts recorded at 107 intersections in the city of Malmö. 2 days per intersection.

RELATION BETWEEN NUMBER OF ACCIDENTS AND NUMBER OF CONFLICTS
(0.25 sec interval)
(same samples as in app. 7.1)

SEV. DEF.	SEV. ZONE	CAR-CAR No of acc/ No of confl.	log	CAR-BICYCLE No of acc/ No of confl.	log	CAR-PEDESTRIAN No of acc/ No of confl.	log
ALT DEF.1	1a	0/14=0	-	0/6 =0	-	0/18=0	-
	1b	0/38=0	-	1/14=0.071	-1.15	0/32=0	-
	2a	0/58=0	-	0/21=0 (*)	-	1/37=0.027	-1.57
	2b	1/91=0.011	-1.96	5/34=0.147 *	-0.83	2/67=0.030	-1.53
	3a	3/66=0.045	-1.34	7/24=0.292	-0.54	1/29=0.034	-1.46
	3b	6/70=0.086	-1.07	20/20=1.00 **	0	8/34=0.235 *	-0.63
	4a	17/26=0.654 ***	-0.18	32/4=8.00 ***	0.90	24/12=2.000***	-0.30
	4b	34/17=2.000 **	0.30	35/0= - *	-	17/2 =8.500 *	0.93
	5a	22/4 =5.500 *	0.74	17/0= -	-	17/0 = -	-
	5b	17/0 = -	-	8/0= -	-	7/0 = -	-
	6a	7/0 = -	-	0/0= -	-	2/0 = -	-
	6b	1/0 = -	-	0/0= -	-	0/0 = -	-
ALT DEF.2	1a	0/5 = 0	-	0/1= 0	-	0/14=0	-
	1b	0/18= 0	-	0/10=0	-	0/11=0	-
	2a	0/46= 0	-	0/18=0	-	0/33=0	-
	2b	0/59= 0	-	0/23=0	-	0/48=0	-
	3a	0/72= 0	-	7/25=0.280 **	-0.55	3/46=0.065 *	-1.19
	3b	3/68= 0.044 *	-1.36	9/26=0.346	-0.46	1/35=0.029 (*)	-1.54
	4a	4/49= 0.082	-1.09	17/14=1.214 **	0.63	13/30=0.433 ***	-0.36
	4b	7/42= 0.167	-0.78	24/5 =4.800 **	0.68	14/10=1.400 **	0.15
	5a	19/15= 1.267 ***	0.10	28/1 =28.000 *	1.45	12/4 =3.000	0.48
	5b	25/7 = 3.571 *	0.55	25/0 = -	-	14/1 =14.000	1.15
	6a	20/7 = 2.857 (*)	0.46	10/0 = -	-	12/0 = -	-
	6b	18/0 = - **	-	3/0 = -	-	8/0 = -	-
	7a	4/0 = -	-	2/0 = -	-	1/0 = -	-
	7b	5/0 = -	-	0/0 = -	-	1/0 = -	-
	8a	1/0 = -	-	0/0 = -	-	0/0 = -	-
	8b	2/0 = -	-	0/0 = -	-	0/0 = -	-

RELATION BETWEEN NUMBER OF ACCIDENTS AND NUMBER OF CONFLICTS , CONT
(0.25 sec interval)

SEV. DEF.	SEV. ZONE	CAR - CAR No of acc/ No of confl.		log	CAR - BIC No of acc/ No of confl.		log	CAR - PED No of acc/ No of confl.		log
ALT.	1a	0/30=0		-	1/12=0.083		-1.08	0/28=0		-
DEF.3	1b	1/59=0.017	⊛	-1.77	0/18=0	⊛	-	2/43=0.047	⊛	-1.33
	2a	1/71=0.014		-1.85	3/28=0.107	*	-0.97	2/45=0.044	⊛	-1.35
	2b	6/87=0.069	*	-1.16	10/25=0.400		-0.40	2/52=0.038	*	-1.41
	3a	13/74=0.176	***	-0.76	19/31=0.613	***	-0.21	5/33=0.152	***	-0.82
	3b	20/33=0.606	***	-0.22	22/4 =5.500	**	0.74	19/19=1.000	***	0
	4a	40/11=3.638	*	0.56	39/0 = -		-	32/0 = -		-
	4b	21/1 =21.000		1.32	31/0 = -			16/0 = -		-
	5a	6/0 = -		-	0/0 = -		-	1/0 = -		-
	5b	0/0 = -		-	0/0 = -		-	0/0 = -		-

* Significant on a 10 % - level (increasing value)

** " " 2.5% - " (" ")

*** " " 0.5% - " (" ")

⊛ Decreasing value

RELATION BETWEEN NUMBER OF ACCIDENTS AND NUMBER OF CONFLICTS, CONT.
(0.25 sec. interval)

SEV. DEF.	SEV. ZONE	CAR - CAR No of acc/ No of confl.	CAR - CAR log	CAR - BIC No of acc/ No of confl.	CAR - BIC log	CAR - PED No of acc/ No of confl.	CAR - PED log
ALT. DEF. 4	1a	0/12 = 0	-	0/0 = -	-	0/0 = -	-
	1b	0/6 = 0	-	1/5 = 0.200	- 0.70	0/7 = -	-
	2a	1/36 = 0.028	-1.56	0/10 = 0 (*)	-	0/26 = 0 **	
	2b	1/10 = 0.100	-1.00	1/7 = 0.143	- 0.85	4/14 = 0.286	-0.54
	3a	1/70 = 0.014 (*)	-1.85	3/19 = 0.158	- 0.80	1/45 = 0.022 (*)	-1.65
	3b	5/69 = 0.072 *	-1.14	5/24 = 0.208 *	- 0.68	0/41 = 0 (*) **	-
	4a	18/84 = 0.214 **	-0.67	12/21 = 0.571	- 0.24	6/35 = 0.171	-0.77
	4b	31/66 = 0.470 *	-0.33	24/27 = 0.889 *	- 0.05	14/47 = 0.298 ***	-0.53
	5a	34/40 = 0.850 ***	-0.07	30/14 = 2.143 ***	0.33	22/21 = 1.048 ***	0.02
	5b	17/3 = 5.667	0.75	49/1 = 49.000	1.69	32/1 = 32.000	1.51
ALT. DEF. 5	1a	0/5 = 0	-	2/2 = 1.000	0	6/28 = 0.214	-0.67
	1b	0/31 = 0	-	5/18 = 0.278 (*)	-0.56	4/13 = 0.308 (*)	-0.51
	2a	1/45 = 0.022	-1.66	10/31 = 0.323	-0.49	2/27 = 0.074	-1.13
	2b	0/54 = 0 (*)	-	16/29 = 0.552 *	-0.26	4/37 = 0.108 (*)	-0.97
	3a	2/41 = 0.049	-1.31	13/10 = 1.300	0.11	2/34 = 0.059 **	-1.23
	3b	5/53 = 0.094	-1.03	14/12 = 1.167	0.07	12/36 = 0.333	-0.48
	4a	9/48 = 0.188 (*)	-0.73	22/8 = 2.750	0.44	6/16 = 0.375	-0.43
	4b	6/49 = 0.122 ***	-0.91	10/6 = 1.667 (*)	0.22	11/19 = 0.579	-0.24
	5a	18/26 = 0.692	-0.16	9/2 = 4.500 (*)	0.65	9/12 = 0.750 (*)	-0.12
	5b	20/28 = 0.714 ***	-0.15	5/9 = 0.556 ***	-0.26	8/12 = 0.667 *	-0.18
	6a	25/8 = 3.125 (*)	0.49	14/1 = 14.000	1.15	8/2 = 4.000	0.60
	6b	6/7 = 0.857 **	-0.07	4/0 = -	-	4/1 = 4.000	0.60
	7a	8/0 = -	-	0/0 = -	-	0/0 = -	-
	7b	1/1 = 1.000 (*)	0	0/0 = -	-	1/0 = -	-
	8a	4/0 = -	-	0/0 = -	-	1/0 = -	-
	8b	1/0 = -	-	1/0 = -	-	1/0 = -	-
	9a	1/0 = -	-	0/0 = -	-	0/0 = -	-
	9b	1/0 = -	-	0/0 = -	-	0/0 = -	-

