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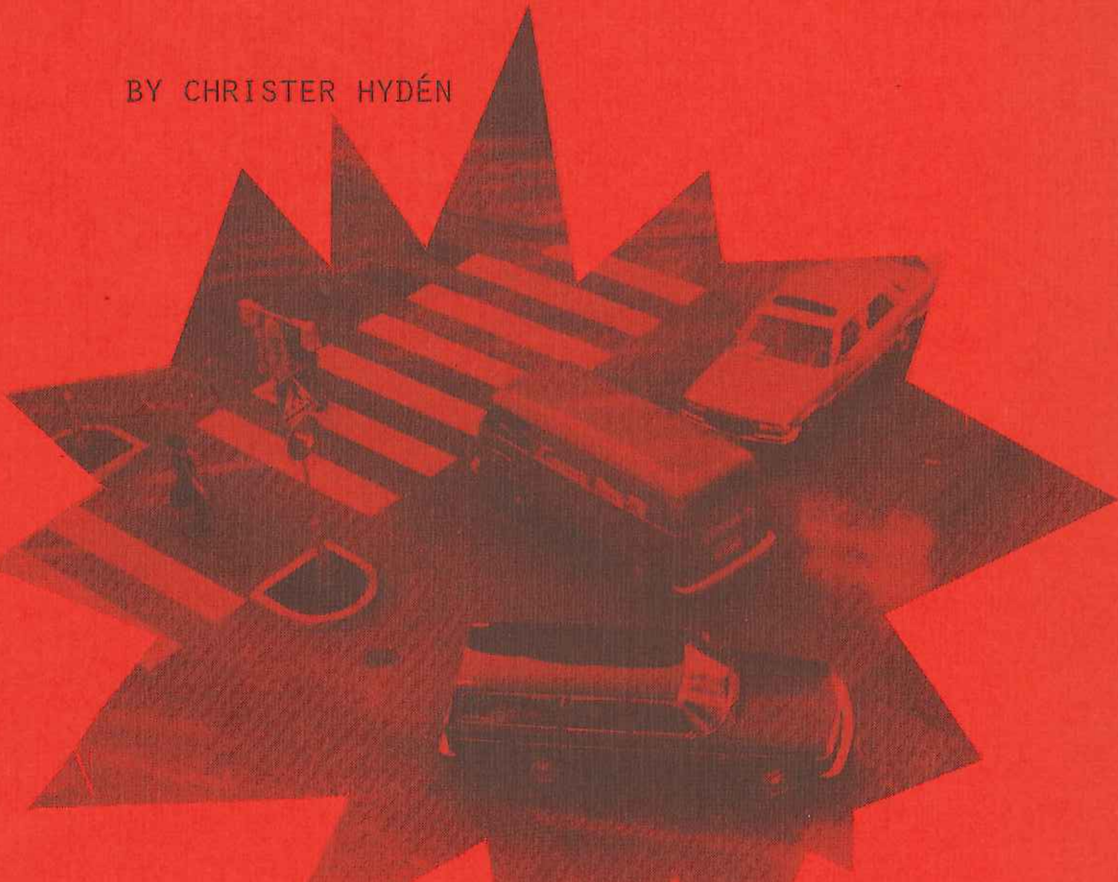
A TRAFFIC - CONFLICTS TECHNIQUE FOR DETERMINING RISK

BY CHRISTER HYDÉN



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BY CHRISTER HYDÉN

THIS REPORT REFERS TO RESEARCH GRANT TFD 51/75-52 FROM THE TRANSPORT RESEARCH DELEGATION TO THE DEPARTMENT OF TRAFFIC PLANNING AND ENGINEERING, LUND INSTITUTE OF TECHNOLOGY, LUND, SWEDEN.

LUND 1977

PREFACE

The development of a traffic conflicts technique for describing accident risk in street intersections has been underway by the Department of Traffic planning and Engineering at Lund Institute of Technology for several years. This work is based in part upon earlier research by Lövemark, Hydén and others within the departments' earlier affiliated research group, "Planfor".

The project manager has been Christer Hydén - also responsible for this report.

The research work has been carried out by Lars Leden, Leif Linderholm, Göran Möller and Agneta Ståhl and Per Gårder who also participated in the final compiling of this report. Translation into English was done by Ann Odasz and Arne M Gustafson.

Per Överbeck has carried out the statistical analyses.

Agneta Ståhl and Majvi Magdeburg were responsible for the typing and final copy.

The extensive literature list covering conflict studies is compiled by the Institute for Road Safety Research SWOV in the Netherlands by Mr Joop H Kraay.

This research program was financed with resources from the Swedish Transport Research Delegation and with contributions from the cities of Malmö and Stockholm.

A warm thank you to all who have worked with this report, named or not.

NOTE! Throughout this report, the european (Swedish) manner of denoting decimals is used. For example, one and a half second is written 1,5 sec.

Lund 1977.09.01

Gösta Lindhagen	Christer Hydén
professor	project leader

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A TRAFFIC-CONFLICTS TECHNIQUE FOR DETERMINING RISK

Summary of a final report to the Transport Research Delegation.
Contract TFD Dnr 51/75-52, 1975-07-01--1976-06-30

Traffic safety planning on local and federal levels is lacking the know-how that enables the estimation of actual effects of different countermeasures.

Analysis of occurring accidents is very time-consuming and there are often interfering changes in the variables that preferrably should be kept constant during the period of analysis (i e traffic intensity). Furthermore, information of how and why the accidents have occurred is lacking.

Many of the problems related to the analysis of accidents could be solved, if there was a method of determining risk by a conflict technique. The aim of this project is to develope such a method.

The basic hypothesis is, that there is a distinct relation between conflicts with a certain degree of seriousness and accidents.

The following definition is used: A serious conflict occurs when two road-users are involved in a conflict-situation where a collision would have occurred within 1,5 seconds if both road-users involved had continued with unchanged speed and direction. The time is calculated from the moment one of the road-users starts braking or swerving to avoid the collision.

The recording of conflicts is made by observers at the traffic site. Tests show that observers, after approximately four days of training, are able to recognise serious conflicts with a large degree of certainty.

To analyze the relations between accidents and serious conflicts, studies have been made in a total of 115 intersections in three stages:

1. Malmoe 1974-75, 50 intersections
2. Malmoe 1976, 15 intersections
3. Stockholm 1976, 50 intersections

At each intersection, conflict registration has taken place during approximately seven hours and has been compared with previous accidents of personal injury during seven to eight years.

Analyses of the relations between accidents and serious conflicts has shown that two variables have a definate influence, namely the kind of road-user and the speed-standard type of intersection.

An estimation of the relations between serious accidents and serious conflicts (π^*) has been made in four cells. The resemblance between the results of the three stages is clear enough that at unification is possible.

From this union we have the following results:

	Car-Car	Car-Pedestrian Car-Bicycle
Situations with turning motor-vehicles involved, and situations with straight-on driving motor vehicles in low-speed intersections (non-signalized, mean speed < 30 km/h)	π^*= 3,2 (2,2-5,1) 1/	π^*= 14,5 (12,2-17,4) 1/
Situations with straight on driving motor-vehicles in signalized intersections and high-speed intersections (non signalized, mean speed > 30 km/h in any flow)	π^*= 13,2 (11,2-15,7) 1/	π^*= 77,2 (64,8-91,9) 1/

1/ Confidence interval with 90 % degree of confidence.

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

The results obtained in this project shows that the developed conflict-technique offers practical application, mainly within the following areas:

- Description of present state of situations involving risk in urban traffic.
  This description includes causes likely to arise situations involving risk, suitable countermeasures for increasing traffic safety and their probable effect.
- Pilot and follow-up studies to establish the effect on traffic safety of countermeasures implemented.
  The conflict-technique offers possibilities to study both the immediate and long-range effect of countermeasures.

The conflict-technique is simple to apply, as no technical devices are necessary.

The only preparation needed, is a few days training of conflict-observers.

DEFINITIONS

Basic events

1. Conflict free passage: the road users pass by each other with such a great time interval, as to cause no influence on each others presence
2. Potential conflict: the road users are on a "collision course", so that they would meet in the intersection. With ample time one of the road users must adjust his speed to avoid a conflict with the other
3. Conflict: one of the road users must brake or swerve to avoid a serious conflict
4. Serious conflict: one of the road users must suddenly swerve or brake heavily to avoid the occurrence of a collision
5. Accident: one of the road users realizes the situaton so late that the time to react is too short to avoid a collision

Each basic event occurs with a certain frequency in each intersection, accidents with a very low relative frequency, and conflict free passages with a very high frequency.

Cell, element

	Car- Car	Car-Bicycl.	Car-Pedestrian
Traffic class 1	element 1	element 5	element 9
	CELL 1	CELL 3	
Traffic class 2	element 2	element 6	element 10
Traffic class 3	element 3	element 7	element 11
	CELL 2	CELL 4	
Traffic class 4	element 4	element 8	element 12

Conflict class

Speed 1/ < 35 km/h, 1,0 ≤ TO ≤ 1,5 seconds
Speed < TO < 1,0 seconds
Speed ≥ 1,0 ≤ TO ≤ 1,5 seconds
Speed ≥ TO < 1,0 seconds

1/ Speed of the fastest driving vehicle involved

Conversion factor (π)

The ratio between the number of accidents and the number of serious conflicts regulated to the same time and flow value

Correction factor for flows

The flow value during accident recording time/ the flow value during conflict recording time for the kind of road user and city in question

Correction factor for product of flows

The product of the correction factors for flows for the two kinds of road users involved

Intersection classification	All intersections are classified and divided according to the following: 1. Low speed intersection (non-signalized with a median speed for passing vehicles below 30 km/h in all direction of flows) 2. High speed intersection (non-signalized, median speed exceeding 30 km/h in one or more of the direction of flows) 3. Signalized intersection
Period	Part of the day during which the traffic intensity is considered homogeneous
Reliability	
External reliability	The ability of different observers to judge the same situations as serious conflicts according to the objective criterion (TO< 1,5 seconds)
Internal reliability	The ability of one observer to record serious conflicts in the same way at different occasions
Serious conflict	A serious conflict occurs when the "time to accident", TO, (see definition of TO) is below 1,5 seconds
TO (time to accident) (TO = abbreviation for Swedish "Tiden till olycka)	The time that passes from the exact moment one of the road users has reacted and starts braking or swerving until the moment that the involved had reached the point of collision if both road users had continued with unchanged speed and direction
Traffic class 1	All situations in low speed intersections (see Intersection classification) and situations with only turning vehicles involved in high speed intersections (see Intersection classification)
2	Situations with only turning vehicles involved in signalized intersections
3	Situations with at least one straight forward going vehicle involved in high speed intersections
4	Situations with at least one straight forward going vehicle involved in signalized intersections

TERMS

x_i = Number of recorded accidents in element i

y_i = Number of recorded serious conflicts in element i

$\Phi_{i\nu}$ = Product of crossing flows per hour for each separate period of observation ν

$t_{i\nu}$ = The time of observation during period ν

T_{is} = Number of days included in the accident data material for element i and intersection s

p_k^* = Σx_i / Σy_i (ie number of accidents/number of serious conflicts summed up within cell k)

N = Number of elements in the cell

A_{is} = Product of crossing flows for element i and intersection s during the time of conflict recording

B_{is} = Product of crossing flows for element i and intersection s during the time of the accident recording

Λ_i^* (lambda) = $\dfrac{x_i+y_i}{p^*+1}$

λ_i = Conflict intensity for the traffic situation in question

π = Ratio between the number of accidents and the number of serious conflicts regulated to the same time and flow value

1. BACKGROUND

1.1 General

During recent years traffic planning has been charactarized by a decreasing alotment of means for building new streets and roads with, at the same time, a continually increasing vehichle traffic.

The building of new roads must therefore be substituted with improved countermeasures in existing traffic networks.

To make maximum use of these measures, there is a demand for cognizance of the present situation and what effect varying measures will have.

Within the traffic safety sector, this leads to a need for a method of determining risk in various situations, environments etc. Such a method is called for to make a description of the present situation, which could then be a base for making preferences of measures and plans to increase traffic safety. The prediction of the effect of various measures can be, difficult with regard to the complicated interaction between man, vehicle and road. A method of determining risk should therefore also enable a prompt evaluation of countermeasures. In this manner, the results can be fed back and contributed to a continous traffic safety program.

During recent years there has been an increasing demand for a standardized method for evaluating the effects of countermeasures, both internationally and in Sweden. The lack of such a method has been very inhibiting to the possibilities of comparing results from different studies.

The main reason for this is the complexity of constructing a method of determining risk that complies with the demands mentioned earlier. This has brought about a planning within traffic safety that largely has been forced to work without the ncessary basic knowledge. This has led to a non-optimal utilization of the means available for traffic safety programs. The result of this lack of knowledge is that authorities have not been able to set a definite objective of traffic safety standards, or to specify policies for traffic safety programs, neither in general nor in detail.

1.2 Various methods to determine traffic accident risks

For the surveying of accident risks in existing traffic networks, the common method is to use occured accidents as a base. Sometimes the simple method of ranking the sites in a network by the number of occured accidents is used. In other cases, the relation of the accidents to some measure of bypassing traffic is used.

Both these manners of describing accident risk, aim at a ranking of sites as a base for priorities of efforts to be made. In other cases, attempts have been made to define accident risks in different kinds of intersections. The intention has been to attain knowledge of the influence on safety of varying design and traffic engineering devices.

In the same manner, accidents have been related to various light and weather conditions, etc, to enable the study of accident risk variation at different external conditions. Finally, to establish what risk different categories of road-users are exposed to, occured accidents have been related to the categories involved and their individual exposure to risk.

Great problems are encountered with the use of accidents to describe risk. Especially, when you want to combine various measures of risk. For instance, in describing the risk of a certain category of road-user in a specific environment, with specific external conditions.

These problems arise due to the lack of knowledge of the accident's cause and representativity and because of the relatively low frequency of accidents. The information that is usually available, for example, police records, includes little information on the details of the accident or what factors actually had influence on the cause of the accident. Furthermore, these records contain no information on traffic flows at the accident site. It is also a well known fact, that police-reported accidents are only a minor part of the actual number of occured accidents.

A study carried out by Rosmark and Fräki (VTI, special report 60, Stockholm 1968) has shown that the official statistics include approximately 20% of the total occured accidents (excluding parking accidents) and approximately half of the total person-injury accidents (both serious and slight).

In yet another study where the Uppsala region hospital statistics were used, Sande and Thorson found that from just more than 2.500 seriously injured reople recorded only 32% were reported as seriously injured, while 25% were recorded as slight injuries in Sweden Central Bureau of Statistics' traffic accident record, (police reported accidents), during the year 1966.

The missing values from the official statistics of seriously injured persons are thus 68%. If reported slight injury accidents are added the missing values are 43%. The missing values were biased with regard to the categories of road-users and age groups.

In the previously mentioned study with VTI the percentage of traffic accidents reported to auto insurance companies was also studied. It was found that the percentage of reports varied with the cost of repairs.

On the whole, approximately 40% of the total traffic accidents and almost all traffic accidents with repair costs of more than 1.000 S.kr were reported to the auto insurance companies. The frequency of police reported accidents remains approximately constant for repair costs up to 500 S.kr. Following this, the percentage of reported accidents increases to repair costs of 2.000 S kr and holds constant at 50% thereafter.

The frequency of accidents, though, are often too rare to permit a more indepth analysis. This is illustrated with the following example:

The ability to draw conclusions on the effect of a specific safety measure, for example a signal at an intersection, depends on the traffic accident analysis from many years previous to, and following, the installation of traffic signals. Even under these circumstances analysis is difficult due to other influencial factors that might not be constant over the time period. For example, the traffic intensity may have a substantial variation during the lengty extent of the analysis.

The amount of collected data in general, does not allow for detailed analyses. Neither is there a feasibility to differentiate between immediate and long term effects of the countermeasure.

The difficulties in working with the occured accidents for determining risks, which has been previously described, exposes the need for a risk criteria which satisfactorily complies with the conditions that must be established.

The common approach has been to study a type of behaviour/event directly in the traffic. This behaviour/event has to be considerably more frequent than accidents, but still be related in some way to actually occured accidents.

A common approach has been to define dangerous and "critical" behaviour for different traffic situations. This approach is based on theories regarding the actual cause of the accidents. The main problem with this approach is the large difficulty of validating the methods, i e to define at what degree a real relation exists between the defined behaviour and the actual accident risk.

In regard to the validation problem, it appears that approaches based on the study of conflicts (near accidents or near misses) are more promising.

Here one tries to discern the critical situations that, if allowed to continue, would result in a traffic accident.

This is based on the fundamental idea that if occured conflicts can be measured in some degree of seriousness, then it is possible to see what involvment the actual accident risk has in the conflict. The problems with this approach include measuring the degree of seriousness in occured conflicts.

Internationally, there have been studies and developmental work underway concerning conflict technique for almost 10 years.

1.3 Foreign research

For litterature references to this section refer to the litterature list on the use of conflict technique in traffic safety research which is found at the end of this report.

1.3.1 U S A

The first developed conflict technique was presented in 1968 by Perkins and Harris of General Motors Laboratories in the USA. The conflict definition which was chosen is very wide and included everything from precautionary braking to very serious situations which almost led to accidents. The operational definition used was the lighting of the brake lights or a lane change in a flow under observation when the observed vehicle braked or swerved to avoid an accident.

The conflict-technique developed at General Motors was tested in a federal project where Ohio, Virginia and Washington took part. The aim was to test the practical usefulness of the method and to study the relation between conflicts and accidents.

Conflict counts were carried out in approximately 400 intersections before and after a change had been made in the design of the intersections. The correlation coefficient was calculated for different conflict/accident types. The result is given in Table 1. The table shows that most of the relations are significant at the 5% level but with quite low correlation coefficients.

The conclusions of the project can be summarized in the following way:

1. The data compiled in this study tend to support the hypothesis that conflicts and accidents are associated

2. On the basis of the experience of the three states, it appears that safety deficiencies at intersections can be pinpointed more quickly and reliably by using the traffic conflicts technique than by using conventional methods:

3. The traffic conflicts technique may be particularly valuable at low-volume rural intersections where the accident reporting level is low.

4. The traffic conflicts technique, because of its usefulness in pinpointing intersection problems more precisely, should lead to lower cost remedial actions

5. The traffic conflicts technique can be applied with minor modification to locations other than intersections.

6. The effect of intersection improvements may be demonstrated from conflict counts taken shortly after completion of a spot-improvement type of change and

7. The general surveillance information obtained during the conduct of conflict counts may be valuable in improving the overall operations of intersections.

In all three of the mentioned states, the advantages of using the conflict technique were considered so large, that their use was continued even after the federal project was terminated. The state of Ohio continued to build upon its own database. In Ohio it was considered important to construct prediction models for accidents, so that more efficient evaluation studies could be carried out on the countermeasrues taken. The following regression model was constructed for the prediction of accident in an approach to a non-signalized intersection:

$$AP2Y = 1{,}162 + 11{,}6345(ADT) - 0{,}0503(CPT) - 0{,}0321(RROPP)$$
$$+ 0{,}0387(OCPO2) + 0{,}0285(TTOPP) - 0{,}02225(OPOPP)$$

For an approach to a signalized intersection the following equation was arrived at:

$$AP2Y = 0{,}36 + RATE(ADT) = 0{,}36 + ADT\ 22{,}3568 + 17{,}773$$
$$\cdot\ (SPLIT) - 36{,}7045(ADT^{1/2})) - 1{,}6785(SPLIT)^2 +$$
$$+ 18{,}2544(ADT) - 0{,}0264(OPOPP) + 0{,}8385(OPCON)$$

where

AP2Y	=	Accidents per 2 years
ADT	=	Average Daily Traffic in 10.000's
SPLIT	=	Ratio of the sum of the counted cross-street volumes to the counted approach volume (vehicle traffic)
OPOPP	=	Opposing Conflict Opportunities (opportunity is a term used to denote the maximum number of potential conflicts - traffic volume)
RROPP	=	Rear-End Conflict Opportunities
TTOPP	=	Total observed Conflict Opportunities
OPCON	=	Opposing conflicts
CPT	=	Total conflicts per 10 opportunities
OCOP2	=	Square of opposing Conflicts per 10 opportunities
RATE	=	Accidents per 2 years per 10.000 ADT

The prediction af accidents using the developed regression equations resulted in the following prediction errors:

Data class	Number of sites	Prediction error (accidents per 2 years) at various levels of significance		
		50%	75%	95%
All intersections	611	± 1,2	± 2,0	± 4,2
Signalized	220	1,5	2,4	4,6
Non-signalized	391	1,1	1,8	3,8

As shown by the equations the conflicts have only contributed to a small part of the explanation of the variation. This is instead mainly explained by the traffic flows.

1.3.2 England

At the TRRL (Transport and Road Research Laboratory) in England a somewhat different conflict-technique has been developed.

This differs from the technique developed at the General Motors in that the degree of seriousness is divided into 5 different types. In the table below the 5 types are described.

GRADE		DESCRIPTION
SLIGHT	1	Precautionary braking or lane change (e g for vehicle waiting to enter junction) or other anticapatory braking or lane change when risk of collision minimal
SLIGHT	2	Controlled braking or lane change to avoid collision but with ample time for manoeuvre
SERIOUS	3	Rapid deceleration, lane change or stopping to avoid collision; resulting in a near miss situation. No time for steady controlled manoeuvre
SERIOUS	4	Emergency braking or violent swerve to avoid collision resulting in a very near miss situation or minor collision
SERIOUS	5	Emergency action followed by collision

Recording of conflicts is done mainly by film-recording with a filming speed of 2 frames per second. To study the relation between conflicts and accidents a rank correlation was made for different situations in a studied intersection or for different studied intersections.

The studies showed that the correlation was largest when only the serious conflicts were considered in the analyses (grade 3, 4 and 5 according to the above table). The slight conflicts seemed to describe the complexity and traffic congestions primarily and not the accident potential.

1.3.3 Canada

In Canada the Ministery of Transport has used a conflict technique similar to the technique developed at TRRL. The technique was compared to other models for accident prediction at intersections. The different variables that were studied were:

1. Traffic volumes
2. Manoeuvring times for vehicles
3. Conflicts
4. Traffic violations

The results obtained, supported the hypothesis that there is a relation between conflicts and accidents. However the correlation was not especially large and it was considered, therefore, that the conflict-technique in this form was not especially useful to study individual intersections. It was found that the best prediction was obtained when the model was based on traffic volumes.

The main reason for the low correlation between accidents and conflicts was though to be the conflict definition that was used. Because of this, a project was then started where accidents, as well as conflicts, were recorded with the time lapse photography technique in the same intersection a couple of months. With the help of the time lapse technique the recording speed was decreased 24 times while the first play back was done at normal speed, thus with a 24 times higher speed in the studied course of events. After the conflicts and accidents are discerned, detailed studies are made with the course of events at normal speed. The aim of the project is to find a conflict definition, such that the course of events of conflicts and accidents agree as much as possible.

At the University of Toronto professor Ezra Hauer has studied different conflict techniques that have been used during recent years. The purpose was to answer the question: "Which conditions should be considered so that the conflict restering gives more satisfactory accident ratios than those that were obtained through the analyses of occured accidents". To study this, Hauer has calculated a term for the variation in expected number of accidents per year, both with help of accident data and conflict data. Based on different applications of the conflict technique Hauer has determined the variation in the relation between accidents and conflicts.

Figure 1 shows the list that Hauer has compiled of these variations.
Figure 2 shows under which conditions the conflict-technique is useful for the determination of accident intensity with reference to available accident data, number of accidents a year and the variation in the relation between accidents and conflicts.

The applicability that Hauer has studied concerns mainly conflicts between motor vehicles in highway intersections. The most important conclusions were:

1. It appears as if the conflict technique may be advantageously used in places with less than 4 accidents per year or where accident data is missing

2. One day field study seems optimal

3. Hauer suggested a narrower conflict definition than that used in North America.

1.3.4 Other countries

The use of the conflict-technique in traffic safety research has been initiated in a number of countries during the recent years.

In Norway, the Institute of Transport Economy has made conflict studies using a somewhat modified TRRL-technique.

A ranking was made concerning conflicts, accidents and traffic intensity in the intersections studied. The results indicated that the relation between the three variables was significant (P = 1% in an intersection regulated to the right and p=5% in right-of-way regulated intersections). To study whether traffic intensity or conflicts represented the degree of danger (i e number of accidents) best, the partial ranking correlation coefficient was calculated. The coefficient showed that in intersections regulated to the right, the traffic intensity was as good a measure of the degree of danger as the number of conflicts, while it was vice verse in right-of-way regulated intersections.

In Finland, V Rauhala conducted conflict studies based on the american definition of a conflict.

In Holland, the state research institute, SWOV, developed a technique for studying traffic safety in residential areas, which focused on conflicts between pedestrians/cyclists and vehicle traffic. A reliable technique has been called for, in this case that means a technique where the conflicts are recorded in an reliable way.

In various other countries, research has started during recent years with aims to develope a conflict technique. Among these countries are France, West Germany and Austria.

Within the OECD[1] road-research program the importance of an internationally accepted conflict technique for evaluating traffic safety measures has been emphasized. This has been included in the recommendations of the symposium "Method for Determining Geometris Road Design Standard", Helsingör, Denmark, May 1976 and in recommendations for continued research of the OECD/ECMT[2] group "Pedestrian Safety", 1976.

1. Organisation for Economic Cooperation and Development

2. European Conference of Ministers of Transport

2. PURPOSE, STATEMENT OF PROBLEM

The aim of this project has been to develope a conflict technique which is of practical use for describing risk.

Hypothesis: There is a definite relation between conflicts with at certain degree of seriousness, and accidents.

The following main problems have been delt with:

1. Definition of a serious conflict
2. Selection of a recording method and test of the methods' reliability
3. Selection af accidents
4. Analyses of the relation between recorded conflicts and accidents.

3. METHOD AND REALIZATION

3.1 General

The interaction between road users passing an intersection may be characterized by a number of basic events. The passages can take place in all mutually possible directions (both in parallel, and perpendicular directions etc).

Definitions:

1. Conflict free passage : the road users pass by each other with such a great time interval, as to cause no influence on each others presence
2. Potential conflict: the road users are on a "collision cource", so that they would meet in the intersection. With ample time one of the road users must adjust his speed to avoid a conflict with the other
3. Conflict: one of the road users must brake or swerve to avoid a serious conflict
4. Serious conflict: one of the road users must suddenly swerve or brake heavily to avoid the occurrence of a collision
5. Accident: one of the road users realizes the situation so late that the time to react is too short to avoid a collision

Each basic event occurs with a certain frequency in each intersection; accidents, with a very low relative frequency, and conflict free passages with a very high frequency.

3.2 Definition of a serious conflict

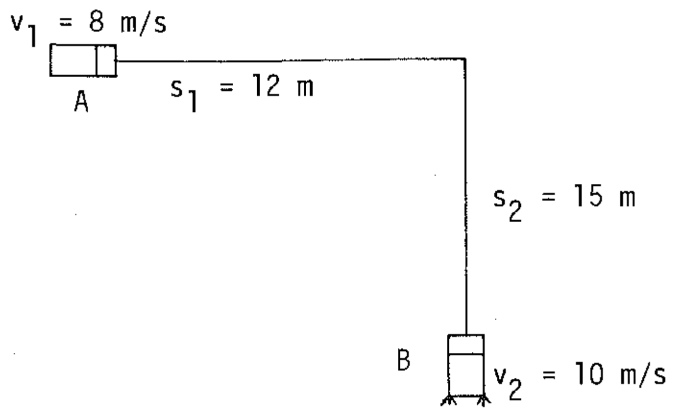
One way to measure the degree of seriousness of a conflict is to determine the amount of time from the revival, until the collision would occur.

The following definition of this amount of time has been used in this project:

Two road users find themselves on a "collision course". One (or both) realizes this danger before a certain stage and react by braking or swerving.

Time to accident (TO = abbreviation for Swedish "Tiden till Olyckan") is the time that passes from the exact moment one of the road users has reacted and starts braking or swerving until the moment that the involved had reached the point of collision if both road users had continued with unchanged speed and direction.

EXAMPLE



In the diagrammed situation, B has realized the danger, reacted and just begun a braking.

Time to accident (TO): A: $\frac{12}{8}$ = 1,5 sec

B: $\frac{15}{10}$ = 1,5 sec

TO, between those involved, can vary within a few tenths of a second depending upon the road users respective positions in regard to the imagined collision. One of the road users may, for example, have enough time to pass the imagined point of collision, just previous to the arrival of the other road user. In this case the highest TO-value is calculated. If the difference in TO is greater than the given marginal by a few tenths of a second, no collision would have occured if both continued with unchanged speeds. According to the original definition, such a situation would not be classified as a serious conflict.

Thus the TO-value for a conflict is a measure of the time the involved road users have at their disposal to avoid an accident. A high TO-value means that the conflict is not serious and that the involved road users have plenty of time to decide if and how they shall react.

A low TO-value indicates a serious conflict where an immidiate action must be taken to avoid an accident. Certain road users can consiously lower the TO-value by braking "as late as possible", in spite of their early realization of the danger. In this case the TO-value functions poorly as a measure of the degree of seriousness in a situation.

One may suppose that there is a "threshold level" for TO such that no road user consiously continues into a conflict with a TO-value that is less than the "threshold level"

The road users involved is conflicts of this type have such a small margin to act, that an immediate action is required to avoid an accident. In these cases, the conflicts' TO-value is a measure of the degree of seriousness designated by the situation. It follows that the threshold level should be an adequate selection of the critical value for serious conflicts.

Serious conflicts come about as a result of a disturbance in the interaction between the road user, the vehicle and the traffic environment. The demand for the road users awareness of the overwhelming amount of stimulus becomes too large, which causes the TO-value to fall below the critical limit.

An accident results when the TO-value in a serious conflict falls below a minimum value required to avoid the accident. This can happen either by the lack of awareness of the dangerous situation by one or more of the involved road users or by the road users missjudgement of the situations' seriousness.

The minimum value is hard to determine exactly. The value varies depending - among other things - upon the speed of the involved, immediately prior to the conflict.

Application of the theory of serious conflicts on actual traffic situations was tested in a first attempt. This was done with the help of a continous video taping of traffic flows in different type intersections. These studies resulted in the setting of 1,5 seconds as a critical value for the serious conflicts. This gives the following definition:

A serious conflict occurs when "time to accident" (TO according to the previous definition) is less than 1,5 seconds

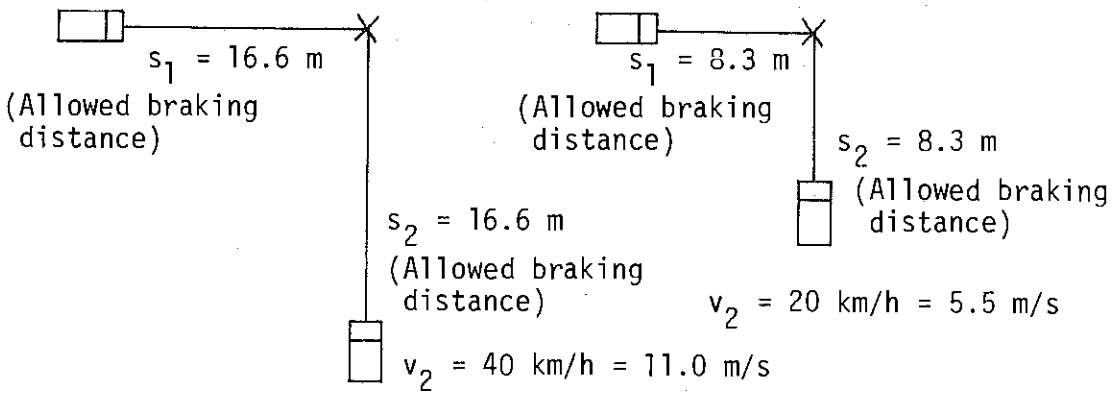
The probability that a serious conflict leads to an accident is obviously dependant upon the avoiding possibilities. These possibilities are mainly dependant upon the offered reaction time.

However, the possibilities depend also, with a large degree of probability, on the speed of the involved road users. The reason for this is stated in the definition of serious conflicts, while the road users distance from the "point of collision", with a certain TO-value, are directly proportional to the respective speed, the braking distance are proportional to the square of the respective speed.

The following example illustrates this:

Case 1. TO = 1.5 sec
v_1 = 40 km/h = 11.0 m/s

Case 2. TO = 1.5 sec
v_1 = 20 km/h = 5.5 m/s



Actual braking distance=15,0 m
(Dry pavement, level road)

Actual braking distance=3,7 m
(Dry pavement, level road)

Case 1:

$$\frac{\text{Actual braking distance}}{\text{Allowed braking distance}} = \frac{15,0}{16,6} = 0,90$$

Case 2:

$$\frac{\text{Actual braking distance}}{\text{Allowed braking distance}} = \frac{3,7}{8,3} = 0,45$$

The example above shows that the relation between the actual and allowed braking distance is considerably different in both of the conflictsin spite of the same TO-value. In Case 2, where the involved road users are driving at a lower speed, the braking distance is considerably shorter, and accordingly, the spatial margin is proportionately larger. Thereby, the probability of the conflict resulting in an accident is less likely.

The description of the speed of the involved can be done in various ways. One possibility is to classify each studied intersection by its "speed-standard" in some way.

Such a classification becomes equally important with regards to both the conflicts and accidents that are registered and analysed for a specific intersection.

In the conflict studies, the possibility exists to directly classify the conflicts by the travelling speed of those involved. However, the difficulties are large in obtaining a corresponding speed classification for accidents.

3.3 Method of recording serious conflicts

3.3.1 General

The selected recording method must be both practical and reliable. Filming or video-taping can give a high reliability for recording conflicts. The involved road-users' speed and distance from the imagined point of collision can be determined with relative accuracy through play-back of the cource of events. This means that the TO-value, which is the only necessary criteria for the recording of conflicts, can be determined.

However, filming and video-taping have certain practical problems:

1. With the use of one camera, only one part of the whole intersection may be observed at any one time

2. When studying many intersections and with fairly short observation periodes, the requirement for preparation time becomes too long (selection of filming location, permission to film, etc).

3. The resource expense becomes high, because personnel are required for both the filming and analysing of the recorded material.

Based on these reasons, film or video-taping was rejected for the extended studies included in this project.

Instead, a method has been selected for the direct ground-level observation with the help of specially trained observers. This method is free of the above mentioned disadvantages. At the same time, the method requires careful control of the observers' ability to record serious conflicts according to the objective criteria.

3.3.2 Collection of data

The recording of serious conflicts in field studies is done with the form shown in figure 3. The figure also includes an example of how the form is used.

The observer judges first the conflict class, which is a ranking by the TO value and the travellers speed according to the following:

Conflict-class 1:	Speed[1] < 35 km/h,		$1{,}0 \leq TO \leq 1{,}5$ s
2:	Speed < 35 km/h,		$TO < 1{,}0$ s
3:	Speed ≥ 35 km/h,		$1{,}0 \leq TO \leq 1{,}5$ s
4:	Speed ≥ 35 km/h		$TO < 1{,}0$ s

1/ Speed of the motor vehicle with the highest speed

After that, he records the kind of road users involved, their movements, etc. Finally, the observer makes a description of the course of events prior to the conflict and specifies the factors which may be clearly separated and which in some way contributed to "trigger" the conflict.