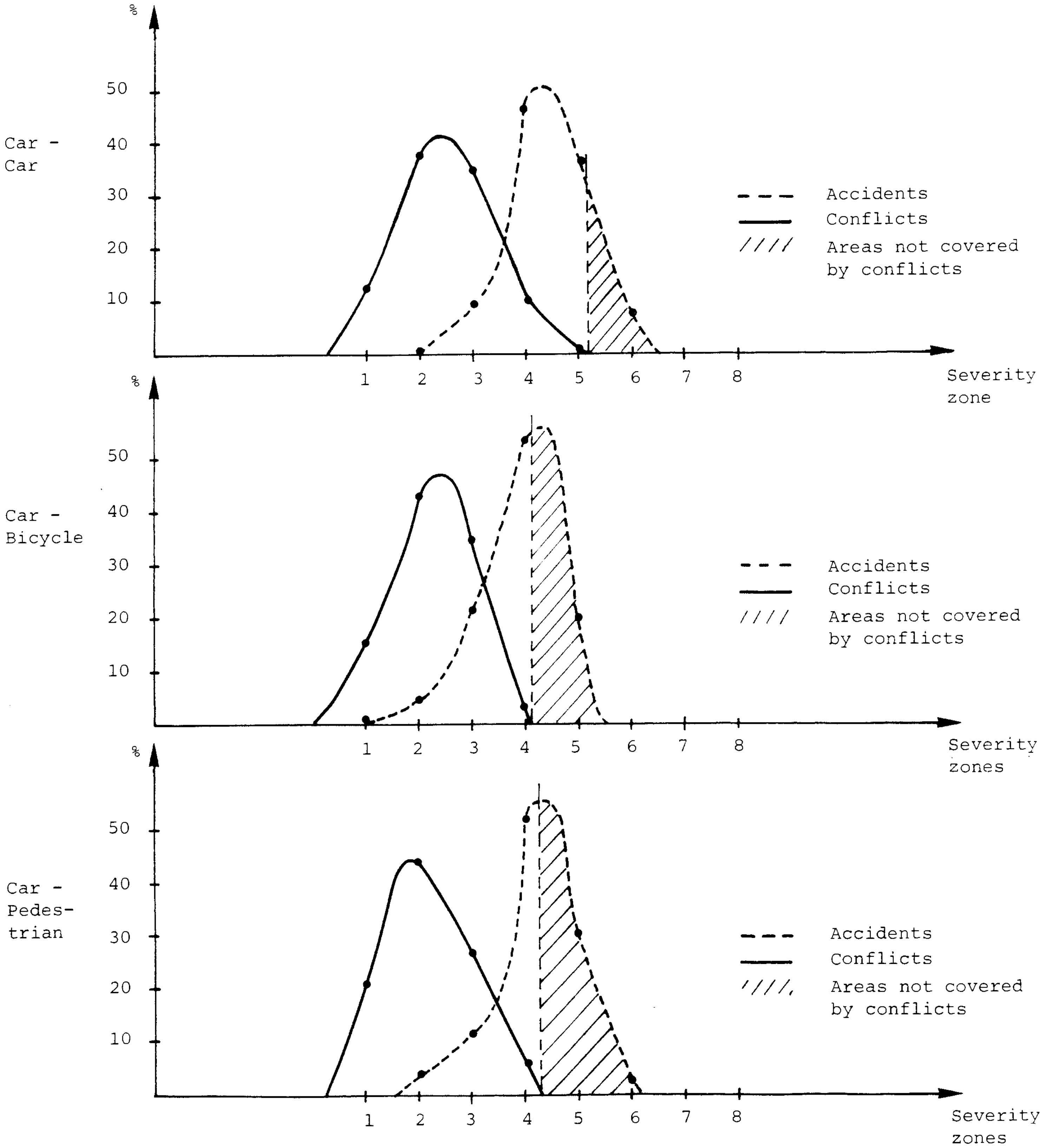
* = Significant on a 10% - level (increasing value)
** = " " 2.5% level (" ")
*** = " " 0.5% level (" ")
(*) = Decreasing value

RELATION BETWEEN NUMBER OF ACCIDENTS AND NUMBER OF CONFLICTS (0.5 sec. interval)
(Same sample as in app. 7.1)

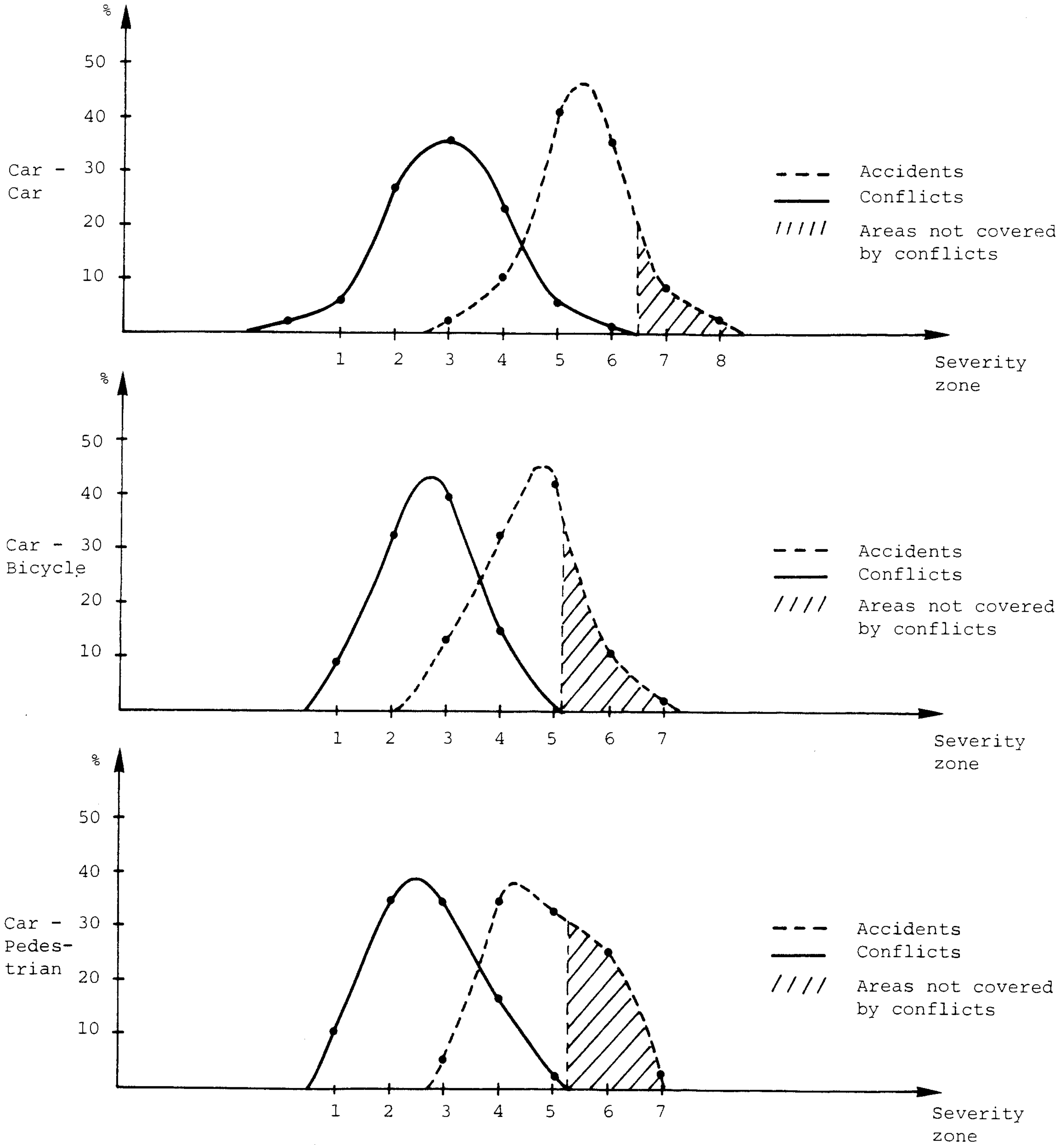
	Zone	Car - Car	log	Car - Bic.	log	Car - Ped.	log
ALT. DEF.1	1	-	-	1/20=0.05	-1.30	-	-
	2	1/149=0.007	-2.17	5/55=0.091	-1.04	3/104=0.029	-1.54
	3	9/136=0.066**	-1.18	27/44=0.614***	-0.21	9/ 63=0.143**	-0.85
	4	51/ 43=1.186***	0.07	67/ 4=16.75***	1.22	41/ 14=2.929***	0.47
	5	39/ 4=9.75***	0.99				
ALT. DEF.2	3	3/140=0.021	-1.67	16/51=0.314	-0.50	4/ 81=0.049	-1.31
	4	11/ 91=0.121***	-0.92	41/19=2.158***	0.33	27/ 40=0.675***	-0.17
	5	44/ 22=2.00***	0.30	53/ 1=53***	1.72	26/ 5=5.200***	0.72
	6	38/ 7=5.429*	0.73				
ALT DEF.3	1	1/ 89=0.011	-1.95	1/30=0.033	-1.48	2/ 71=0.028	-1.55
	2	7/158=0.044	-1.35	13/53=0.245*	-0.61	4/ 97=0.041	-1.38
	3	33/107=0.308***	-0.51	41/35=1.171***	0.07	14/ 52=0.269***	-0.57
	4	61/ 12=5.083***	0.71				
ALT DEF.4	1			1/ 5=0.20	-0.70		
	2	2/ 46=0.043	-1.36	1/17=0.059	-1.23	4/ 40=0.100	-1.00
	3	6/139=0.043	-1.36	8/43=0.186	-0.73	1/ 86=0.012*	-1.93
	4	49/150=0.327***	-0.49	36/48=0.750***	-0.12	20/ 82=0.244***	-0.61
	5	51/ 43=1.186***	0.07	79/15=5.267***	0.72	54/ 22=2.455***	0.39
ALT DEF.5	1			7/20=0.350	-0.46	10/ 41=0.244	-0.61
	2	1/ 99=0.010	-2.00	26/60=0.433	-0.36	6/ 64=0.094*	-1.03
	3	7/ 94=0.074*	-1.13	27/22=1.227***	0.09	14/ 70=0.200	-0.70
	4	15/ 97=0.155	-0.81	32/14=2.286	0.36	17/ 35=0.486*	-0.31
	5	38/ 54=0.704***	-0.15	14/11=1.273	0.10	17/ 24=0.708	-0.15
	6	31/ 15=2.067***	0.32	18/ 1=18.000***	1.26	12/ 3=4.000**	0.60
	7	9/ 1=9.000	0.95				