This method of recording conflicts is possible for use because of the relatively low number of conflicts which occur per time-unit. A maximum of 10 serious conflicts occur per hour. The recording system also makes it possible to describe a relatively complicated course of events.

Another great advantage with this method is the lack of complex devices. This enables the observer to move freely and attract a minimum of attention. This is of great importance, as the observer otherwise could cause distraction contributing to conflicts.

To calculate the relation between serious conflicts and accidents, conflict studies have been carried out in a total of 120 intersections. 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 in 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 to enable comparison and to represent a mean value of traffic intensity.

The following table shows the months and periods of the various studies:

		Studied part of period Period 1 9.00-11.30	Period 2 11.30-13.00	Period 3 13.00-16.00 (13.00-15.45	Period 4 16.00-18.30 15.45-18.15)[2)]
I.	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, 20 intersections, May 1976	1,0	0,9	1,0	1,0
III.	Stockholm, 50 intersections May, June 1976	0,6	1,0	0,5	1,0

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

2/ The values between brackets refer to the Stockholm studies

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.

3.3.3 Training of observers

All road-users find themselves often in situations where they (subconsciously) must judge the time remaining until an accident would occur. In the absolute majority of these cases, they judge correctly, so the TO-value doesn't fall below the critical limit.

The road-users' ability to indirectly judge time values is the basis for the understanding that people may be trained to judge serious conflicts with reference to the objective criteria.

Experiences have shown that the training should be set up so that the observer learns to indirectly judge the degree of seriousness. The observers are trained to compare the TO-value in video recorded conflicts with the degree of seriousness experienced in the studied conflicts. The degree of seriousness is made tangible by the suddeness an acuteness of the involved road-users reactions.

It's been shown, also, that the observers should be well informed of the theory behind the calculation of the TO-value. This enables them to make a correct judgement of, for example, a situation where one of the road-users makes an acute manoeuvre in spite of an adequate time margin. A direct judgment of the TO-value by judging the road users speed and distance to the imagined point of collision, also functions as a complement to the judging of conflicts with a TO-value close to 1,5 seconds.

As a basis for the training of observers, conflicts were collected and documented with the use of portable videotaping equipment. The equipment consists of a camera and a videotape recorder with enough magnetic tape for 30 minutes of videotaping. This videotaping technique has a great advantage over the filming technique in these situations. This is mainly dependant upon the reusability of the videotape, which greatly reduces the material costs. This is particularly true during its' use for the documentation of conflicts, which requires continous taping, and, because the conflicts occur relatively infrequently (maximum 5 times per half hour).

The portable video technique has proved itselt very practical and reliable. The quality has been completely satisfactory.

In section 7.4 the development of video technique as a useful tool to facilitate the documenting and recording of conflicts is given.

3.3.4 Test of observer reliability

Two studies have been carried out on the external and internal reliability to control the judgement ability of the observers. The external reliability test concerns the ability of the observers to judge the serious conflicts in the same way among themselves and in accordance with the objective criteria (TO $<$ 1,5 sec). The internal reliability concerns a specific observer's ability to judge serious conflicts in the same way in different occasions.

The studies were carried out in a way that during a continous videotaping, a number of observers were conflict-recoring. The observer-recorded conflicts were then compared to the video-taped conflicts.

Two helpful methods were used:

1. The observers noted the exact time for each conflict and at the same time every even minute was sound-recorded on the video tape.

2. The observer made a fairly detailed description of each conflict, including among other facts, the kind of road-users involved and their direction of travel.

The results of the reliability test are shown in section 4.1.

3.4 Traffic counts

In conjunction with the conflict studies, flow counts were done in accordance with an approximate-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" devided the total number of flows into two or three sections and counts each for five minutes. The minimum demand 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.

A special form for "checking off", was used for the counts, (see Figure 4). 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.

3.5 Accident selection

When studying the relation between serious conflicts and traffic accidents, the selection of accidents must be defined exactly. The selection must be representative and easily accessible for data collecting. As stated earlier, the police reporting of occured accidents is incomplete and dependant upon the degree of accident seriousness. The more serious the consequences of an accident, the greater probaility that it will be reported by the police.

With reference to the large problems in completing police statistics, for example by the accidents reported only to the insurance companies, police reported personal injury accidents were primarily chosen for the statistical analyses. The missing volumes could not be accounted for, but there is cause to believe that this has not influenced the primary analyses. With reference mainly to the fact that investigations of the degree of accident-reporting did not show any significantly biased distribution in the reporting between intersection of the type the analyses included (central and semi-central urban intersections).

For the comparison of conflicts, only the police reported personal injury accidents that occured during time periods covered by the conflict studies were included for study material, i e week days, except Saturdays 09.00 - 18.30. A division into four periods was made comparable to the conflict study's time divisions.

To be able even to carry out certain studies on the conflict's relations to the total number of traffic accidents, police reported property damage accidents for the first 50 studied intersections were also collected with reference to the principles that have been previously described for personal injury accidents.

For the three different studies the following analysis periods were chosen:

For the 50 Malmoe intersections, 7 years of accident statistics were collected (1968-74).

For the following 20 intersections in Malmoe, 8 years of accident statistics were used (1968-75). In Stockholm 7 years of accidents statistics were collected (1970-76).

3.6 Selection of intersections

As shown in previous chapter, the comparative analyses are based on studies in a total of 120 intersections in three steps:

I. Malmö, 50 intersections

II. Malmö, 20 intersections (different from (I))

III. Stockholm, 50 intersections

The intersections were randomly chosen among the intersections of 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 occured during the accident analysis period

2. The increase 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. This amount had to be estimated because no counts were available.

All of the intersections have been classified and grouped with reference to the following:

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

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

3. Signalized intersection

For the first 50 Malmoe intersections, certain data has been collected regarding the physical design of the intersections, including traffic refuges, pedestrian crossings and sight distances.

For the random selection of the 70 intersections in Malmoe (50+20) a list of all the intersections in Malmoe with at least one personal injury accident during the period 1968-74 (a total of 596 intersections) was used.

The selection was a little biased, as some of the intersections which by chance had not had any accidents during the chosen period, were not included in the list used for random selection.

A sample test among all intersections in Malmoe showed that out of a hundred randomly selected intersections which met the required traffic flow criteria, at least 96 were within the selection limits. The importance of the bias in selecting is decreased, as among the 596 studied intersections there were a considerable number of intersections where no accidents had occured during the period of study (approx 20%).

Because traffic counts made by Malmoe authorities showed that the construction of a new bypass markedly decreased the traffic flow in 5 intersections in 1976, these were not considered in the remainder of the analyses. These traffic counts were not available at the time of the selection of intersections, otherwise they could have been excluded from the beginning.

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 personal injury accidents whatsoever. For the same reasons given for the Malmoe intersections, this selection criteria must be considered fully acceptable.

For the classification of non-signalized intersections in high- respectively low-speed intersections primarily a subjective judging was done. In uncertain cases and for control reasons special speed recordings were carried out in 11 Stockholm intersections and 11 Malmoe intersections. Recording were made with the use of a speed analyzer, which registers the passing time of the cars via two rubber tubes stretched across the street. The speed can be registered in 5 km/h intervals.

Table 2 shows an example of a compiled recording.
In table 3 the results of the speed recordings are compiled.

4. RESULTS

4.1 Studies of observer reliability

Two studies were carried out on the observers who co-operated in the Malmoe studies.In the first study the observers external reliability was tested, i e the observers ability to accurately register serious conflicts with reference to the objective criteria (TO < 1,5 seconds). The study was done in May 1974 with the help of 5 observers who were trained during a period just before the test.

The results are given in Table 4.

In May 1975 nine observers who were trained on different occasions, November 1974, April 1975, respective May 1975,were tested. This test which couvered both external and internal reliability is shown in Table 5.

The two studies indicates an error factor of 15 respective 20 percent. "Error" refers either to the observers judgement of a situation as a serious conflict and the videotaping could not verify this judgement or that the observer did not register the serious conflict that was identified from the videotape. No direct consideration to the classification into 4 conflict classes was done as this classification was not used in the analyses of relations between conflicts and accidents. It is shown in the tables that the more serious the conflict is, the more certain the observer is in his judgement.

A control of the observers' reliability was also completed from the studies in the 50 intersections i Malmoe. In certain intersections during the period 11.30 - 13.00 and 16.00 - 18.30 studies were carried out in both 1974 and 1975. These studies were done during the same time of the year (May) on weekdays with approximately the same weather conditions and with no physical changes in the intersections. The traffic flow was approximately unchanged.

The results of this comparison are given in Table 6.
The table shows that during the period 11.30 - 13.00, where one observer was used for the studies both in 1974 and 1975, the difference in conflict frequency is less than 6%.
The studies during the period 16.00 - 18.30 show an increase of conflict frequency reaching 21% in 1975. This difference can be explained because two observers were used in 1975 while only one was used in 1974.

4.2 Studies of the relation personal injury - accidents/ serious conflicts

4.2.1 Introduction

The purpose of the statistical analysis is to study how the number of observed conflicts per accident with personal injury varies with different variable factors and, at the same time, study the relation between the number of conflicts per time unit and number of accidents per time unit under different conditions. It is reasonable to consider that the ratio, conflict per accident is not totally firm. It should for example vary with different kind of road-users. For the method to have practical application the ratio should not be heavily dependant upon too many variables.

Tests with stepwise regression were used to show which variables should be included in the method. The results showed that the kind of road user and the speed of the involved clearly had the absolute greatest influence. This showed that the relation between the number of observed conflicts per time unit and the number of accidents per time unit varies with the kind of road user in 3 classes and by speed and type intersection in 4 classes, this gives a total of 12 classes. Further tests showed that these 12 classes could be combined into 4 classes by dividing the kind of road users into 2 classes and the speed of the involved into 2 classes.

4.2.2 Model selection for Malmoe 50 intersections

4.2.2.1 Primary analysis

For the 50 Malmoe intersections tests were carried out to determine which variables should be included in the model of the relation between conflicts and accidents.

In the first attempt, the material was devided with reference to 6 different parameters. Three of them described physical design of the intersection, namely the signal-speed standard refuges and sight distances. The remaining three kind of road user, travel situation and time period describe the studied traffic situation. The kind of road user tells which categories are involved in the conflicts or accidents. (Exclusively car dirvers, or cardrivers and pedestrians, bicyclists respectively moped drivers). The description of the travel situation states whether the involved turned or continued in the same direction. In the case where non-car road users were also involved the case was classified with regards to the car. In conflicts between two cars, the situation was classified as no change of direction, if at least one vehicle continued straight ahead. The variable period tells the time of the day that the accident respectively conflict occured. Period 1 09.00 - 16.00. Period 2 16.00 - 18.30.

The accidents that occured on Saturdays and Sundays, as those that occured on ice covered roads have been disregarded. This was to obtain as similar conditions as possible compared to the period of conflict observation. A total of 247 accidents and 765 conflicts were studied.

The tables below show the variation in physical design in the 50 studied intersections, including the number of conflicts respectively accidents that were divided in the study by the variables, kind of road user, time period and travel situation.

VARIABLE	PARAMETER VALUE		NUMBER OF INTERSECTIONS
Signal	Signal regulated	= 0	12
	Low speed intersection without signal	= 1	16
	High speed intersection without signal	= 2	22
Refuge	No refuge	= 0	5
	Refuge exists in some of the approaches	= 1	45
Sight distance	Good sight distances in all directions	= 0	27
	Poor sight distances in some directions	= 1	23

			NUMBER OF ACCIDENTS	NUMBER OF CONFLICTS
Kind of road users	Car - pedestrian	= 1	127	247
	Car - bicyclist	= 2	52	109
	Car - car	= 3	36	384
	Car - mopeddriver	= 4	32	25
Time period	09.00 - 16.00	= 1	130	345
	16.00 - 18.30	= 2	117	420
Travel situation	Straighton traffic	= 1	193	518
	Turning traffic	= 2	54	247

All of the variables have a discrete variation and the coded number values 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 (BMD02R). In this way the ratio between the number of conflicts per time period and the number of accidents per time period and the number of accidents per time period have been the dependant variable while the six above mentioned variables have been independant.

It should be noted that the purpose of using the stepwise regression is only to obtain a qualitative understanding of whether the dividing by some of the independant variables gives a marked decrease in the variation in the dependant variables. The regression is used actually as an alternative to Morgans and Sonqvists AID-method. The precedure should function 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 relations between the values.

In the previously mentioned case, all the variables except for the kind of road user and signal, are of the above mentioned type. Within the variable of kind of road user no probable order can be expected. Because such variation is not shown by the regression at an early stage doesn't mean that there is no variance-reducing division based on this variable. This only shows that no linear reduction based on the code values of the variable is effective.

Because of the extensive division of the data, the number of accidents and conflicts is often low. In those cases any of them is zero, the construction of the program made it necessary to desregard such cases from the rest of the data. This has meant that more than half of the elementary cases have been sorted out. The first regression gave the following results:

Step	Inserted variable	(Multiple correlation coefficient)^2 R^2	Increase in R^2
1	Time period	0,0364	0,0364
2	Kind of road user	0,0664	0,0300
3	Travel situation	0,0940	0,0276
4	Sight distance	0,1030	0,0090
5	Signal	0,1151	0,0127
6	Refuge	0,1203	0,0045

The fact that the number of conflicts and accidents often are small 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 give an increase in the correlation coefficient. One may observe two quite different groups with regards to importance.

The variables that describe the intersections physical layout seem to have less of an influence than the remaining varibles. In the second regression therefore no consideration has been taken with regard to the physical variables. Kind of road user is divided into 4 variables, namely pedestrian, bicycle, car and moped. These variables are equal to 1 with actual kind of road user and equals 0 otherwise.

The results are shown below.

Step	Inserted variable	(Multiple correlations coefficient)^2 R^2	Increase in R^2
1	Bicycle	0,1100	0,1100
2	Car	0,2119	0,1019
3	Time period	0,2483	0,0364
4	Pedestrian	0,2542	0,0058
5	Travel situation	0,2573	0,0031

The result shows that the kind of road users has a large influence. This conclusion is drawn if one studies the summary of the number of conflicts and accidents in the above table. The correlation coefficient has increased to 0.257.

On the basi of the conflict definition the kind of road user has an influence on the ratio between conflicts and accidents. So has probably the speed of the involved. To test this, a new classification was incorporated which included a new division of variables which should give more homogeneous classes with consideration to the speed of the involved.

Traffic class 1 = All situations in low speed intersections (see DEFINITIONS: Classification of intersections) and situations with only turning vehicles involved in high speed intersections (see DEFINITIONS: Classification of intersections)

Traffic class 2 = Situations with only turning vehicles involved in signalized intersections

Traffic class 3 = Situations with at least one straight forward going vehicle involved in high speed intersections

Traffic class 4 = Situations with at least one straight forward going vehicle involved in signalized intersections

A regression sum with the new division of variables gave the following results:

Step	Inserted variable	(Multiple correlations coefficient)^2 R^2	Increase in R^2
1	Car	0,3097	0,3097
2	Traffic class 1	0,5358	0,2262
3	Time period	0,5424	0,0065
4	Traffic class 4	0,5491	0,0068
5	Traffic class 2	0,5509	0,0018

The results from this regression verify that the kind of road user and the speed of the involved vehicles have the greatest influence. The low correlation coefficient probably depends on the limited data volume and at the same time on the random selection variation both in the number of accidents and conflicts which is quite large.

According to 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 3 variables for the kind of road user and 4 speed variables. The following descriptive chart may then be compiled.

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

In this chart the travel by moped has been completely omitted. This is because the number of registered conflicts and accidents is so small that no certainty in the relation between conflicts and accidents may be obtained.

4.2.2.2 Selection of a conversion model

Definition: Conversion factor = Number of accidents / Number of conflicts per time unit

In Table 7 and 8 the number of accidents and conflicts for respective kind of road user and traffic class are shown, also the observation times for the 50 Malmoe intersections 1974 respectively 1975. A combining of the 1974 and 1975 studies and of the observation periods 1 and 2 is done. This gives no important variation in the conversion factor. This became the first attempt with the conversion factor which is shown in Table 9 together with the number of accidents and conflicts.

A clear tendency is shown by the table:

1. The conversion factor increases with increased speed among the involved (From class 1 to class 4).
2. The factor is higher for non vehicle road user than for the car drivers

These tendencies agree with the basic hypothesis, namely:

1. The influence of the speed depends mainly on the definition of a serious conflict, which is based on a set time until accident (TO)
2. The kind of road user involved is important because only personal injury accidents were used in the comparison.

It is also made evident by the table that certain of the 12 elements include a small number of accidents or conflicts. This leads to a great incertainty with in the estimated ratios.

It is seen by studying the traffic class division, which mainly describes the speed differences of the involved road users that class 1 and 2 may be considered equal as can class 3 and 4. It should be possible, then, to combine into two classes.

A division by kind of road user is mainly done to describe differences in the probability of a personal injury occuring in a conflict. From this point of view, it should be possible to merge classes where unprotected road users (pedestrians/bicyclists) are involved.

The merges can be described by the following figure with the twelve elements as a base.

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

The statistics have been tested in the following way, to confirm the reasonability of the merging:

One has 12 observation elements as in Table 9. 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, element i is defined in each set by the kind of road user and traffic class.

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

For each intersection is calculated:

A_{is}, which is the product of crossing flows with in the respective element per time period of conflict observation, i e $A_{is} = \sum_{\upsilon} \phi_{i\upsilon} \cdot t_{i\upsilon}$, where $t_{i\upsilon}$ is the length of the period of conflict observation υ and $\phi_{i\upsilon}$ is for the respective cell, the product of the crossing flows per hour for each individual period of observation υ.

The observation periods are accounted for in section 3.3.2.

$$A_i = \sum_s A_{is}$$

B_{is} which is the product of the corssing flows with in the respective element and time period, during which the accident recording was under way. An estimation of B_{is} is

$$B_{is} = (\sum_\mu \phi_{i\mu} \cdot t_{i\mu}) \cdot T_{is},$$

where $t_{i\mu}$ is the length of the period of accident observation μ and T_{is}= the number of days included in the accident data. $\phi_{i\mu}$ is the flow product $\phi_{i\upsilon}$, corrected with a factor which describes the normal change in the flow from the time of the conflict observation to a mean value for the accident recording time. These flow product corrections are accounted for in Table 10A.

$$B_i = \sum_s B_{is}$$

λ_i is an intensity, which specifies the frequency of conflicts for the traffic situation in question

π_i specifies the probability that in this element a conflict ends in an accident

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 divisions into 4 cells, π_i is constant within each cell.

We shall study whether this hypothesis is consistent with present observations.

The first step is to estimate the models parameters under the assumption that the hypothesis is true. To begin with, the "accident times" T_i are equal for all elements i e T_i = T. Then if one calculates $B_i/T=\sum_{s\mu}\sum\phi_{i\mu} \cdot t_{i\mu}$ respective $A_i=\sum_{s\upsilon}\sum\phi_{i\upsilon} \cdot t_{i\upsilon}$,

it is found that the ratio $A_i \;/\; \frac{B_i}{T}$ and consequently $A_i \;/\; B_i$

are fairly constant with in each cell. This is given in Table 10B.

We can then do the following simplication:

If we introduce new $\Lambda_i = \lambda_i \cdot A_i$ and $p_i = \pi_i \cdot \frac{B_i}{A_i}$, the model becomes $x_i \varepsilon p_o(\Lambda_i \cdot p_i)$, $y_i \varepsilon p_o(\Lambda_i)$. Because B_i / A_i are approximately constant within each cell, our hypothesis is approximately equivalent with the following:

p_i is constant within each cell.

To test the hypothesis it is enough to estimate Λ_i for each element, i e 12 each and p for every cell, i e 4 each.

It is easily found that with the maximum likelyhood method that the estimation with in each cell becomes

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

where the sums are drawn via the cell's element. Then, for each element in the cell it becomes

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

Now we look at some of 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. It is fairly easy to count numerically the distribution functions F_i for the different Q_i with Λ_i respective p substituted by the estimations Λ_i^* respective p^*.

The next step is to look at the observed ratios within the 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" ? Lets assume that a cell contains n elements and that we want to choose a small number a so that Q_i is "to far off in the tale " if $F_i(Q_i) < a$ or $F_i(Q_i) > 1-a$. We want to test at the 5% level, and have the test rule that we reject the hypothesis of the constant p in the cells as soon as any of the Q:s lie "too far out". Then a should be chosen so that

$$(1-2a)^n = 0,95, \text{ i e } a = \frac{1}{2}(1 - \sqrt[n]{0,95}).$$

The result of the test is shown in Table 11. This shows that the hypothesis may not be rejected at the 5% level, i e that the suggested merging of the 4 cells is reasonable.

The following patterns holds for the conversion factors:

	Car - Car	Unprotected road user
Traffic class 1 and 2	Cell 1	Cell 3
Traffic class 3 and 4	Cell 2	Cell 4

4.2.2.3 Estimation accuracy

The next task is to account for the accuracy in the estimation p^* within the 4 cells. This is best accomplished by stating a confidence interval for p. One then states two numbers k_1 and k_2 ($k_1 < 1 < k_2$) with the characteristic that the interval (k_1p^*, k_2p^*) with a certain given probability $1 - \alpha$ encloses the correct p-value, i e $1-\alpha = P(k_1p^* \leq p < k_2p^*)$.
The number $1-\alpha$ is called the degree of confidence.

This demand does not distinctly define k_1 and k_2. 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 $P(p < k_1p^*) = \alpha_1$ respective $P(p \geq k_2p^*) = \alpha_2$. Then k_i and k_2 gives an interval with the degree of confidence equal to $1-\alpha$. There are however two ways of chosing α_1 and α_2, which are more obvious from a practical point of view than others. The first way is to choose

$$\alpha_1 = \alpha_2 = \frac{\alpha}{2}$$

then the two interval limits become equally "critical" in the sense that the risk that p lies above the interval or that p lies below the interval is equally great.

If, as in this case, the distribution for p^* is biased, then this interval isn't the shortest possible with the confidence degree $1 - \alpha$, and neither does it become symmetric around p^*.

The other way is more obvious if you are only interested in a one-way limit. As p indicates the accident risk in a conflict, it is possible that only an upper limit for p is interesting, while a downward limit is of less interest. To do this you choose $\alpha_1 = 0$, $\alpha_2 = \alpha$ which means that the lower interval limit equals 0. This is called a one sided confidence interval with a confidence degree of $1 - \alpha$.

After determining the values of α_1 and α_2 the following procedure applies:
We have earlier arrived at $p^* = \frac{\Sigma x_i}{\Sigma y_i}$, where $\Sigma x_i \varepsilon p_0(p \cdot \Sigma A_i)$ and $\Sigma y_i \varepsilon p_0(\Sigma A_i)$. The distribution function, F, for p^* is then determined by the two parameters p and ΣA_i.
We are now to determine k_1 and k_2 so that:

$$\alpha_1 = P(p<k_1p^*) = P(p^*> \frac{p}{k_1}) = 1 - F(\frac{p}{k_1})$$

$$\alpha_2 = P(p<k_2p^*) = P(p^*> \frac{p}{k_2}) = F(\frac{p}{k_2})$$

But in this case F is dependant upon the unknown p and ΣA_i, and furthermore p is part of the arguments for F. The normal procedure is then to approximate the unknown parameters with their estimations and then solve the equations above, which results in approximate confidence intervals.

In this case $\alpha_1 = \alpha_2 = 0{,}05$ has been chosen and with the help of the above mentioned program for calculation of F the equations have been solved. Thus for each cell $(k_1 p^*, k_2 p^*)$ is a two sided confidence interval for p with a 90% degree of confidence.

As per above p_i was proportional to π_i within each cell, then, with the same k-values, the interval $(k_1\pi^*, k_2\pi^*)$ will be the corresponding confidence interval for π.

4.2.2.4 Final selection of model for Malmoe 50

The π estimation (the probability that a conflict leads to a personal injury accident) for respective cell i is done with the following formula

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

The 90% confidence interval for respective cell i, is calculated as in section 4.2.2.3.

The following conversion factors between conflict - accident were obtained:

	Car - Car	Car - unprotected road user
Traffic class 1 and 2	3,2 (2,0-6,9)	15,3 (12,2-19,6)
Traffic class 3 and 4	11,1 (8,2-16,1)	89,2 (70,5-113,3)

The confidence interval is within brackets.

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

4.2.3 Selection of model for Malmoe 15 intersections

4.2.3.1 Selection of conversion model

In Table 12 the number of accidents and conflicts are shown for respective kind of road user and traffic class, as well as the periods of observation.

The same test was done here as for Malmoe 50 to test whether a merging of the 12 elements into 4 cells could be accepted. The results are shown in Table 13. Even at this point it appears that a merging is reasonable (on a 5% level).

4.2.3.2 Final selection of model for Malmoe 15

π-estimation and calculation of confidence intervals were done as before.

The following conversion factors between conflicts - accidents were obtained:

	Car - Car	Car - Unprotected road user
Traffic class 1 and 2	3,5 (1,8-14,0)	16,0 (10,6-26,2)
Traffic class 3 and 4	13,7 (8,9-24,0)	81,4 (44,8-140,0)

The 90% confidence intervals are within brackets.

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

4.2.4 Selection of model for Stockholm 50 intersections

4.2.4.1 Selection of conversion model

In table 14 the number of accidents and conflicts for respective kind of road user and traffic class are given, as well as periods of observation.

Even in this case the reasonability of merging of twelve elements into four cells was tested. From the result, shown in Table 15, it is evident that one of the elements in cell 3, deviates a bit too much from the mean value of the cell. The fact that we, in spite of this deviation, carry out the merge into four cells depends on the relatively small deviation and may be found within the test methods' margin of error. If there, for example, had been only one additional personal injury accident in this element, the test had not rejected the hypothesis of a merge at the chosen 5% level.

4.2.4.2 Final selection of model for Stockholm 50

π estimation and calculation of confidence intervals was done as before.

The following conversion factors between conflict - accident were obtained:

	Car - Car	Car - Unprotected road user
Traffic class 1 and 2	3,1 (1,8-8,7)	12,8 (9,3-18,7)
Traffic class 3 and 4	14,1 (11,6-17,6)	62,1 (44,7-85,7)

The 90% confidence intervals are within brackets.

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

4.2.5 Common model selection

Both of the Malmoe study's respective conversion factors and conflicts intervals are schematically shown in Figure 5. The results are similar, thus a merge is fully reasonable.

For the merge, new confidence intervals were calculated as in 4.2.2.3 with the total number of accidents and conflicts as a base. These commom conversion factors are weighed by the respective confidence intervals length for the cells, i e approximately according to the amount of data for the respective study.

The following conversion factors with a 90% confidence interval were obtained for Malmoe.

	Car - Car	Car - Unprotected road user
Traffic class 1 and 2	3,3 (2,2-6,0)	15,5 (12,7-19,1)
Traffic class 3 and 4	12,1 (9,4-16,3)	86,9 (70,4-106,9)

The 90% confidence intervals are within brackets.

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

A comparison between the conversion factors for Malmoe and Stockholm is shown in Figure 6. It is evident that a deviation is present in cell 4. A merging following the principle described above gives the following conversion factors between conflicts and accidents for the total data material

	Car - Car	Car - Unprotected road user
Traffic class 1 and 2	3,2 (2,2-5,1)	14,5 (12,2-17,4)
Traffic class 3 and 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.

4.3 The relation between the total number of accidents and serious conflicts

For the Malmoe - 50 studies data were collected from the police reported property damage accidents. As shown earlier, the degree of reporting of these accidents is low. The consequense of which is that the calculated conversion factors for the conflicts / total number of accidents (including property damage accidents) indicates tendencies only.

The following conversion factors were obtained:

	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}.

4.4 Comparison of pedestrian risk through the analyses of accident data respective conflict data

In table 16 a comparison is shown for Malmoe 15 and Stockholm pedestrian risk in different parts of the intersection.

5. CONCLUSION, COMMENTS

5.1 Introduction

The fundamental problems encountered during the formulation of an analytical model for the relation between accidents and serious conflicts, caused us at an early stage, to concentrate on an empirical model. We realized also that it was important to choose a definition of a serious conflict that could best eliminate the psycological factors that govern the road users behaviour. Our definition of a serious conflict, which is based on the time to accident being less than 1,5 seconds, is chosen so that this is well accomplished. This is dependent, among other things, on the elimination of reaction time and, that the road users choice of behaviour in encountering an accident is strongly limited because the situation requires an immidiate action.

To test the variation in the empirically found relation between accidents and serious conflicts the study was constructed in the following manner:

1. The 50 intersections in Malmoe were studied in 1974 to differentiate which variables were important for the relation.

2. 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.

3. 15 new intersections in Malmoe were studied in 1976 to clarify the relation's variation within the same urban area.

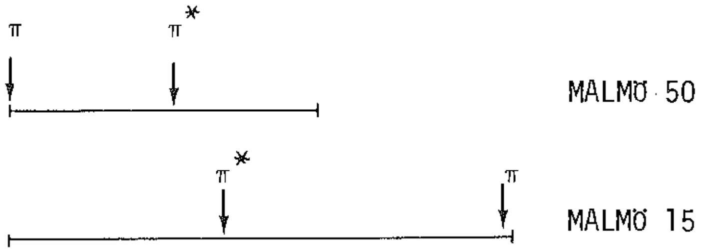
4. The 50 intersections in Stockholm were studied in 1976 to study whether the relations vary with the characteristics and size of the urban area.

5.2 Selection of common model

It must be considered fully established that the physical variables which have been tested do not have any significant influence on the estimation of accident risk.

The results from the different Malmoe studies show a very good correspondence regarding the estimated ratio between accidents and serious conflicts (π^*). However, this does nor mean, with total certainty, that the real π-values are indentical.

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



It is impossible to establish the existance of this situation.

It could be stated though that there is a 5% risk of the one groups of data's real value to fall outside the estimated π-value's confidence intervals limit on one side. The risk that the other group of data's real π-value will fall outside of its confidence interval is equally large. The probability that this would be the case simultaneously for both estimations is very unlikely.

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 groups of data's real π-values lie close enough to each other. It is a question of judgement whether this is the case for the Malmoe 15 and Malmoe 50. We do believe this to be the case.

If we consider the π-estimations of the Stockholm material we find that this corresponds wery well with that of Malmoe's for the car- car cells. However in the cells that concern unprotected road users the Stockholm π-estimations are lower.

The most probable explanation of the differences between Stockholm and Malmö is the special difficulties for bicyclists in Stockholm due to heavy vehicle traffic. Another explanation can be that the number of serious conflicts and accidents is rather small for unprotected road users. A third reason may be that the Stockholm traffic has a different character than Malmö's. It is possible that a more thorough analysis than this project allowed could explain these differences.

So far we can not establish that the differences are so large that a unification is not considered appropriate. Finally, it must be stated, that there are tendencies in the accomplished tests that a merge into four cells may prove to be too rough if the number of data could be extended. Primarily a division of pedestrians and bicyclists is most probable. The present data base however is not big enough to make a division into more than four cells reasonable. A further division would result in too great an uncertainty in the estimated values when using the technique in practise.

5.3 Prediction of accident intensity

What do the uncertainties in the estimated ratios imply, when trying to estimate the actual number of accidents occuring in a certain location? Lets look at the part of the traffic in 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 number of conflicts. We shall see what information this results in regarding the expected accident-frequency.

The model is based on that y is an observation of $Y \varepsilon p_o(\lambda \cdot t)$,

and 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 $X \varepsilon p_o(\lambda \cdot \pi \cdot T)$ according to our model. If the goal is to predict X, then it must be realized that even if the intensity $\lambda \cdot \pi$ was known exactly a spread in X would occur, which is measured by the standard deviation $\sqrt{\lambda \cdot \pi \cdot T}$.

An actual future accident-number, can not be better predicted by any other method. A more reasonable and pragmatic goal is to get a good estimation of the accident-intensity $\lambda \cdot \pi$, 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 occurs. This gives the estimation $(\lambda \cdot \pi)^* = \frac{X}{T}$, which has a standard error $d((\lambda \cdot \pi)^*) = \sqrt{\frac{(\lambda \cdot \pi)^*}{T}}$. The longer the T, the better the estimation. 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 at 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 $\frac{t}{\pi}$.

With help of the previously constructed confidence intervals for π_i (the total data-material) the confidence intervals for T can be calculated:

$$\text{Cell 1:}\quad \frac{t\cdot 10^5}{5,1} = 19608t < T < 45455t = \frac{t\cdot 10^5}{2,2}$$

$$\text{Cell 2:}\quad \frac{t\cdot 10^5}{15,7} = 6369t < T < 8929t = \frac{t\cdot 10^5}{11,2}$$

$$\text{Cell 3:}\quad \frac{t\cdot 10^5}{17,4} = 5747t < T < 8197t = \frac{t\cdot 10^5}{12,2}$$

$$\text{Cell 4:}\quad \frac{t\cdot 10^5}{91,9} = 1088t < T < 1543t = \frac{t\cdot 10^5}{64,8}$$

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

When the conflict-technique is used for prediction of the accident intensity, the number of conflicts and the number of accidents must be related to the same flow product.

6. PRACTICAL APLICATION

6.1 General

The conflict-technique should, because of its advantages over the use of accident data when determining risk, be of great use within the traffic safety sector. The most important advantages can be summarized in the following way:

1. A conflict study covers all the situations that occur in the studied location

2. A conflict study describes the correct situation in a location and not an average for the previous years, which is the case with the accident analyses.

3. The conflict studies' extent can be adapted to the nature and size of a problem. With a problem of large general interest the studies can be done extensively so that a very detailed analyses may be carried out.

4. When recording conflicts, the course of events prior to a conflict may be recorded, as well as the factors which contributed to the occurance of the conflict.

6.2 Description of present situation

6.2.1 General

The advantages of the conflict-technique over accident-analyses ought to result in the use of the technique for the delineation of the present situation as a base when planning countermeasures for increased traffic safety. This concerns general planning (ie urban area traffic restrictions) as well as more detailed planning (i e the physical lay-out of intersections).

Practical use of the conflict technique in the USA has shown that this results in a higher accident reduction, at a given cost.

6.2.2 Ranking

When deciding upon the priority of different countermeasures, the recording of conflicts can be used for the final selection criterion. At the same time these studies give the required base for judging of appropriate counter measures. In principle, a community should be able to choose a standardized procedure concerning the following:

1. A preliminary selection of points is done with the help of accident analysis, public opinion and from the expert knowledge community employees have acquired.

2. Conflict studies are carried out in all selected points. After that, a judgement priority of countermeasures can take place.