* Significant on 10 %-level (increase)
** Significant on 2.5 %-level (increase)
*** Significant on 0.5 %-level (increase)

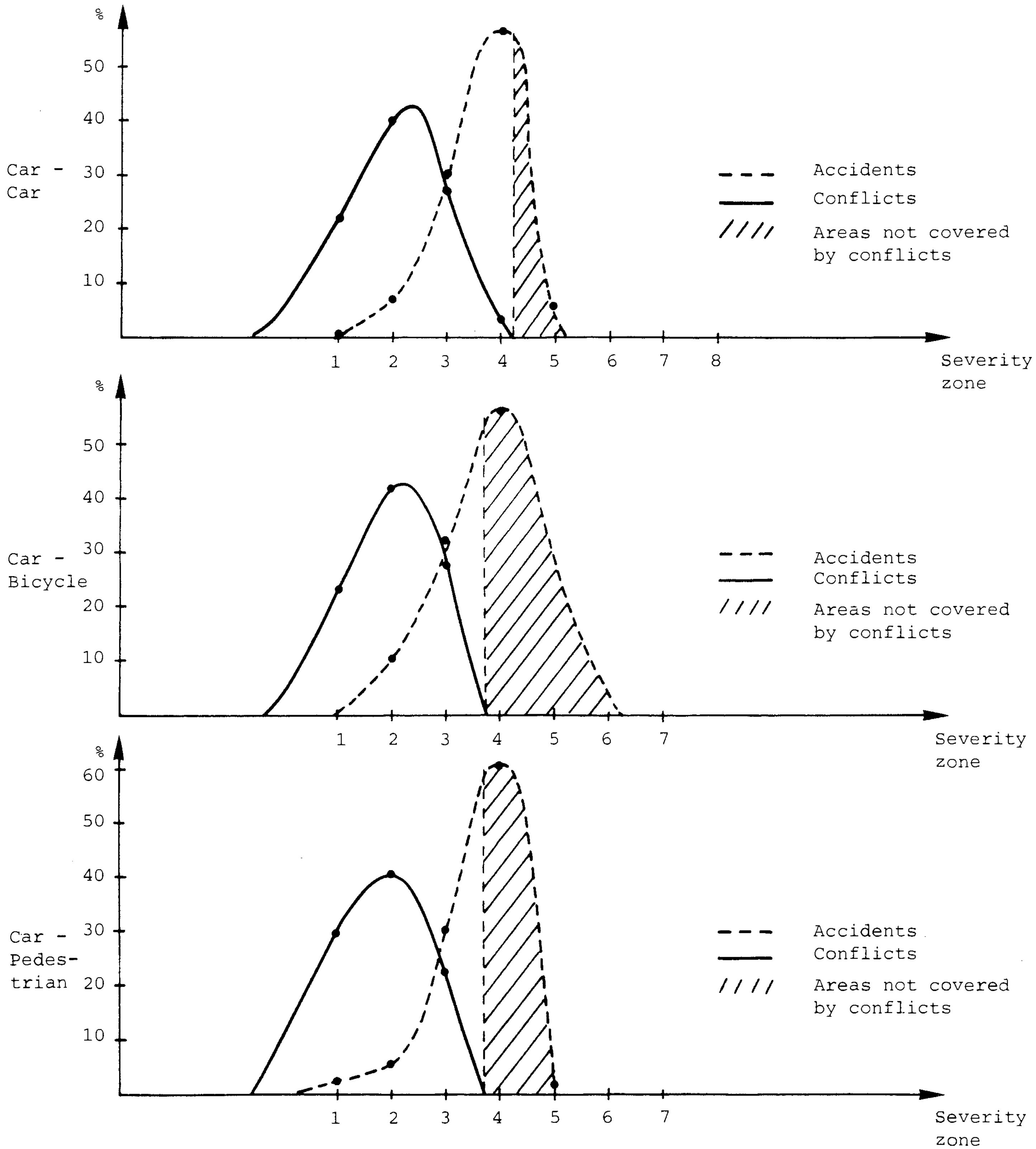
DISTRIBUTION OF CONFLICT AND ACCIDENT PROPORTIONS WITH REGARD TO SEVERITY ZONES
Severity definition: ALT. DEF. 1