3. A follow up of the taken counter measures should be done, especially where the effects of the counter measures are most difficult to anticipate (see section 6.3)

6.2.3 Description of causual connections

The description of the course of events that precede the conflicts and the factors that influence the development of the situation are recorded, as mentioned before, by the observers. With this detailed description, the possibilities increase to solve each problem in the most appropriate way. In addition, it should be possible to predict the effect of the countermeasure in each case with a considerably higher degree of accuracy than what is possible with accident analyses. This is of great importance when the complicated interaction between the road users/vehicles and the road, makes each prediction of the effect of a specific counter measure difficult to determine.

In Table 17 and 18 a summary is given of the cause description and type-of-conflict classification for the first 50 Malmoe intersections.

These tables must be looked upon as examples of how a course of events description can be done. The selection of intersections was mainly done with consideration taken to the relation between serious conflicts and accidents. Therefore the results may not be considered as a representative risk description for certain types of intersections.

6.2.4 Example - description of present situation, one intersection

The standardized procedure for the selection of locations for traffic safety counter measures as described in section 6.2.2 can be completed with a standard procedure for the description of the conflict study results.

In appendix 1 an example of a conflict study based on a total of 11,5 hours in the intersection Kungsgatan - Östra Förstadsgata in Malmoe is given. It is shown in this example how the conflicts can be described in a special intersection with regard to site, type and cause. The example also includes the number of occured personal injury accidents compiled for 1968 - 1974.

An intersection description of this type should then be updated so that the taken counter measures and their effects on safety is shown (in the cases where follow-up studies were done). In this way a standardized procedure has great importance as a base for the exchange of valuable information between the communitity authorities and other interested parties.

6.3 Countermeasure evaluation

6.3.1 General

In this area the conflict technique should have its greatest short term importance. Earlier in the report (see chapter 1) the difficulties in using accidents as a basis for the evaluation of effects was shown. The conflict technique makes it possible to quickly check whether a taken countermeasure has actually had the mentioned effect. If this is not the case, supplementary countermeasures or changes may be taken and the effects controlled. It is possible with the use of a conflict technique, to show that in many cases only a small adjustment is needed to reach the best solution.

To determine the remaining effect and to compare this with the immidiate yet another conflict study may be carried out.

The requirement of a conflict technique, when evaluating countermeasures, is mainly that the recording technique is reliable and the agreement that serious conflicts and accidents are related in some way. The relation conflicts/accidents in absolute numbers is less important when a comparison is made of the number of conflicts of different types before and after a change.

6.3.2 Effect of local speed limit at schools

Under assignment of The Swedish Road Safety Office the Department has carried out before - after studies on four locations where local speed limits of 30 km/h were enforced. The goal was to expose whether the school-childrens' safety improved, and if so, what this improvement was dependent upon. The speed limit was posted on two types of signs.

1. Ordinary sign that stated that the speed limit was valid only Mondays - Fridays 07.30 - 16.00

2. Adjustable sign automatically controlled indicating 30 km/h during the time the children were on their way to and from school.

In each test, one before- and two afterstudies were completed. Each study covered five weekdays except for one test where the study time was doubbled because the conflict frequency was too low. This decision to double the length of the time was already determined during the before study.

The table on the following page describes the different test-locations

City, street	Stockholm Abrahamsbergsvägen	Stockholm Kommendörsgatan	Vetlanda Nygatan	Södertälje Erik Dahlbergs väg
Street function	secondary link	local street	secondary link	secondary link
Priority rule in intersections	right hand rule	right hand rule	right of way	right of way
Street width	9 m	12 m	9 m	9 m
Parked cars	both sides	both sides	occasionally a few cars	occasionally a few cars
Distance between intersecting streets	appr 100 m	appr 75 - 90 m	appr 180 m	appr 150 m
Length of regulated section	430 m	75 m	350 m	500 m
Traffic volume vehicles per ADT	appr 5.700	appr 4.100	appr 4.000	appr 10.000
Speed limit by: (30 km/h)	ordinary sign with added text: Mon - Fri 07.30-16.00	ordinary sign with added text: Mon - Fri 07.30-16.00	time regulated adjustable sign	time regulated adjustable sign

In each study conflict recording,traffic counting and speed recording was done. The speed was measured with the use of the "datalogg" developed at the department. Two tubes stretched across the road recorded in the datalogg the passage time of each vehicle. The collected data was registered on tape, which then were computerized. Besides the vehicle time of passage, the number of vehicles and pedestrians in different flows was also recorded with use of the datalogg.

The vehicles passages were devided with regard to whether children were on or close to the street or whether no children were visible and also which speed limit was enforced.

The results of the conflict studies are given in the following table, which concerns the number of conflicts with pedestrians involved

Location	Before	After I[1]	After II[2]
Kommendörsgatan, Stockholm	22	13	8
Abrahamsbergsvägen, Stockholm	8	4	6
Nygatan, Vetlanda	10	4	2
Erik Dahlbergsg, Södertälje	22	14	7
Total	52	35	23

1/ Approximately one month after the introduction of the speed limit
2/ One half to on year after the introduction of the speed limit

The number of conflicts have decreased significantly in all four tests. Besides, in three of the four tests the number of conflicts continued to decrease by the second afterstudy. This is true for both tests with adjustable signs.

It can also be mentioned that the conflicts before and after the introduction of the speed limit are of the same type except that the speed of the involved motor vehicle was constantly lower in the afterstudies. The relations between accidents and conflicts given in this resport clearly show that the relations are dependent on the speed meaning, the lower the speed, less the probability that an accident should occur.

The positive result of a decreased number of conflicts since the speed limit was enforced is strengthened by the fact that the conflicts have also become less serious.

Through the counts of traffic volumes and control of the weather conditions in the different studies, it could be established that the decrease in the number of conflicts must be clearified by the drivers speed decrease.

The table on next page gives a list of the results from the speed recordings.

Location	Averge speed km/h	Percentage of drivers exceeding 30 km/h when no children are on or near the street	Percentage of drivers exceeding 30 km/h when there are children on or near the street
Abrahamsbergsvägen Stockholm			
Before	39,4	86,8	-
After I	34,8	69,3	-
After II	36,4	79,5	-
Kommendörsgatan Stockholm			
Before	31,0	55,0	47,0
After I	30,1	50,6	38,7
After II	26,7	31,7	18,8
Nygatan Vetlanda			
Before	44,5	94,3	92,7
After I, 50 km/h	42,4	91,2	88,1
After I, 30 km/h	35,8	70,3	64,2
After II, 50 km/h	38,0	68,3	63,5
After II, 30 km/h	31,8	40,5	36,5
Erik Dahlbergs väg Södertälje			
Before	41,3	82,8	75,0
After I, 50 km/h	40,0	76,3	55,7
After I, 30 km/h	35,1	57,0	47,0
After II, 50 km/h	39,2	75,5	58,0
After II, 30 km/h	33,1	47,5	42,5

Using the table on previous page as a starting point, one may demonstrate that in general the speed limit give the following effects:

On locations with ordinary signs the average speed has decreased by 3,2 km/h while the adjustable signs gave a reduction of 8,9 km/h. The presence of children caused a constant decrease of yet one km/h (not shown in the table).

By studying the percentage of drivers exceeding 30 km/h it can be demonstrated that the childrens' presence has the most influence on the drivers who were driving fastest before the introduction of the speed limit.

A conclusion drawn from the speed recordings is that the drivers demonstrated a good understanding of the speed limit through the adjustment of their speed with consideration to the risk of conflicts. This must be the main reason for the positive effects regarding safety.

6.4 Relation between accident-risk/different explanatory variables

At studies of accident risk variation the conflict technique has great advantages over the accident analyses. This is mainly due to the fact that the risk varies with so many factors that a division of accidents would give too small a number in many classes.

Conflict recording makes it possible to study one of these classes at a time. Besides, the conflict counts may be combined with the traffic counts which makes it possible to relate the occured conflicts to the intensity of traffic in different flows at the actual location during an actual time period.

The department has started a project, financed by the Transport Research Delegation with the aim to study, pedestrian risks in different environments and different situations. The project has a set up similar to the one described in this report. The differences is that instead of studying the accident to conflict ratio and its variation the variation in conflict frequency with regard to different factors, will be studied. The purpose is that the new project will give results that may constitute a base for the judgement of the general effects of different countermeasures. The studies concerned with the pedestrians' risk should, for example, give a better understanding of the risks in different types of crossings and the risk variation with different traffic volumes. In this way this information can produce the base for general guidelines regarding the use of different types of pedestrian crossings.

7. FURTHER DEVELOPMENT

7.1 General

The results demonstrated in this report clearly show that the developed conflict technique fulfills the demands regarding the reliability of recording serious conflicts and regarding the possibilities to describe the actual accident risk with reference to serious conflicts.

The certainty with which the relation between accidents and conflicts is, may however be improved further. This certainty is highly dependent on the number of accidents and conflicts that are included in the analyses. In spite of the large field studies that were carried out (appr 800 workhours of conflict recording) more data should be collected to improve the certainty.

This collection of data could be done simultaneously with the use of the conflict technique in practise. Each opportunity should be taken to supplement the amount of data that the analysis so far has been based on.

As was briefly mentioned in the previous chapter, other certain interesting questions within this project could not be satisfactorily answered due to the lack of sufficient resources. This includes for example the question on which observation times for the conflicts counts are most appropriate to give a representative value for the accident risks for all points of time as well as for all kinds of weather and lighting conditions.

Another question, which has been only briefly dealt with is in what way the serious conflicts describe the risk of encountering a property damage accident.

In the three following sections examples are given for alternative development possibilities to further improve the usefulness of the traffic-conflicts technique.

7.2 Alternative approach to classify conflicts/accidents involving only vehicles

With the developed conflict technicue the risk forpersonal injury accidents may be described with good precision in urban intersections. The precision is also good for the description of in which situation the pedestrians may possibly encounter an accident. Even though, it seems that the certainty decrease with the division of accidents involving only vehicle into accident types.

It is possible that an approach built on the classification of the conflicts with regard to the vehicles' relative speed on "approaching angle" should give a more certain description of the risk of a personal injury accident within different accident types. This classification may eventually be combined with the earlier classification of intersections by their standard speed.

A test of this alternative approach requires an important supplement to the present amount of date. With regard to this it could instead be more interesting to study the relation between conflicts and the total number of accidents.

7.3 Alternative definition of serious conflict

In an ongoing study of the usefulness of the conflict technique in rural intersections, carried out by assignment of the Public Roads Administration a new definition of a serious conflict is tested. With regard to the markedly higher vehicle speeds in rural intersections, compared to urban intersections, the previously used conflict technique (TO $\leq$ 1,5 seconds) could not be considered appropriate. The conflict observers have instead done a preliminary division of the conflicts in "risk related" respective "preventive".

The observers proceeded with this classification from their experiences of the relation between the suddeness and violence that the involved in urban intersection conflicts demonstrates and the regarded limit for the "risk related" conflict where TO $\leq$ 1,5 sec. Beside this, the observers have estimated the speed of the involved vehicles and distance from the predicted point of collision for a later calculation of each conflicts TO-value.

In figure 7 and 8 the results from studies in two different rural intersections are shown. The figures primarily indicates two points of interest.

1. There is a distinct relation between the TO-values of the conflicts and the "risk relation" as it is defined by the observers.

2. The limit value between "risk related" conflicts and preventive ones is, in both studies, 2,2 seconds with a certain dispersion around this value.

Both of these studies show that an alternative definition based on the observers judging of the conflicts' risk relation should be possible even in urban intersection studies such a definition would probably decrease the dispersion in the relation between conflicts and accidents so that the classifying by the intersections' speed standard could be abolished. An example of this is rear end conflicts, where the present definition gives an "abnormally" high number of conflicts for each accident.
A direct risk relation of the above mentioned type would most probably noticeably decrease the number of this type of conflicts.

A further development of this alternative conflict definition shall be continued in the previously mentioned Public Roads Administration assigrment.

7.4 Use of video-recording to collect conflict data

In section 3.3.3 the use of video-technique is described for the documentation of conflicts on video types as a base for the training of observers.

Due to the recent advancements in the development of the video-techniques, admitting frame by frame recording (time-lapse), the possibilities for routin use of vedeorecording for data collecting have increased considerably.

Time-lapse recording makes it possible to lower the speed while recording and increase it again during the first run through the material. This should lead to a large decrease in the evaluation costs.

In order to make detailed studies of a conflict the up-speeded video-tape may then be slowed down again so that the course of events may proceed at a normal speed.

The video-recorder may be supplemented with a timer accurate to a thousandth of a second. This timer unables a more accurate evaluation of vehicle speeds, where by the TO-values may be estimated more accurately.

The time-lapse technique is of special interest in studies concerned with low frequency situations, where the recording of conflicts by an observer would not be considered appropriate from an economical point of view.

The lapse-technique will probably be tested in the previously mentioned studies in rural intersections. If proven successful the technique will be very economical due to the fact that at least two observers have to be used for ground level observation in rural intersections according to the high vehicle speeds and consequently an observation area of great distance.

TABLE I

FHWA CORRELATION COEFFICIENTS (r) FOR T AND 4-LEGGED RIGHT - ANGLE INTERSECTIONS

Intersection	Conflict - Accident Situation: Weave	Left-Turn Head-On	Cross-Traffic	Rear- End	All Maneuvers	Critical r	Sample Size
Signalized							
T	-0.207	-0.128	-0.170	0.075	-0.172	±0.532	14
4-legged right-angle	0.360[a]	0.661[a]	0.209[a]	-0.018	0.410[a]	±0.179	122
All[b]	0.402[a]	0.615[a]	0.136	-0.017	0.326[a]	±0.160	157
Nonsignalized							
T	0.294[a]	0.432[a]	0.830[a]	0.410[a]	0.837[a]	±0.205	94
4-legged right-angle	0.159	0.459[a]	0.602[a]	0.213[a]	0.653[a]	±0.192	106
All[b]	0.276[a]	0.453[a]	0.655[a]	0.295[a]	0.671[a]	±0.130	235
All combined[c]	0.356[a]	0.546[a]	0.429[a]	0.154[a]	0.458[a]	±0.100	392

a Indicates statistical significance at the 5 percent level

b. Includes other intersection types such as skewed and multileg as well as T and 4-legged right-angle

c. Composed of all signalized and nonsignalized intersections.

From : Evaluation of the traffic conflicts technique, Draft Report, August 1975, U. S. Department of Transportation, Contract No DOT - FH - 11 - 8121

SPEED ANALYSIS, STOCKHOLM

Location : Hässelbyvägen,

between 1. Spånga Kyrkväg and 2. Värsta Allé tow. 1

Körfält L M R

Speed limit: 50 km/h

Weekday, Date Ti, 76.09.28 Wheather : variable

Road condition: dry

09.00 - 11.00

Total number of vehicles: 774

km/h	<30	<35	<40	<45	<50	<55	<60	<65	<70	<75	>75
accum.	171	356	576	708	759	770	774	774	774	774	774
acc. %	22	46	74	91	98	99	100	100	100	100	100
km/h	<30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	>75
number	171	185	220	132	51	11	4	0	0	0	0

Median ⩽ 36 km/h 85 % ⩽ 43 km/h

11.00 - 13.00

Total number of vehicles: 865

km/h	<30	<35	<40	<45	<50	<55	<60	<65	<70	<75	>75
accum.	196	398	629	784	845	859	862	862	862	862	862
acc. %	23	46	73	91	98	99	100	100	100	100	100
km/h	<30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	>75
number	196	202	231	155	61	14	13	0	0	0	0

Median ⩽ 36 km/h 85 % ⩽ 43 km/h

SPEED ANALYSIS, STOCKHOLM

Location: Hässelbyvägen

between 1. Spånga Kyrkväg and 2. Värsta Allé tow. 1 ~~2~~

L M R

Speed limit: 50 km/h

Weekday, Date , 76.09.28

Wheather : variable

Road condition : dry

13.00 - 15.30

Total number of vehicles: 1214

km/h	<30	<35	<40	<45	<50	<55	<60	<65	<70	<75	>75
accum.	286	606	947	1131	1197	1208	1209	1209	1210	1210	1214
acc. %	24	50	78	93	99	100	100	100	100	100	100
km/h	<30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	>75
number	286	320	341	184	66	11	1	0	1	0	4

Median ≤ 35 km/h 85 % ≤ 42 km/h

15.30 - 18.30

Total number of vehicles: 2708

km/h	<30	<35	<40	<45	<50	<55	<60	<65	<70	<75	>75
accum.	1073	1734	2394	2646	2694	2706	2707	2707	2707	2708	2708
acc. %	40	64	88	98	99	100	100	100	100	100	100
km/h	<30	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	>75
number	1073	661	660	252	48	12	1	0	0	0	1

Median ≤ 32 km/h 85 % ≤ 39 km/h

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
Ystadsgatan-Claesgatan	18	30	Low
Östra Tullgatan-Stora Trädgårdsgatan	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

TABLE 4

TEST OF OBSERVER RELIABILITY, 1

CONFLICT SITUATION NO	TIME OF DAY	KIND OF ROAD USER INVOLVED 1/	SERIOUS CONFLICT ACCORDING TO EVALUATION OF VIDEOTAPES 2/	SERIOUS CONFLICT ACCORDING TO THE OBSERVERS' RECORDING 2/					SCORES	
				A	E	H	J	M	POSSIBLE	ERRATIC
1	16.08	C - B	1	1	1	2	1	-	5	1
2	16.11	C - P	3	3	3	3	3	-	5	1
3	16.17	C - C	-	-	1	-	-	-		1
4	16.20	C - P	3	3	3	3	3	3	5	
5	16.30	C - P	4	4	4	4	4	4	5	
6	16.54	C - C	-	-	3	-	-	-		1
7	16.55	C - B	1	-	-	1	1	1	5	2
8	17.01	C - M	1	1	1	1	1	1	5	
9	17.03	C - C	4	4	4	4	2	4	5	
10	17.35	C - C	2	2	2	1	2	2	5	
Total:				7	9	8	8	6	40	6
Number of errors per observer:				1	3	0	0	2		