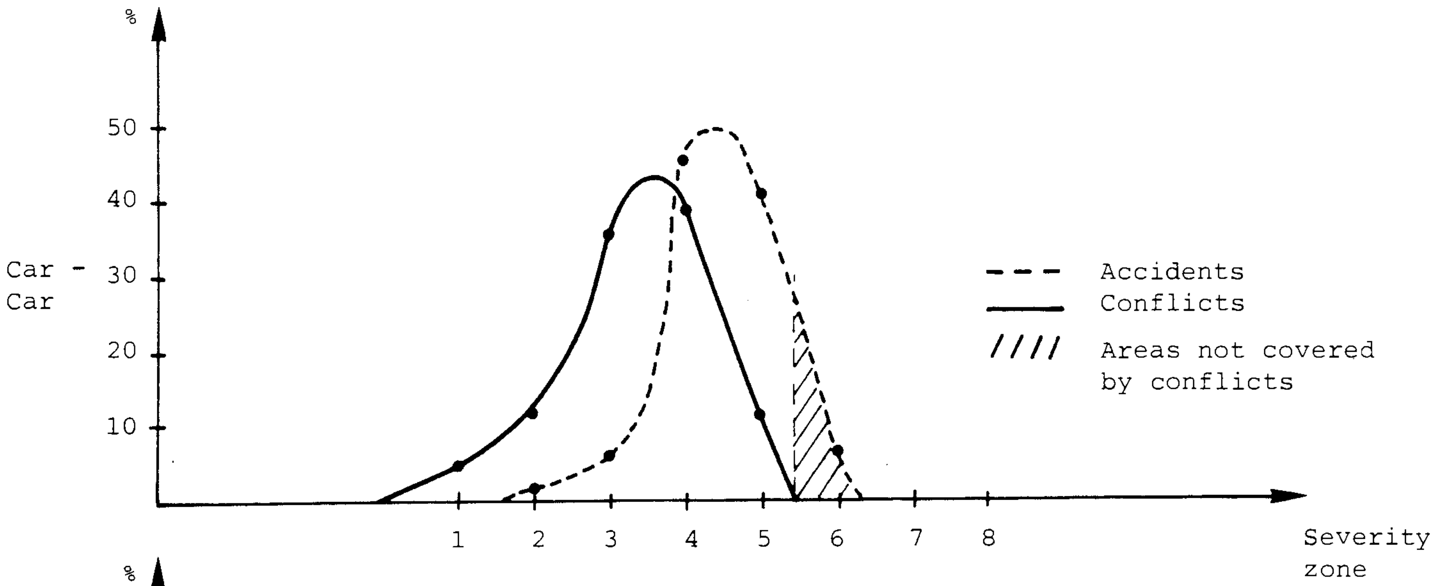
DISTRIBUTION OF CONFLICT AND ACCIDENT PROPORTIONS WITH REGARD TO SEVERITY ZONES
Severity definition: ALT. DEF. 2

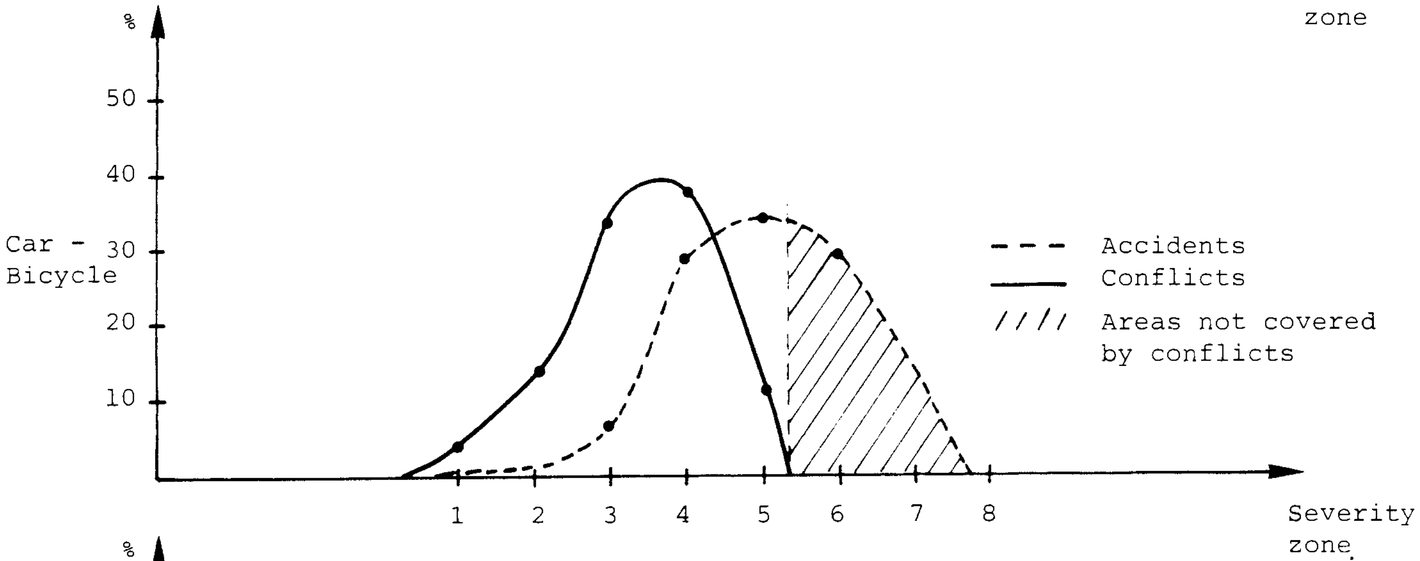


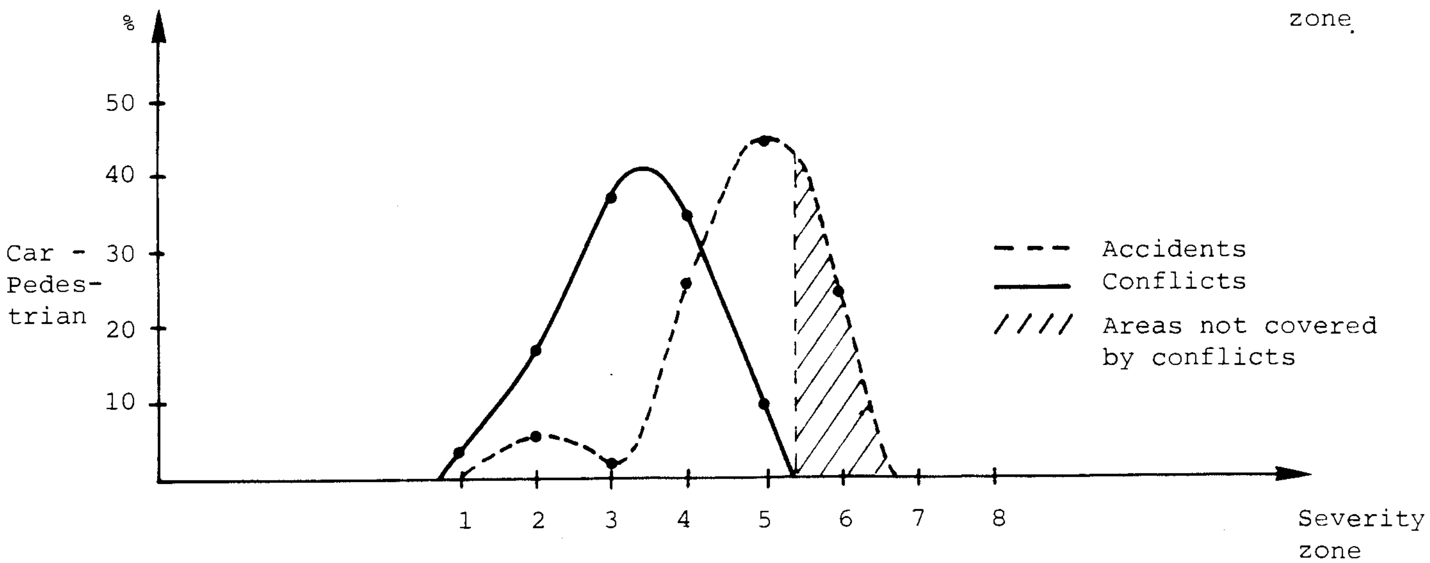
DISTRIBUTION OF CONFLICTS AND ACCIDENT PROPORTIONS WITH REGARD TO SEVERITY ZONES
Severity definition: ALT. DEF. 3



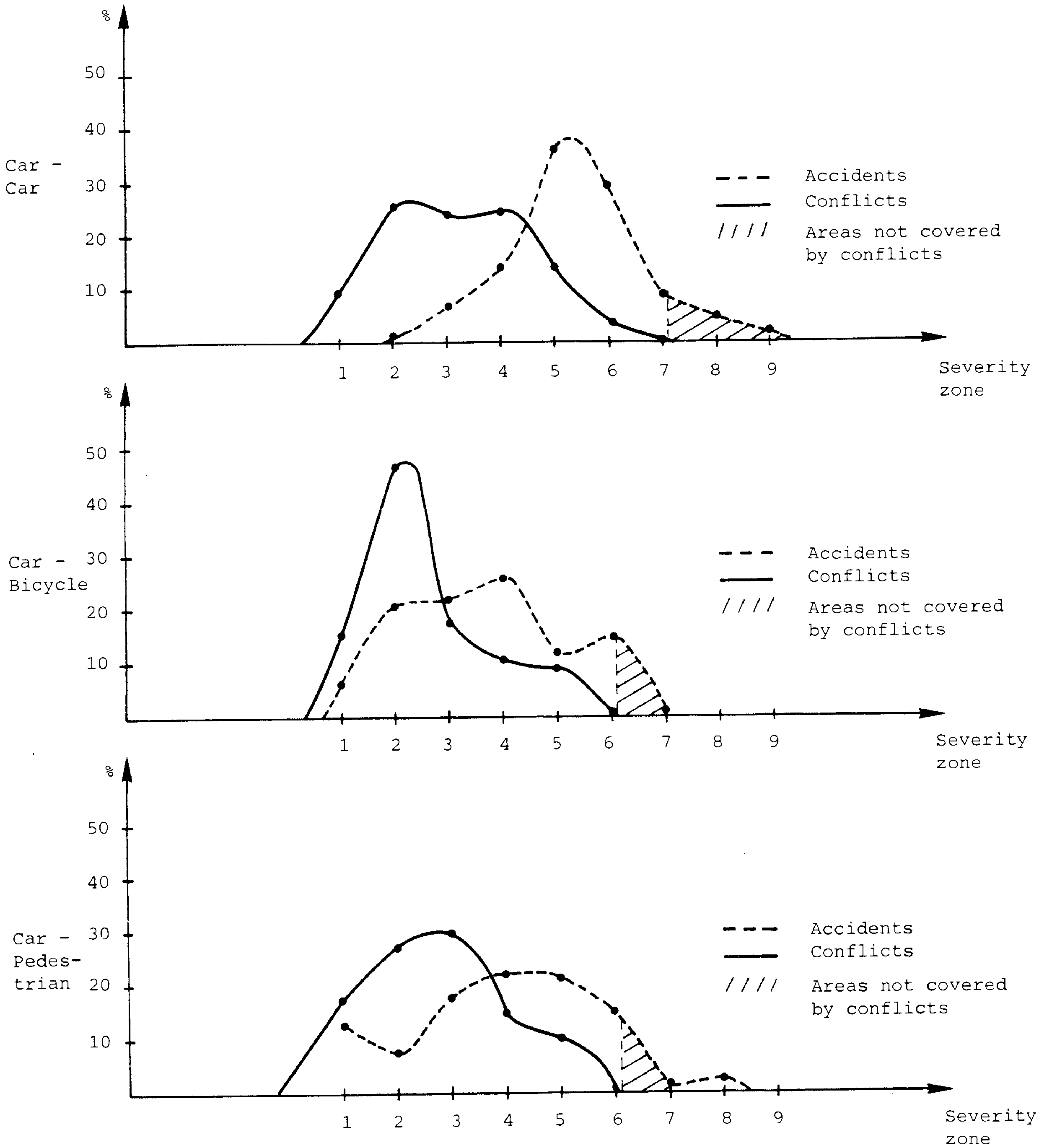
DISTRIBUTION OF CONFLICT AND ACCIDENT PROPORTIONS WITH REGARD TO SEVERITY ZONES
Severity definition: ALT. DEF. 4







DISTRIBUTION OF CONFLICT AND
ACCIDENT PROPORTIONS WITH
REGARD TO SEVERITY ZONES
Severity definition: ALT. DEF. 5



CONFLICT AND ACCIDENT FREQUENCIES
Example from a validation study in Malmö 1982

	CAR-CAR	CAR-BICYCLE	CAR-PEDESTRIAN
Number of policereported injury accidents	85	63	56
Number of obs. hours	1738800	1738800	1738800
Acc/hour	4.89×10^{-5}	3.62×10^{-5}	3.22×10^{-5}
Hours/acc	20450	27600	31050
Number of observed confl.	490	223	216
Number of obs. hours	1344	1344	1344
Conflicts/hour	0.365	0.166	0.161
Hours/conflict	2.7	6.0	6.2
$\frac{\text{Conflicts/hour}}{\text{Accidents/hour}}$	~ 7500	~ 4600	~ 5000

PROPORTIONS (%) OF ACCIDENTS AND CONFLICTS PER SEVERITY ZONE AND DEFINITION

SEVERITY DEF.	ZONE	PROPORTION (%) CAR-CAR ACC	CAR-CAR CONFL	CAR-BIC ACC	CAR-BIC CONFL	CAR-PED ACC	CAR-PED CONFL
	0		(3.0)		(3.9)		(2.5)
ALT DEF 1	1a	0	3.3	0	4.7	0	7.6
	1b	0	9.6	0.8	10.9	0	13.5
	2a	0	14.6	0	16.4	1.3	15.6
	2b	0.9	23.0	4.0	26.6	2.5	28.3
	3a	2.8	16.7	5.6	18.8	1.3	12.2
	3b	5.6	17.7	16.0	15.6	10.1	14.3
	4a	15.7	6.6	25.6	3.1	30.4	5.1
	4b	31.5	4.3	28.0	0	21.5	0.8
	5a	20.4	1.0	13.6	0	21.5	0
	5b	15.7	0	6.4	0	8.9	0
	6a	6.5	0	0	0	2.5	0
	6b	0.9	0	0	0	0	0
	Σ	100	100	100	100	100	100
	0		(2.0)		(3.9)		(2.1)
ALT DEF 2	1a	0	1.3	0	0.8	0	5.9
	1b	0	4.5	0	7.8	0	4.6
	2a	0	11.6	0	14.1	0	13.9
	2b	0	14.9	0	18.0	0	20.3
	3a	0	18.2	5.6	19.5	3.8	19.4
	3b	2.8	17.2	7.2	20.3	1.3	14.8
	4a	3.7	12.4	13.6	10.9	16.5	12.7
	4b	6.5	10.6	19.2	3.9	17.7	4.2
	5a	17.6	3.8	22.4	0.8	15.2	1.7
	5b	23.1	1.8	20.0	0	17.7	0.4
	6a	18.5	1.8	8.0	0	15.2	0
	6b	16.7	0	2.4	0	10.1	0
	7a	3.7	0	1.6	0	1.3	0
	7b	4.6	0	0	0	1.3	0
	8a	0.9	0	0	0	0	0
	8b	1.9	0	0	0	0	0
	Σ	100	100	100	100	100	100