1/ KIND OF ROAD USER INVOLVED: C = Car driver
B = Bicyclist
P = Pedestrian
M = Moped driver

ERRATIC SCORES (MEAN VALUE): $\frac{6}{40} = 15\ \%$

2/ The figures concern the degree of seriousness in four classes of the serious conflicts

Location: No 13 in Malmö, Amiralsgatan-Spånehusvägen. Wednesday, 1974.06.05, 16.00-18.00

CONFLICT SITUATION NO	TIME OF DAY	KIND OF ROAD USER INVOLVED 1/	SERIOUS CONFLICT ACCORDING TO EVALUATION OF VIDEOTAPES 2/	SERIOUS CONFLICT ACCORDING TO THE OBSERVER'S RECORDING 2/							SCORES	
				L	H	M	T	P	J	R	POSSIBLE	ERRATIC
1	12.32	C - C	2	1	2	2	-	2	2	1	7	1
2	12.40	C - C	1	1	-	1	1	1	2	1	7	1
3	12.47	C - P	-	-	-	1	-	-	-	-	-	1
4	16.15	C - C	-	-	1	-	-	-	-	-	-	1
5	16.44	C - P	1	1	-	-	1	1	1	1	7	2
6	16.57	C - C	2	1	3	1	1	1	2	1	7	-
7	18.07	C - C	2	1	1	-	1	2	2	2	7	1
Total:				5	4	4	4	5	5	5	35	7
Number of errors per observer:				0	3	3	1	0	0	0		

1/ KIND OF ROAD USER INVOLVED: C = Car driver
B = Bicyclist
P = Pedestrian
M = Moped driver

ERRATIC SCORES (MEAN VALUE): $\frac{7}{35} = 20\ \%$

2/ The figures concern the degree of seriousness in four classes of the serious conflicts

Location: No 5 in Malmö, Studentgatan - St. Nygatan, Tuesday, 1976.06.03, 11.35-13.00 and 15.55-18.15

NUMBER OF CONFLICTS PER MINUTE 1974 AND 1975 FOR CERTAIN LOCATIONS

Malmö - 50 intersections

Location	Hours 11.30-13.00: Number of conflicts -74 1/	-75 1/	Length of observation (min) -74 1/	-75 1/	Hours 16.00-18.30: Number of conflicts -74 1/	-75 2/	Length of observation (min) -74 1/	-75 2/	Hours 11.30-13.00, 16.00-18.30: Number of conflicts -74	-75
1	1	2	84	84	4	2	144	144	5	4
2	3	0	"	"	2	5	"	"	5	5
3	2	3	"	"	7	3	"	"	9	6
4	4	2	"	"	-	-	-	-	-	-
5	6	7	"	"	-	-	-	-	-	-
6	4	6	"	"	8	12	"	"	12	18
7	4	6	"	"	5	4	"	"	9	10
8	-	-	-	-	3	4	"	"	-	-
9	2	0	"	"	3	4	"	"	5	4
10	3	4	"	"	-	-	-	-	-	-
11	-	-	-	-	3	6	"	"	-	-
14	5	4	"	"	7	8	"	"	12	12
16	0	1	"	"	4	3	"	"	4	4
17	1	3	63	"	5	10	"	"	6	13
18	2	4	84	"	-	-	-	-	-	-
19	-	-	-	-	4	4	"	"	-	-
20	3	2	"	"	7	11	"	"	10	13
Total	40	44	1155	1176	62	76	1872	1872	77	89

Number of conflicts per min.:			Difference
Hours:	11.30-13.00, 1/	1974: 0,035	
	11.30-13.00, 1/	1975: 0,037	+6%
Hours:	16.00-18.30, 1/	1974: 0,033	
	16.00-18.30, 2/	1975: 0,041	+21%

1/ 1 observer per study 2/ 2 observers per study

TABLE 7

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 accidents (min) $x10^{-7}$	Number of accidents $x10^{7}$	Number of confl.	Obs.time conflicts (min) $x10^{-3}$	Number of confl. $x10^{3}$	Number of accidents per minute/ Number of conflicts per minute $x10^{5}$
1	Car - ped	1	14	4.13	3.40	39	6.23	6.26	5.4
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 - cycl.	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: 9.00-16.00 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 acci-dents	Obs.time accidents (min) $x10^{-7}$	Number of acci-dents per min $x10^{7}$	Number of confl.	Obs.time confl. (min) $x10^{-3}$	Number of confl. per min $x10^{3}$	Number of accidents per min/ Number of confl. per minute $x\ 10^{5}$ 1975	1974
1	Car - ped	1	14	3.67	3.81	36	8.36	4.30	8.7	5.4
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 - cycl	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: 9.00-16.00 Time period 2: 16.00-18.30

NUMBER OF ACCIDENTS AND CONFLICTS, INCLUDING PERIODS OF OBSERVATION AND A FIRST ATTEMPT WITH CONVERSION FACTORS.

Malmö - 50 intersections

Table 9 a

Number of accidents, number of conflicts, periods of observation.

Traffic class	Number of accidents/number of conflicts Car - car	Bicycle - car	Pedestrian-car	Time of observation: Conflicts(min)x10^{-3} / Accidents(min)x10^{-7}
1	5/191	13/53	27/156	29,91/5,60
2	3/25	9/19	12/57	6,33/1,14
3	15/125	18/27	72/48	10,39/2,28
4	13/82	12/12	15/4	6,33/1,14

Table 9 b

First attempt with conversion factors:

the table shows the ratio between accidents and conflicts per time period.

Traffic class	Car - Car	Bicycle - Car	Pedestrian - Car
1	1,4	13,1	9,2
2	6,7	26,3	11,7
3	5,5	30,4	68,4
4	8,8	55,5	208,2

The ratios are multipliced by a factor of 10^5

CORRECTION FACTOR FOR FLOWS, MALMÖ AND STOCKHOLM

The correction factors are obtained with the help of flow-counts statistics from the local authorities in respective Malmö and Stockholm.

The flow variation is taken into account both regarding seasonal variations and differences between different years.

As no flow-counts are available for pedestrians, we have assumed that on average there were no changes in pedestrian flows neither between different years nor between different parts of the year. Thus the correction factor for pedestrian flows equals 1,00.

Malmö

	Car	Bicycle	Pedestrian
Correction factors for flows	0,85	1,02	1,00

Stockholm

	Car	Bicycle	Pedestrian
Correction factors for flows	0,87	0,57	1,00

RATIO BETWEEN A (THE PRODUCT OF THE CROSSING FLOWS x CONFLICT OBSERVATION PERIOD) AND B (THE PRODUCT OF THE CROSSING FLOWS x ACCIDENT RECORDING PERIOD X CORRECTION FACTOR FOR PRODUCT OF FLOWS)

Malmö - 50 intersections

Traffic class	Car - Car	Car - Bicycle	Car - Pedestrian
1	$\frac{3422,35}{0,72 \cdot 5502024} = 8,64 \cdot 10^{-4}$	$\frac{2410,87}{0,87 \cdot 4083017} = 6,79 \cdot 10^{-4}$	$\frac{9034,54}{0,85 \cdot 14932027} = 7,12 \cdot 10^{-4}$
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	$\frac{2474,86}{0,72 \cdot 3806020} = 9,03 \cdot 10^{-4}$	$\frac{1130,83}{0,87 \cdot 1669193} = 7,79 \cdot 10^{-4}$	

The correction factors for product of flows are the product of the two correction factors for flows,for the kinds of road users involved:

Car - Car = 0.85 x 0.85 = 0.72

Car - Bicycle = 0.85 x 1.02 = 0.87

Car - Pedestrian = 0.85 x 1.00 = 0.85

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*=189.000
Ratio=0.026 F=0.227 OK

x=3 y=25 N=2 A=0.0126
Lambda*=27.000
Ratio=0.12 F=0.959 OK

Cell 2

$p^*=0.135$

x=15 y=125 N=2 A=0.0126
Lambda*=123.319
Ratio=0.12 F=0.343 OK

x=13 y=82 N=2 A=0.012
Lambda*=83.680
Ratio=0.158 F=0.709 OK

Cell 3

$p^*=0.214$

x=13 y=53 N=4 A=0.006
Lambda*=54.364
Ratio=0.245 F=0.682 OK

x=27 y=156 N=4 A=0.006
Lambda*=150.736
Ratio=0.173 F=0.153 OK

x=9 y=19 N=4 A=0.006
Lambda*=23.063
Ratio=0.473 F=0.967 OK

x=12 y=57 N=4 A=0.006
Lambda*=56.035
Ratio=0.210 F=0.495 OK

Cell 4

$p^*=1.285$

x=18 y=27 N=4 A=0.006
Lambda*=19.687
Ratio=0.666 F=0.017 OK

x=72 y=48 N=4 A=0.006
Lambda*=52.5
Ratio=1.5 F=0.800 OK

x=12 y=12 N=4 A=0.006
Lambda*=10.5
Ratio=1 F=0.304 OK

x=15 y=4 N=4 A=0.006
Lambda*=8.312
Ratio=3.75 F=0.976 OK

FINNISHED. STOP.

NUMBER OF ACCIDENTS AND CONFLICTS DURING RESPECTIVE TIMES OF OBSERVATION

Malmö - 15 intersections

NUMBER OF ACCIDENTS

Traffic class	Car - Car	Bicycle - Car	Pedestrian - Car	Obs.time (min) x 10^5
1	4	5	3	106,997
2	0	2	8	63,524
3	3	2	4	47,554
4	11	11	5	63,524

NUMBER OF CONFLICTS

Traffic class	Car - Car	Bicycle - Car	Pedestrian - Car	Obs.time (min)
1	63	13	29	4860
2	10	6	13	3240
3	38	5	1	2160
4	30	5	4	3240

TEST OF PROBABILITY IN THE MERGING OF THE TWELVE ELEMENTS
INTO FOUR CELLS

Malmö - 15 intersections

Cell 1

p*=0.054

x=4 y=63 N=2 A=0.012
Lambda*=63.519
Ratio=0.063 F=0.643 OK

x=0 y=10 N=2 A=0.012
Lambda*=9.480
Ratio=0 F=0.594 OK

Cell 2

p*=0.205

x=3 y=38 N=2 A=0.012
Lambda*=34
Ratio=0.078 F=0.042 OK

x=11 y=30 N=2 A=012
Lambda*=34
Ratio=0.0366 F=0.943 OK

Cell 3

p*=0.295

x=5 y=13 N=4 A=6.370E-03
Lambda*=13.898
Ratio=0.384 F=0.694 OK

x=3 y=29 N=4 A=6.370E-03
Lambda*=24.708
Ratio=0.103 F=0.028 OK

x=2 y=6 N=4 A=6.370E-03
Lambda*=6.177
Ratio=0.0333 F=0.624 OK

x=8 y=13 N=4 A=6.370E-03
Lambda*=16.215
Ratio=0.615 F=0.938 OK

Cell 4

p*=1.466

x=2 y=5 N=4 A=6.370E-03
Lambda*=2.837
Ratio=0.4 F=0.824 OK

x=4 y=1 N=4 A=6.370E-03
Lambda*=2.027
Ratio=4 F=0.0824 OK

x=11 y=5 N=4 A=6.370E-03
Lambda*=6.486
Ratio=2.2 F=0.772 OK

x=5 y=4 N=4 A=6.370E-03
Lambda*=3.648
Ratio=1.25 F=0.415 OK

FINNISHED. STOP.

NUMBER OF ACCIDENTS AND CONFLICTS DURING RESPECTIVE TIMES OF OBSERVATION

Stockholm - 50 intersections

NUMBER OF ACCIDENTS

Traffic class	Car - Car	Bicycle - Car	Pedestrian - Car	Obs.time (min) x 10^5
1	5	3	1	283,589
2	1	1	21	216,309
3	39	4	19	222,820
4	35	4	33	216,309

NUMBER OF CONFLICTS

Traffic class	Car - Car	Bicycle - Car	Pedestrian - Car	Obs.time (min)
1	89	5	37	11580
2	30	13	62	8710
3	182	9	25	9105
4	119	4	20	8710

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*=89,488
Ratio=0.056 F=0,614 OK

x=1 y=30 N=2 A=0,013
Lambda*=29,512
Ratio=0.033 F=0,390 OK

Cell 2

p*=0,246

x=39 y=182 N=2 A=0,013
Lambda*=177,389
Ratio=0.214 F=0,218 OK

x=35 y=119 N=2 A=0,013
Lambda*=123.611
Ratio=0.294 F=0,823 OK

Cell 3

p*=0,222

x=3 y=5 N=4 A=6,371E-03
Lambda*=6,545
Ratio=0.6 F=0,907 OK

x=1 y=37 N=4 A=6,371E-03
Lambda*=31,091
Ratio=0.027 F=2,137E-03 FÖR LITEN

x=1 y=13 N=4 A=6,371E-03
Lambda*=11,455
Ratio=0.077 F=0,151 OK

x=21 y=62 N=4 A=6,371E-03
Lambda*=67,909
Ratio=0.339 F=0,947

Cell 4

p*=1,034

x=4 y=9 N=4 A=6,371E-03
Lambda*=6,390
Ratio=0.444 F=0,088 OK

x=19 y=25 N=4 A=6,371E-03
Lambda*=21,627
Ratio=0.76 F=0,159 OK

x=4 y=4 N=4 A=6,371E-03
Lambda*=3,932
Ratio=1 F=0,553 OK

x=33 y=20 N=4 A=6,371E-03
Lambda*=26,051
Ratio=1.65 F=0,951 OK

COMPARISON OF ACCIDENTS AND CONFLICTS WITH PEDESTRIANS INVOLVED

Conflicts and accidents in low speed intersections and high speed intersections

Situation[2]	Malmö 15		Stockholm 50	
	Conflicts[1] %	Accidents %	Conflicts[1] %	Accidents %
1	18	25	23	31
2	82	75	77	69

Conflicts and accidents in signalized intersections

Situation[2]	Malmö 15		Stockholm 50	
	Conflicts[1] %	Accidents %	Conflicts[1] %	Accidents %
1	0	5	33	24
2	100	95	67	76

Conflicts and accidents, total

Situation[2]	Malmö 15		Stockholm 50	
	Conflicts[1] %	Accidents %	Conflicts[1] %	Accidents %
1	10	10	27	26
2	90	90	73	74

1) The conflicts are weighed with reference to an estimation of π

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

Situation 2: The car driver is leaving the intersection

TABLE 17:1

CLASSIFICATION OF CONFLICTS AND ACCIDENTS WITH REGARD TO TYPE

Malmö - 50 intersections

Car - Car

T-classification	Low speed inters. Conflicts		Low speed inters. Accidents		High sp. inters. Confl.		High sp. inters. Acc.		Sign. inters. Confl.		Sign. inters. Acc.		Σ Confl.		Σ Accidents	
	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Crossing vehicles (perpend.)	38	23	9	75	35	25	18	64	5	4	14	29	78	18	41	46
Left-turning vehicle/ crossing veh	20	12	0	0	28	20	1	4	5	4	0	0	53	13	1	1
Left-turning vehicle/on-coming veh.	13	8	0	0	6	4	4	14	37	31	26	53	55	13	30	34
Oncoming or crossing veh Turning tow. diff. direct.	5	3	0	0	6	4	0	0	1	1	0	0	12	3	0	0
Weaving	43	26	1	8	24	17	1	4	23	19	4	8	90	21	6	7
Rear-end	29	18	1	8	23	16	0	0	33	28	3	6	85	20	4	5
Overtaking	3	2	0	0	8	6	0	0	8	7	0	0	19	5	0	0
Left-turning veh/approaching veh from the rear	5	3	1	8	5	4	3	11	3	3	1	2	13	3	5	6
Cutting off by a right-turning veh	4	2	0	0	3	2	1	4	3	3	1	2	10	2	2	2
U-turn	3	2	0	0	4	3	0	0	1	1	0	0	8	2	0	0
TOTAL	163		12		142		28		119		49		423		89	

TABLE 17:2

CLASSIFICATION OF CONFLICTS AND ACCIDENTS WITH REGARD TO TYPE

Malmö- 50 intersections

Car - Bicycle

T-classification	Low speed inters. Conflicts No.	%	Low speed inters. Accidents No.	%	High sp. inters. Confl. No.	%	High sp. inters. Acc. No.	%	Sign. inters. Confl. No.	%	Sign. inters. Acc. No.	%	Σ Confl. No.	%	Σ Accidents No.	%
Crossing vehicles (perpend.)	24	46	12	55	22	43	37	49	1	3	12	29	47	34	61	44
Left-turning vehicle/ crossing veh	6	12	0	0	9	18	7	9	2	6	0	0	17	12	7	5
Left-turning vehicle/ oncoming veh.	3	6	4	18	6	12	15	20	23	64	16	38	33	24	35	25
Oncoming or crossing veh Turning tow. diff. dir.	2	4	0	0	3	6	0	0	0	0	1	2	5	4	1	1
Weaving	8	15	0	0	8	16	4	5	1	3	0	0	17	12	4	3
Rear-end	2	4	3	14	0	0	3	4	0	0	5	12	2	1	11	8
Overtaking	1	2	0	0	2	4	0	0	4	11	0	0	7	5	0	0
Left-turning veh/approaching veh from the rear	3	6	3	14	1	2	8	11	1	3	3	7	5	4	14	1
Cutting off by a right-turning veh	3	6	0	0	0	0	2	3	2	6	5	12	5	4	7	5
U-turn	0	0	0	0	0	0	0	0	2	6	0	0	2	1	0	0
TOTAL	52		22		51		76		36		42		140		140	