SEVERITY DEFINITION	ZONE	CAR-CAR ACC	CAR-CAR CONFL	CAR-BIC ACC	CAR-BIC CONFL	CAR-PED ACC	CAR-PED CONFL
	0		(7.6)		(7.8)		(7.2)
ALT DEF 3	1a	0	7.6	0.8	9.4	0	11.8
	1b	0.9	14.9	0	14.1	2.5	18.1
	2a	0.9	17.9	2.4	21.9	2.5	19.0
	2b	5.6	22.0	8.0	19.5	2.5	21.9
	3a	12.0	18.7	15.2	24.2	6.3	13.9
	3b	18.5	8.3	17.6	3.1	24.1	8.0
	4a	37.0	2.8	31.2	0	40.5	0
	4b	19.4	0.3	24.8	0	20.3	0
	5a	5.6	0	0	0	1.3	0
	5b	0	0	0	0	0	0
	Σ	100	100	100	100	100	100
ALT DEF 4 (TA)	1a	0	3.0	0	0	0	0
	1b	0	1.5	0.8	3.9	0	3.0
	2a	0.9	9.1	0	7.8	0	11.0
	2b	0.9	2.5	0.8	5.5	5.1	5.9
	3a	0.9	17.7	2.4	14.8	1.3	19.0
	3b	4.6	17.4	4.0	18.8	0	17.3
	4a	16.7	21.2	9.6	16.4	7.6	14.8
	4b	28.7	16.7	19.2	21.1	17.7	19.8
	5a	31.5	10.1	24.0	10.9	27.8	8.9
	5b	9.3	0.8	9.5	0.8	16.5	0.4
	6	6.5	0	29.6	0	24.1	0
	Σ	100	100	100	100	100	100
ALT DEF 5 (SPEED)	1a	0	1.3	1.6	1.6	7.6	11.8
	1b	0	7.8	4.0	14.1	5.1	5.5
	2a	0.9	11.4	8.0	24.2	2.5	11.4
	2b	0	13.6	12.8	22.7	5.1	15.6
	3a	1.9	10.4	10.4	7.8	2.5	14.3
	3b	4.6	13.4	11.2	9.4	15.2	15.2
	4a	8.3	12.1	17.6	6.2	7.6	6.8
	4b	5.6	12.4	8.0	4.7	13.9	8.0
	5a	16.7	6.6	7.2	1.6	11.4	5.1
	5b	18.5	7.1	4.0	7.0	10.1	5.1
	6a	23.1	2.0	11.2	0.8	10.1	0.8
	6b	5.6	1.8	3.2	0	5.1	0.4
	7a	7.4	0	0	0	0	0
	7b	0.9	0.2	0.8	0	1.3	0
	8a	3.7	0	0	0	1.3	0
	8b	0.9	0	0	0	1.3	0
	9a	0.9	0	0	0	0	0
	9b	0.9	0	0	0	0	0
	Σ	100	100	100	100	100	100

ICTCT CALIBRATION STUDY IN MALMÖ: COMPARISON OF SWEDISH, FINNISH AND COMMON SEVERITY SCORES.

Confl number	Swe 1**)	Fin	Princals score*) ("common severity score" for all teams)	Confl nu	Swe 1**)	Fin	Princals score*)
502	-	1		633	1	-	
587	-	1		130	2	2	
776	-	1		439	2	1	
156	-	-		279	1	1	
539	-	-		099	1	1	
475	-			187	1	1	
526	-	-		370	1	1	
818	-	-		615	1	2	
781	1	1		338	-	1	
820	1	1	-1.20	856	1	1	-0.18
835	1	-		549	-	2	
831	-	-		089	1	-	
916	1	1		302	-	1	
513	-	1		963	1	1	
504	-	1		029	1	2	
076	-	-		906	2	2	
658	-	-		545	-	1	
790	-	-		696	2	2	
078	-	-		152	1	-	
436	-	-	-1.00	477	-	2	-0.07
440	-	-		605	1	1	
229	-	-		240	-	2	
446	-	-		498	-	-	
925	-	2		239	1	2	
811	1	1		589	-	-	
610	-	1		650	-	1	
640	1	-		829	-	2	
771	-	1		376	2	2	
778	-	2		494	-	2	
206	-	1	-0.87	847	1	1	+0.06
031	1	2		569	-	-	
284	1	1		624	2	2	
059	1	1		151	3	-	
175	-	1		836	-	-	
460	1	2		095	2	-	
488	-	-		030	-	2	
144	1	1		590	1	2	
454	-	1		218	-	2	
955	-	-		942	-	3	
940	-	2	-0.61	082	-	-	+0.39
621	-	-		560	-	-	
868	-	1		266	1	2	
911	2	-		217	1	3	
324	-	1		676	1	-	
736	2	2		784	3	-	
243	-	-		321	1	2	
686	1	1		971	-	2	
421	-	2		777	3	2	
369	-	2		084	2	2	
432	-	1	-0.41	023	-	-	+0.76

continue

713	1	2	
437	1	2	
510	2	2	
035	1	2	
495	1	2	
760	-	3	
754	3	2	
967	-	3	
519	2	2	
769	-	2	+1.27
255	2	2	
349	3	3	
642	2	2	
309	2	3	
960	2	3	
675	-	3	
900	3	3	+2.67

*) Mean value
**) 1.0 sec < TA ≤ 1.5 sec = 1
0.5 sec < TA ≤ 1.0 sec = 2
TA ≤ 0.5 sec = 3

ICTCT CALIBRATION STUDY IN MALMÖ:
OBJECTIVELY MEASURED TIME TO ACCIDENT FOR ALL CONFLICTS SCORED BY THREE TEAMS DURING THE FIRST THREE DAYS AND A COMPARISON WITH THE SWEDISH SCORINGS.

CONFLICT NUMBER	OBJECTIVELY MEASURED TIME TO ACCIDENT ≤ 1.5s	OBJECTIVELY MEASURED TIME TO ACCIDENT not to be scored (> 1.5s)	SWEDISH SCORING ≤1.5s	SWEDISH SCORING not scored	NOT SCORED BUT SHOULD BE SCORED	SCORED BUT SHOULD NOT BE SCORED
5		> 5		x		
18	0		0			
23	0.96			x	x	
29	1.35		1.29			
30	0.74			x	x	
31	1.29		1.35			
35	1.33		1.22			
48	1.50			x	x	
50		> 5		x		
53		1.73		x		
54		> 5		x		
59	1.04		1.44			
62		1.52		x		
76		> 5		x		
78		3.05		x		
82		2.66		x		
84	1.10		0.76			
86	0.79			x	x	
92						
95	0.77		0.90			
99	1.35		1.08			
104		> 5		x		
108		2.41		x		
114	0.76			x	x	
135		>1.5		x		
144	1.33		1.44			
151	0.27		0.36			
152	1.40		1.23			
156	1.37			x	x	
161		1.84		x		
175		1.85		x		
178	1.40			x	x	
179		>1.5		x		
187	1.25		1.35			
Σ	19	14	12	21	7 (37%)	0 (0%)

ICTCT CALIBRATION STUDY IN MALMÖ:
OBJECTIVELY MEASURED TIME TO ACCIDENT FOR ALL CONFLICTS SCORED BY FOUR OR MORE TEAMS AND A COMPARISON WITH THE SWEDISH SCORINGS.

CONFLICT NUMBER	TIME OF THE DAY	OBJECTIVELY MEASURED TIME TO ACCIDENT		SWEDISH SCORINGS		NOT SCORED BUT SHOULD BE SCORED	SCORED BUT SHOULD NOT BE SCORED
		≤ 1.5s	>1.5s	Scored (≤1.5s)	Not scored		
18		0		0			
29	14.19	1.35		1.02			
30	14.34	0.74			x	x	
31	14.23	1.29		1.35			
35	14.50	1.33		1.22			
59	16.15	1.04		1.44			
76	18.17		> 5		x		
78	18.38		3.0		x		
84	09.21	1.10		0.76			
95	10.05	0.77		0.90			
99	10.18	1.35		1.08			
144	16.02	1.33		1.44			
151	16.18	0.27		0.36			
152	16.18	1.40		1.23			
156	16.28	1.37			x	x	
175	07.21		1.8		x		
187	13.18	1.25		1.35			
206	11.15		> 1.5		x		
217	11.30	1.01		1.27			
218	11.30		> 1.5		x		
229	11.50		1.9		x		
239	12.11		> 5	1.35			x
243	12.14		> 1.5		x		
255	12.28	1.04		0.75			
266	12.34	0.25		1.08			
279	12.51	1.14		1.35			
284	12.54	1.12		1.02			
302	14.30	0.73			x	x	
309	14.47	0.95		0.72			
321	15.34	1.03			x	x	
338	15.59		> 5		x		
341	16.11		1.80		x		
369	16.34		> 5		x		
370	16.37	1.07		1.44			
376	16.44	0.77		0.51			
421	19.54		1.80		x		
432	09.27		2.74		x		
436	09.41		> 1.5		x		
437	09.45	1.20			x	x	
439	09.51	0.68		0.90			
440	09.52		> 1.5		x		
446	10.24		> 5		x		
454	10.51		> 5		x		
475	12.24		1.75		x		
477	12.25		> 1.5		x		

CONFLICT NUMBER	TIME OF THE DAY	OBJECTIVELY MEASURED TIME TO ACCIDENT ≤ 1.5s	>1.5s	SWEDISH SCORINGS Scored (≤1.5s)	Not scored	NOT SCORED BUT SHOULD BE SCORED	SCORED BUT SHOULD NOT BE SCORED
488	12.35		> 1.5		x		
494	12.46	0.88			x	x	
495	12.48	0.92		1.02			
498	12.54		> 1.5		x		
502	13.03		> 5		x		
504	13.08		> 5		x		
510	13.22	1.37		0.94			
513	13.25		1.56		x		
519	13.34	0.86		0.96			
526	13.49		1.95		x		
539	15.46		1.68		x		
545	15.56		2.07		x		
549	16.03		2.38		x		
587	16.52		> 5		x		
589	16.54		> 5		x		
590	16.54	1.37		1.35			
605	07.35	1.36		1.20			
610	07.52		1.59		x		
615	08.09	1.16		1.44			
621	08.43		2.93		x		
624	08.54	0.95		1.03			
633	12.14	1.10		1.35			
640	12.39		> 1.5	x			x
642	12.43	0.71		0.96			
650	13.01		> 1.5		x		
658	13.08		1.6		x		
675	13.45		> 1.5		x		
676	13.46	1.37		1.44			
686	11.08	1.12		1.26			
696	11.22	0.64		0.90			
713	11.58	0.86		1.20			
736	14.08	1.50		0.90			
754	14.50	0.24		0.36			
769	15.43	0.79			x	x	
771	15.48		> 1.5		x		
776	16.00	1.10			x	x	
777	16.06	1.08		0.24			
778	16.06		> 1.5		x		
781	16.13	1.04		1.17			
784	16.15	0.95		0.68			
790	16.22		> 1.5		x		
811	09.40	1.44		1.20			
818	10.14		1.83		x		
820	10.26		1.80	1.15			x
829	12.02		2.13		x		

CONFLICT NUMBER	TIME OF THE DAY	OBJECTIVELY MEASURED TIME TO ACCIDENT		SWEDISH SCORINGS		NOT SCORED BUT SHOULD BE SCORED	SCORED BUT SHOULD NOT BE SCORED
		≤ 1.5s	>1.5s	Scored (≤1.5s)	Not scored		
831	12.06		1.73		x		
835	12.32	1.34		1.23			
836	12.33		> 1.5		x		
847	13.01		1.59	1.32			x
856	13.25	1.47		1.34			
868	15.34		> 1.5		x		
906	17.13	0.55		0.72			
911	07.50	0.67		0.96			
916	08.15		2.03	1.26			x
925	08.54		1.73		x		
940	12.32	1.16			x	x	
942	12.39	0.98			x	x	
955	13.05		2.54		x		
960	13.24	1.08		0.54			
963	13.30	1.43		1.54			x
967	13.32		> 1.5		x		
971	13.37	1.10			x	x	
		57	50	51	56	11 (19 %)	6 (12 %)

ICTCT CALIBRATION STUDY IN MALMÖ: A COMPARISON OF ESTIMATED TIME TO ACCIDENT (TA_{est}) WITH OBJECTIVELY MEASURED (TA_{obj}) AND THE SAME FOR VEHICLE SPEEDS

CONFLICT Number	ESTIMATED TIME TO ACCIDENT (TA_{est}) *)	OBJECTIVELY MEASURED TIME TO ACCIDENT (TA_{obj}) **)	TA_E-TA_O	TYPE OF ROAD-USER INVOLVED			TYPE OF MANOEUVRE				VEHICLE SPEEDS	
				Car-Car	Car-Bic.	Car-Ped.	Right angle	Left turners vs on-com	Rear-end	Weave	Est.	Obj.
18	0	0	0			Bic-P	x				16	15
29	1.02	1.35	-0.33		x			x			14	19
31	1.35	1.29	+0.06	x				x			40	42
35	1.22	1.33	-0.11		x			x			50	41
59	1.44	1.04	+0.40	x				x			20	15
84	0.76	1.10	-0.34	x				x			38	38
95	0.90	0.77	+0.13	x						x	32	40
99	1.08	1.35	-0,27			x					20	14
144	1.44	1.33	+0.11	x				x			25	18
151	0.36	0.27	+0.09		x				x		10	13
152	1.23	1.40	-0.17	x					x		35	35
187	1.35	1.25	+0.10	x				x			40	47
217	1.27	1.01	+0.26		x		x				17	15
239	(1.35)	> 5s	-	x			x				40	40
255	0.75	1.04	-0.29		Bic-Bic			x			24	24
266	1.08	0.25	+0.83	x			x				10	10
279	1.35	1.14	+0.21	x						x	40	39
284	1.02	1.12	-0.10	x				x			42	44
309	0.72	0.95	-0.23		x		x				20	22
321	(1.03)	> 5s	-	x						x	35	39
349	0.48	1.80	-1.32	x					x		15	29
370	1.44	1.07	+0.37	x			x				50	59
376	0.51	0.77	-0.26	x			x				35	35
437	(1.20)	> 5s			x		x				45	54
439	0.90	0.68	+0.22	x					x		20	38
495	1.08	0.92	+0.16	x			x				10	19
510	0.94	1.37	-0.43			x					50	56
519	0.96	0.86	+0.10		Mop-Bic		x				30	43
590	1.35	1.37	-0.02		x		x				40	41
605	1.20	1.36	-0.16		x		x				30	33
615	1.44	1.16	+0.28		x		x				25	27
624	1.03	0.95	+0.08	x				x			7	16
633	1.35	1.10	+0.25	x			x				40	48
642	0.96	0.71	+0.25	x			x				45	52
676	1.44	1.37	+0.07	x			x				50	52
686	1.26	1.12	+0.14			x					20	36
696	0.90	0.64	+0.26	x					x		12	20
713	1.20	0.86	+0.34	x			x				30	34
736	0.90	1.50	-0.60	x					x		20	28
754	0.36	0.24	+0.12			Mop-Ped					30	38
777	0.24	1.08	-0.84	x						x	15	12
781	1.17	1.04	+0.13	x			x				40	33
784	0.68	0.95	-0.27		x					x	8	21
811	1.20	1.44	-0.24		x		x				15	10
820	1.15	1.80	-0.65	x					x		25	35
835	1.23	1.34	-0.11	x			x				35	31
847	1.32	1.44	-0.12			x					30	23
856	1.34	1.47	-0.13	x			x				35	36
906	0.72	0.55	+0.17	x			x				15	11
911	0.96	0.67	+0.29	x						x	30	35
916	1.26	2.03	-0.77	x			x				20	20
960	0.54	1.08	-0.54			x					40	43
963	1.54	1.43	+0.11	x			x				35	35
Mean	1.028	1.083	-0.05 (with sign) 0.28 (without sign)								28.6 (53) 1)	31.6 (53) 1)
	(50) 1)	(50) 1)	(50) 1)									

1)The number of conflicts included in the mean values, i.e. the number of conflicts where relevant data was available.