CLASSIFICATION OF CONFLICTS AND ACCIDENTS WITH REGARD TO TYPE

Malmö 50 intersections

Car - Pedestrian

T-classification	Low speed inters. Conflicts No	%	Low speed inters. Accidents No	%	High sp. inters. Confl. No	%	High sp. inters. Acc. No	%	Sign. inters. Confl. No	%	Sign. inters. Acc. No	%	Σ Confl. No	%	Σ Acc. No	%
Vehicle/pedistrian at crossing before intersection	27	22	11	46	15	21	27	24	2	3	12	29	44	17	50	28
Vehicle/pedestrian at crossing after intersection Veh. in the back of the pedestrian	23	18	5	21	13	18	6	5	38	66	7	17	76	30	18	10
Vehicle/pedestrian after intersection Veh. from the side or front	75	60	8	33	45	62	79	71	18	31	23	55	136	53	110	62

CLASSIFICATION OF CONFLICTS WITH REGARD TO CAUSES

Malmö - 50 intersections

Car - Car

Cause of event	Low speed intersect. Conflicts Number	%	High speed intersect. Conflicts Number	%	Signalized Intersections Conflicts Number	%	Σ Conflicts Number	%
Secondary car hides or distracts car, bicycl. or ped.	6	3	11	7	5	4	22	4
Secondary car blocks for car bicycl. or ped.	16	8	20	13	24	17	60	12
Overtaking at a pedestrian crossing secondary car	0	0	0	0	0	0	0	0
Secondary pedestrian	24	12	16	11	15	10	55	11
2 or more primary pedestrians in a group	0	0	0	0	0	0	0	0
Pedestrian against red light	0	0	0	0	0	0	0	0
Bicyclist against red light	0	0	0	0	0	0	0	0
Car does not stop in spite of a stop sign	2	1	0	0	0	0	2	0
Unobservance	0	0	0	0	1	1	1	0
Car against red light	0	0	0	0	12	8	12	2
Car or bicyclist changes lane for the overtaking	1	0	5	3	7	5	13	3
Missjudgment Missunderstanding	1	0	0	0	1	1	2	0
No cause given	59	28	35	23	23	16	117	23

TABLE 18:2

CLASSIFICATION OF CONFLICTS WITH REGARD TO CAUSES

Malmö - 50 intersections

Car - Bicyclist

Cause of event	Low speed intersect. Conflicts Number	%	High speed intersect. Conflicts Number	%	Signalized intersections Conflicts Number	%	Σ Conflicts Number	%
Secondary car hides or distracts car, bicycl. or ped.	2	1	7	5	4	3	13	3
Secondary car blocks for car, bicycl. or ped.	0	0	0	0	0	0	0	0
Overtaking at a pedestrian crossing secondary car	0	0	0	0	0	0	0	0
Secondary pedestrian	3	1	1	1	1	1	5	1
2 or more primary pedestrians in a group	0	0	0	0	0	0	0	0
Pedestrian against red light	0	0	0	0	0	0	0	0
Bicyclist against red light	0	0	0	0	0	0	0	0
Car does not stop in spite of a stop sign	0	0	0	0	0	0	0	0
Unobservance	0	0	1	1	0	0	1	0
Car against red light	0	0	0	0	0	0	0	0
Car or bicyclist changes lane for the overtaking	1	0	1	1	0	0	2	0
Misjudgment Misunderstanding	1	0	0	0	0	0	1	0
No cause given	25	12	11	7	14	10	50	10

CLASSIFICATION OF CONFLICTS WITH REGARD TO CAUSES

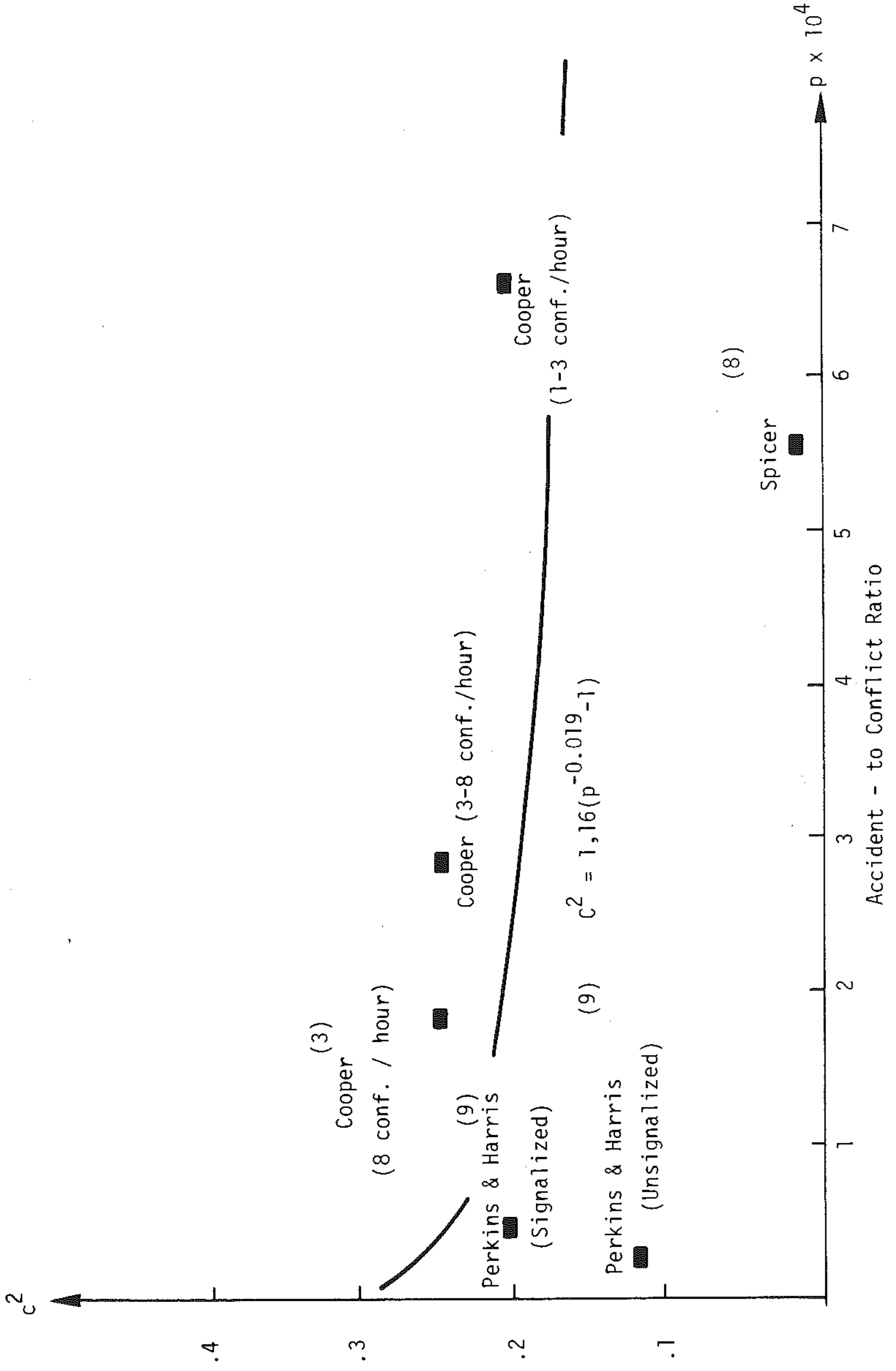
Malmö - 50 intersections

Car - Pedestrian

Cause of event	Low speed intersect. Conflicts		High speed intersect. Conflicts		Signalized intersections Conflicts		Σ Conflicts	
	Number	%	Number	%	Number	%	Number	%
Secondary car hides or distracts car, bicycl. or ped.	6	3	2	1	2	1	10	2
Secondary car blocks for car, bicycl. or ped.	1	0	0	0	1	1	2	0
Overtaking at a pedestrian crossing secondary car	5	2	13	9	1	1	19	4
Secondary pedestrian	0	0	0	0	0	0	0	0
2 or more primary pedestrians in a group	5	11	5	3	1	1	11	2
Pedestrian against red light	0	0	0	0	8	6	8	2
Bicyclist against red light	0	0	0	0	0	0	0	0
Car does not stop in spite of a stop sign	0	0	0	0	0	0	0	0
Unobservance	2	1	9	6	2	1	13	3
Car against red light	0	0	0	0	1	1	1	0
Car or bicyclist changes lane for the overtaking	0	0	0	0	0	0	0	0
Misjudgment Misunderstanding	1	0	0	0	0	0	1	0
No cause given	49	23	13	9	20	14	82	16

FIGURE 1

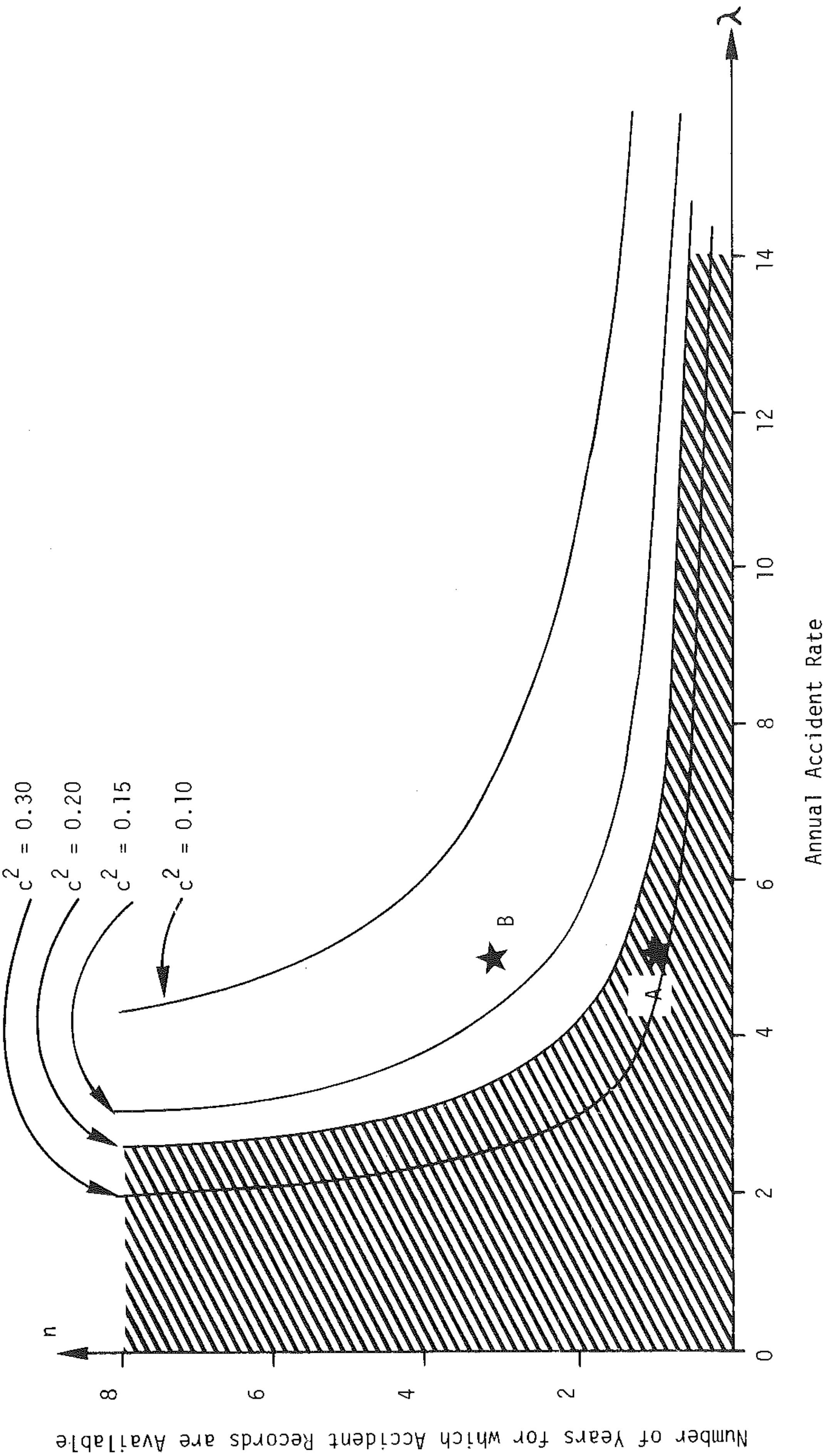
RELATIONSHIP BETWEEN THE ACCIDENT - TO CONFLICT RATIO AND ITS VARIABILITY



From: The traffic conflicts technique - Fundamental Issues, Ezra Hauer - Dep of Civil Engineering, University of Toronto

FIGURE 2

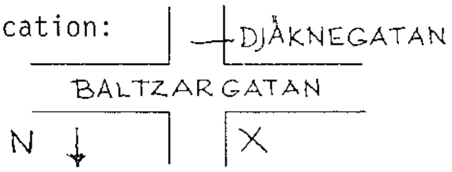
DETERMINATION OF CONDITIONS IN WHICH THE TCT COULD BE CONSIDERED



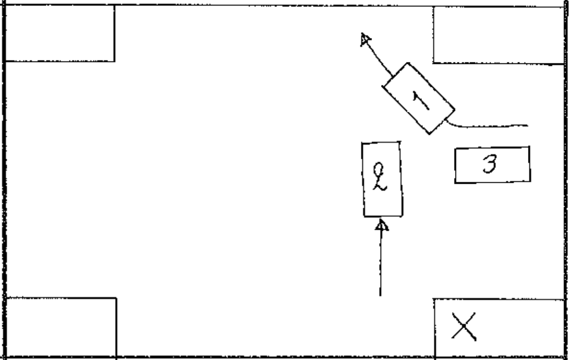
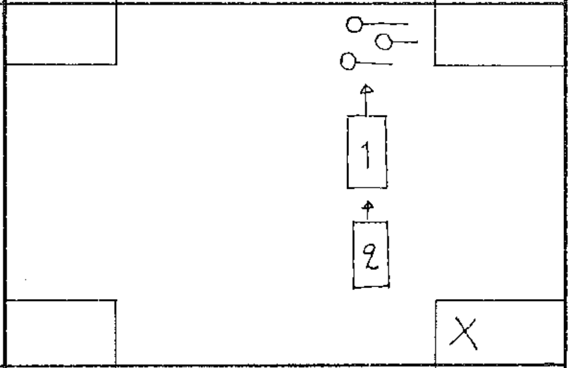
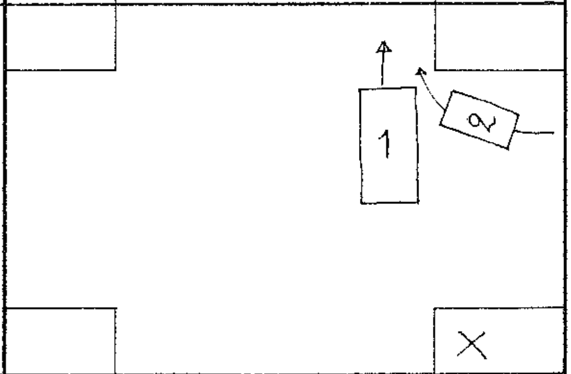
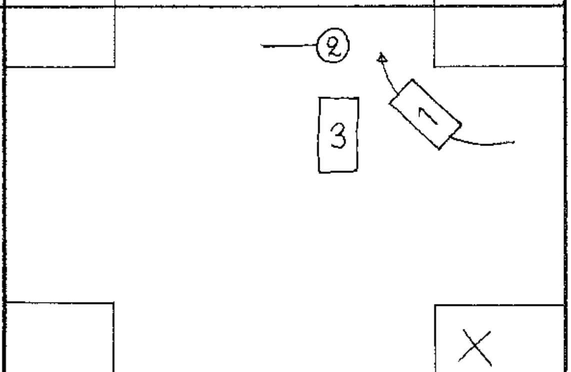
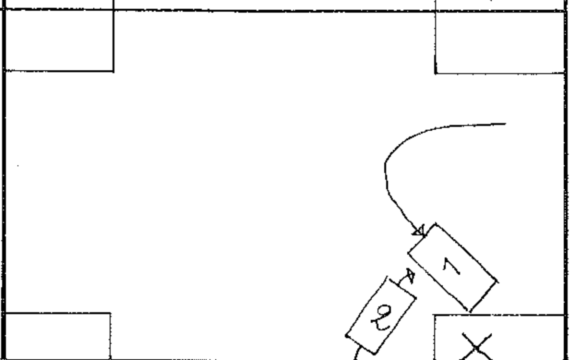
From: The traffic conflicts technique - Fundamental Issues, Ezra Hauer - Dep of Civil Engineering, University of Toronto

RECORDING PROTOCOL FOR SERIOUS CONFLICTS FIGURE 3

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

Location:


Climate: CLOUDY, RAIN WET ROAD

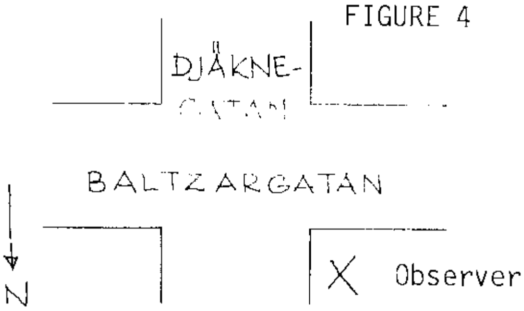
confl. sit. no.	Description of the conflict situation	Sketch of the involved
1 TIME: 1605 SPEED: 35	CLASS: 2 PRIMARY INVOLVED: C–C SHORT DESCRIPTION OF COURSE OF EVENTS: AGE: 1 SWUNG OUT BEHIND 3 WHO BLOCKED 2. BOTH CARS BRAKED AT A SHORT DISTANCE	
2 TIME: 1615 SPEED: 30	CLASS: 1 PRIMARY INVOLVED: C–C SHORT DESCRIPTION OF COURSE OF EVENTS: AGE: 1 BRAKES TO ALLOW PEDESTRIANS TO CROSS. CONFLICT BETWEEN 1 AND 2 WHO 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. 2 IS VERY CLOSE TO HIT THE TRUCK ON THE SIDE.	
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 MISSES HIS TURN AND STOPS AT AN ANGLE OVER R-LANE. 2 THEN COMES AROUND THE CORNER AND IS FORCED TO STOP BY THE UNEXPECTED OBSTRUCTION.	