*) Collected from the observer's data streets

**) Evaluated from TTC-graphs.

OBJECTIVELY MEASURED TIME TO ACCIDENT (TA_{obj}), AND MINIMUM TIME TO COLLISION (MTTC) AND ESTIMATED TIME TO ACCIDENT (TA_{est})

Concflict nr	TA_{est} (sec)	TA_{obj} (sec)	MTTC (sec)	TA_{est}-MTTC (sec)	TA_{obj}-MTTC (sec)	Conflicting speed (objectively measured) (km/h)
18	0	0	0	0	0	15
29	1.02	1.35	1.29	-0.27	+0.06	19
31	1.35	1.29	1.29	+0.06	0	42
35	1.22	1.33	1.16	+0.06	+0.17	41
59	1.44	1.04	1.04	+0.40	0	15
84	0.76	1.10	0.59	+0.17	+0.51	38
95	0.90	0.77	0.55	+0.35	+0.22	40
99	1.08	1.35	1.08	0	+0.27	14
144	1.44	1.33	1.33	+0.11	0	18
151	0.36	0.27	0.27	+0.09	0	13
152	1.23	1.40	1.19	+0.04	+0.21	35
187	1.35	1.25	1.13	+0.22	+0.12	47
217	1.27	1.01	1.01	+0.26	0	15
255	0.75	1.04	0.86	-0.11	+0.18	24
266	1.08	0.25	0.16	+0.92	+0.09	10
279	1.35	1.14	0.98	+0.37	+0.16	39
284	1.02	1.12	1.05	-0.03	+0.07	44
309	0.72	0.95	0.86	-0.14	+0.09	22
349	0.48	1.80	0.98	-0.50	+0.82	29
370	1.44	1.07	0.62	+0.82	+0.45	59
376	0.51	0.77	0.74	-0.23	+0.03	35
439	0.90	0.68	0.64	+0.26	+0.04	38
495	1.08	0.92	0.87	+0.21	+0.05	19
510	0.94	1.37	1.37	-0.43	0	56
519	0.96	0.86	0.49	+0.47	+0.37	43
590	1.35	1.37	1.22	+0.13	+0.15	41
605	1.20	1.36	1.28	-0.08	+0.08	33
615	1.44	1.16	0.15	+1.29	+1.01	27
624	1.03	0.95	0.87	+0.16	+0.08	16
633	1.33	1.10	0.98	+0.35	+0.12	48
642	0.96	0.71	0.71	+0.25	0	52
686	1.26	1.12	1.08	+0.18	+0.04	36
696	0.90	0.64	0.61	+0.29	+0.03	20
713	1.20	0.86	0.48	+0.72	+0.38	34
736	0.90	1.50	0.37	+0.53	+1.13	28
754	0.36	0.24	0.18	+0.18	+0.06	38
777	0.24	1.08	1.08	-0.84	0	12
781	1.17	1.04	0.64	+0.53	+0.40	33
784	0.68	0.95	0.83	-0.15	+0.12	21
811	1.20	1.44	1.19	+0.01	+0.25	10
820	1.15	1.80	1.80	-0.65	0	35
835	1.23	1.44	1.34	-0.11	+0.10	31
847	1.32	1.44	1.35	-0.03	+0.09	23
856	1.34	1.47	0.98	+0.36	+0.49	36
906	0.72	0.55	0.49	+0.23	+0.06	11
911	0.96	0.67	0.64	+0.32	+0.03	35
916	1.26	2.03	2.03	-0.77	0	20
920	0.54	1.08	0.49	+0.05	+0.59	43
963	1.54	1.48	0.39	+1.15	+1.09	35

A COMPARISON OF ROAD-USERS NOTICE OF CONFLICTS WITH TIME TO ACCIDENT AND CONFLICTING SPEED

	SERIOUS CONFLICT												NON-SERIOUS CONFLICT											
Time to Accident	TA < 1.0 s						1.0 s < TA ≤ 1.0 s						1.5 s < TA ≤ 2.0 s						TA > 2.0 s					
Conflicting Speed	> 30 km/h			≤ 30 km/h			> 30 km/h			≤ 30 km/h			> 30 km/h			≤ 30 km/h			> 30 km/h			≤ 30 km/h		
Answer to question 6*)	Yes	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes	No	No	Yes	No	No
Answer to question 7**)	-	Yes	No	-	Yes	No	-	Yes	No	-	Yes	No	-	Yes	No	-	Yes	No	-	Yes	No	-	Yes	No
BICYCLISTS/MOPED RIDERS/PEDESTRIANS																								
Number	4	2	0	4	1	0	6	6	1	8	2	1	1	2	0	1	3	0	2	1	1	0	5	2
%	67	33	0	80	20	0	46	46	8	73	18	9	33	67	0	25	75	0	50	25	25	0	71	29
CAR DRIVERS																								
Number	8	1	1	6	0	1	12	9	2	13	3	1	6	6	4	6	4	4	3	3	4	5	7	5
%	80	10	10	86	0	14	52	39	9	76	18	6	38	38	25	43	29	29	30	30	40	29	41	29
TOTAL																								
Number	12	3	1	10	1	1	18	15	3	21	5	2	7	8	4	7	7	4	5	4	5	5	12	7
%	75	18	7	83	8	8	50	42	8	75	18	7	37	42	21	39	39	22	36	28	36	21	50	29

*) Question 6: "Did anything particular happen when you passed the intersection?"

**) Question 7: "Did you see the car/bicyclist/pedestrian/ coming from ....., that had to stop for you/you had to stop for, etc?"

A COMPARISON OF ROAD-USER'S PERCEIVED RISK IN CONFLICTS RELATED TO TIME TO ACCIDENT AND CONFLICTING SPEED OF THE CONFLICT
Malmö, I + II

Time to Accident	TA < 1.0 s						1.0 s < TA ≤ 1.5 s						1.5 s < TA ≤ 2.0 s						TA > 2.0 s					
Conflicting Speed	>30 km/h			≤30 km/h			>30 km/h			≤30 km/h			>30 km/h			≤30 km/h			>30 km/h			<30 km/h		
Answer to question 8*)	Ea	Po	Ha	Ea	Po	Ha	Ea	Po	Ha	Ea	Po	Ha	Ea	Po	Ha	Ea	Po	Ha	Ea	Po	Ha	Ea	Po	Ha
BICYCLISTS/MOPED RIDERS/PEDESTRIANS																								
Number	2	1	1	1	2	2	4	1	5	2	3	5	0	1	2	1	1	2	1	1	1	1	1	3
%	50	25	25	20	40	40	40	10	50	20	30	50	0	33	67	25	25	50	33	33	33	20	20	60
CAR DRIVERS																								
Number	1	3	5	2	0	5	2	3	16	2	2	12	1	6	4	0	2	8	1	1	2	2	0	10
%	11	33	56	29	0	71	10	14	76	12	12	76	9	55	36	0	20	80	25	25	50	17	0	83
TOTAL																								
Number	3	4	6	3	2	7	6	4	21	4	5	17	1	7	6	1	3	10	2	2	3	3	1	13
%	23	31	46	25	17	58	19	13	68	15	20	65	7	50	43	7	22	71	29	28	43	18	6	76

*) Question 8: "What was your appreciation of the perceived risk in the situation you were involved in?"
- Could easily have led to an injury accident (EA)
- Could possible have led to an injury accident (PO)
- Could hardly have led to an injury accident (HA)

PERCEIVED RISK IN CONFLICTS WITH REGARD TO TYPE OF ROAD-USER INVOLVED

Time to Accident		$TA \leq 1.0s$			$1.0<TA \leq 1.5s$			$1.5s<TA \leq 2.0s$			TOTAL		
Answer		EA	PO	HA*)	EA	PO	HA	EA	PO	HA	EA	PO	HA
Unprotected road-users in conflicts with protected road-users	Number	3	3	3	6	3	11	1	3	5	10	9	19
	%	33	33	33	30	15	55	11	33	56	26	24	50
Protected road-users in conflicts with unprotected road-users	Number	3	2	8	1	3	16	1	3	9	5	8	33
	%	23	15	62	5	15	80	8	23	69	11	17	72
Protected road-users in conflicts with protected road-users	Number	0	1	4	3	3	18	0	4	11	3	8	33
	%	0	20	80	12	12	75	0	27	73	7	18	75
TOTAL	Number	6	6	15	10	9	45	2	10	25	18	25	85
	%	22	22	56	16	14	70	5	27	68	14	20	66

*) EA = The conflict could EAsily have led to an injury accident

PO = The conflict could POssibly have led to an injury accident

HA = The conflict could HArdly have led to an injury accident