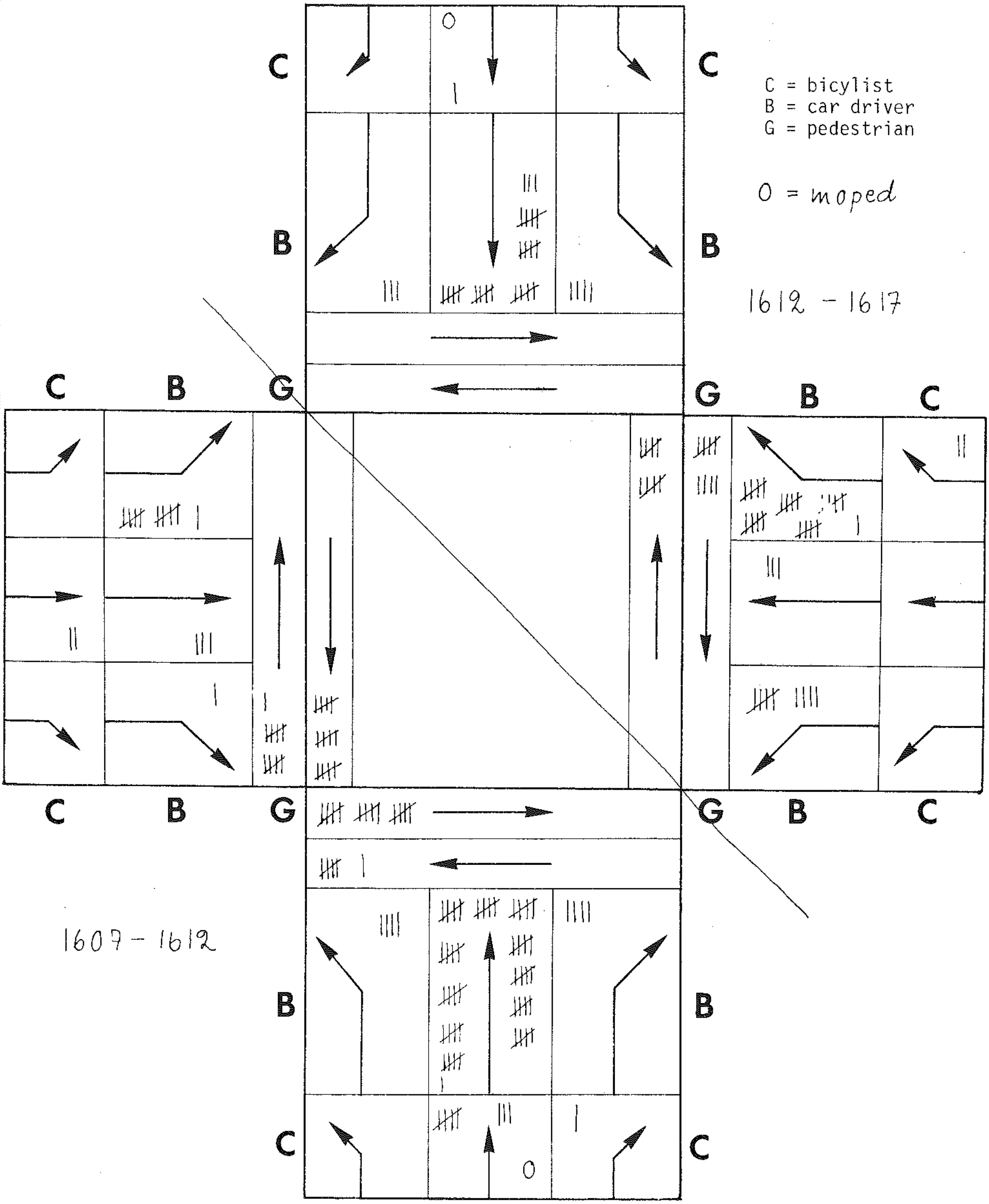
TRAFFIC COUNT PROTOCOL

FIGURE 4

Location No: 6
Time: 1607 – 1617
Climate: Fair Weather
+ 12° C
1975-05-12

Location:





ESTIMATION OF THE RATIO BETWEEN ACCIDENTS AND CONFLICTS (π^*)
CONFIDENCE INTERVAL WITH 90% DEGREE OF CONFIDENCE FOR MALMÖ

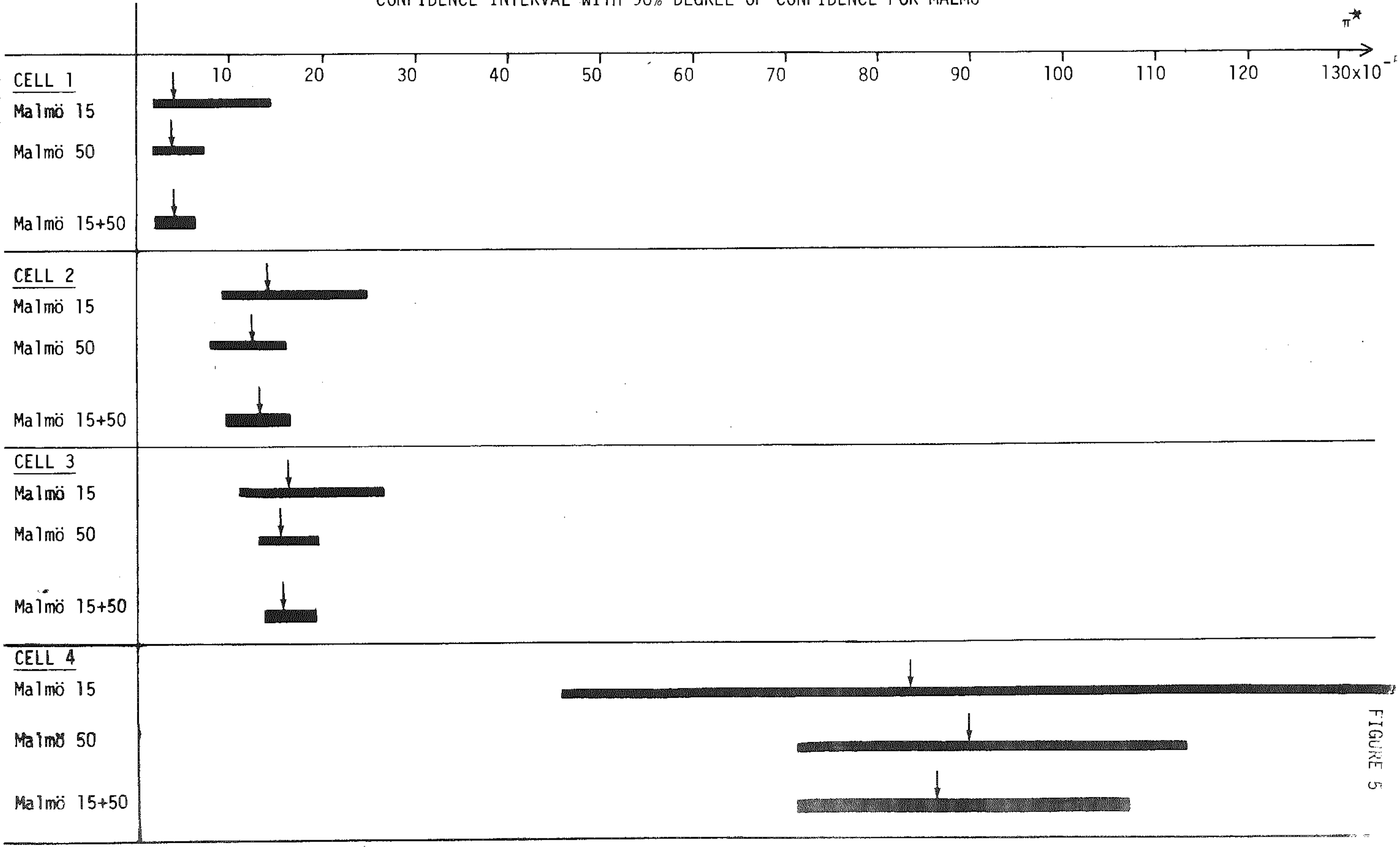
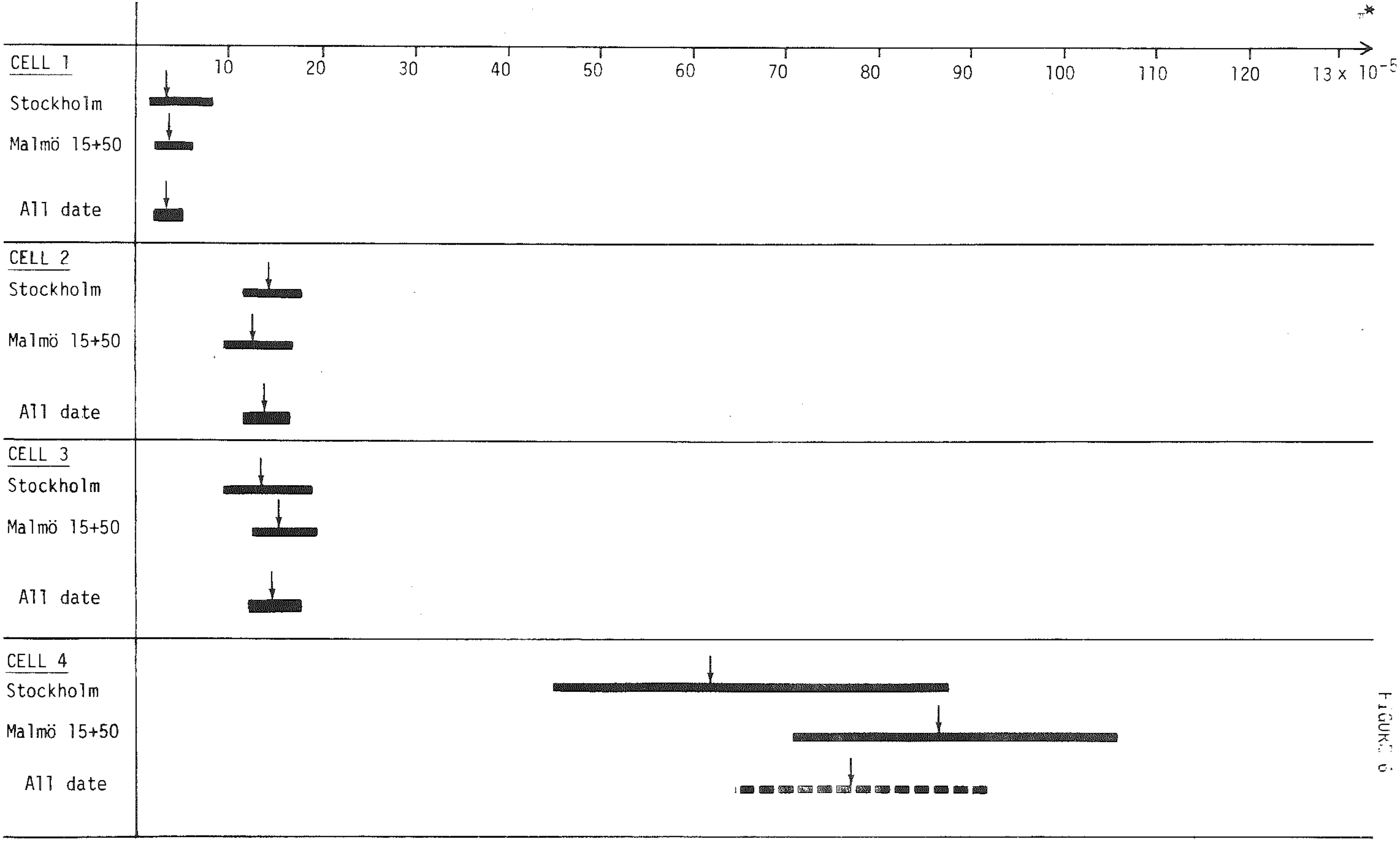


FIGURE 5

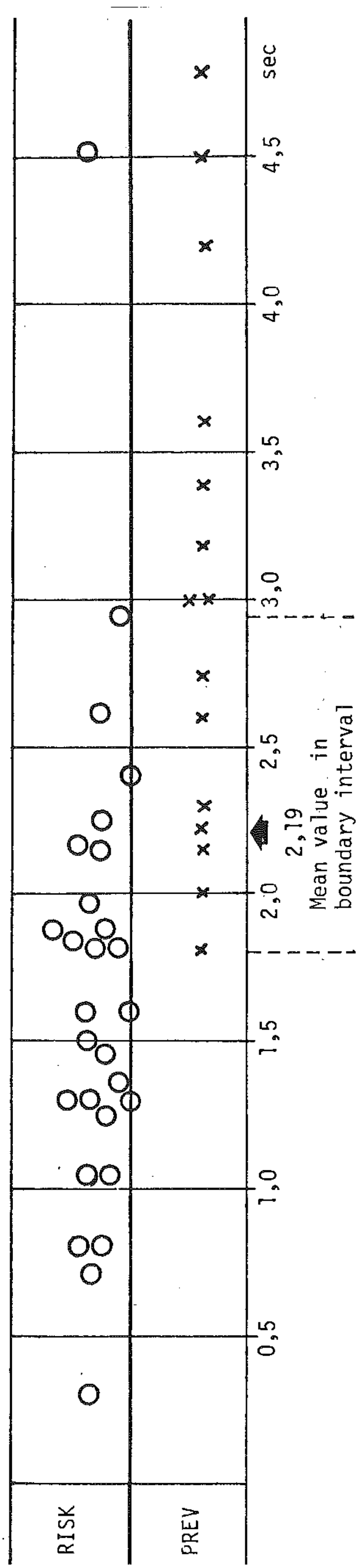
FIGURE 6

ESTIMATION OF RATIO BETWEEN ACCIDENTS AND CONFLICTS (π^*)
CONFIDENCE INTERVAL WITH 90% DEGREE OF CONFIDENCE FOR STOCKHOLM AND MALMÖ



CONFLICT STUDIES IN RURAL INTERSECTIONS. TIME TO ACCIDENT RELATED TO ESTIMATED DEGREE OF SEROIUSNESS. PILOT STUDY, RINGELIKORS COUNTY OF KRISTIANSTAD

FIGURE 7

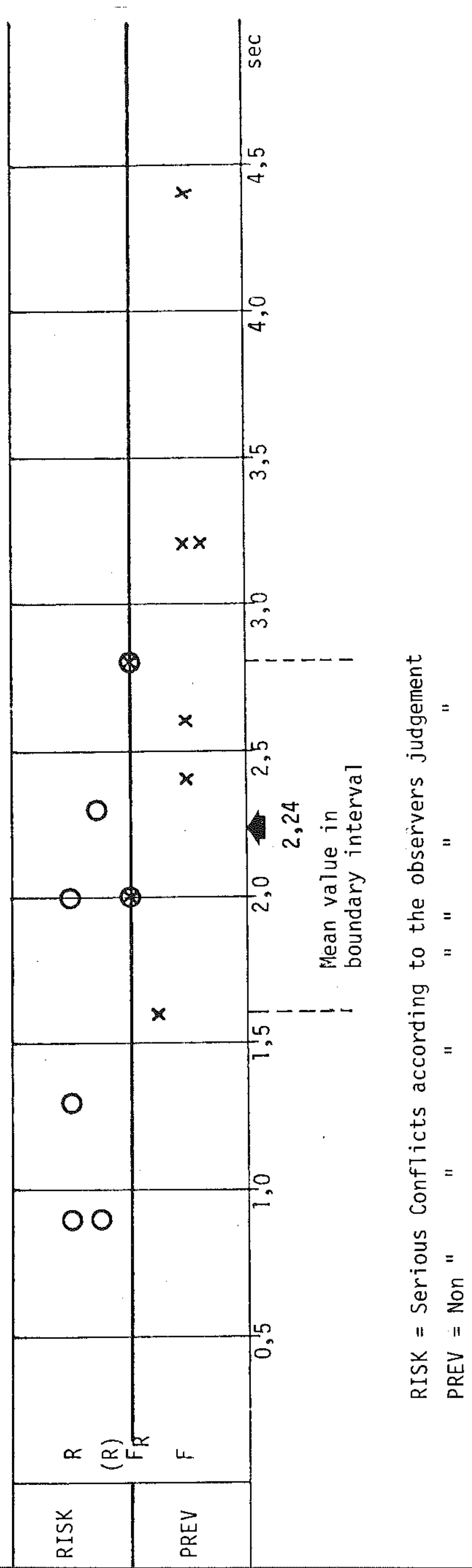


RISK= Serious Conflicts according to the observers judgement

PREV= Non "

CONFLICT STUDIES IN RURAL INTERSECTIONS. TIME TO ACCIDENT RELATED TO ESTIMATED DEGREE OF SERIOUSNESS. FOLLOW UP STUDY, GUALÖV COUNTY OF KRISTIANSTAD

FIGURE 8



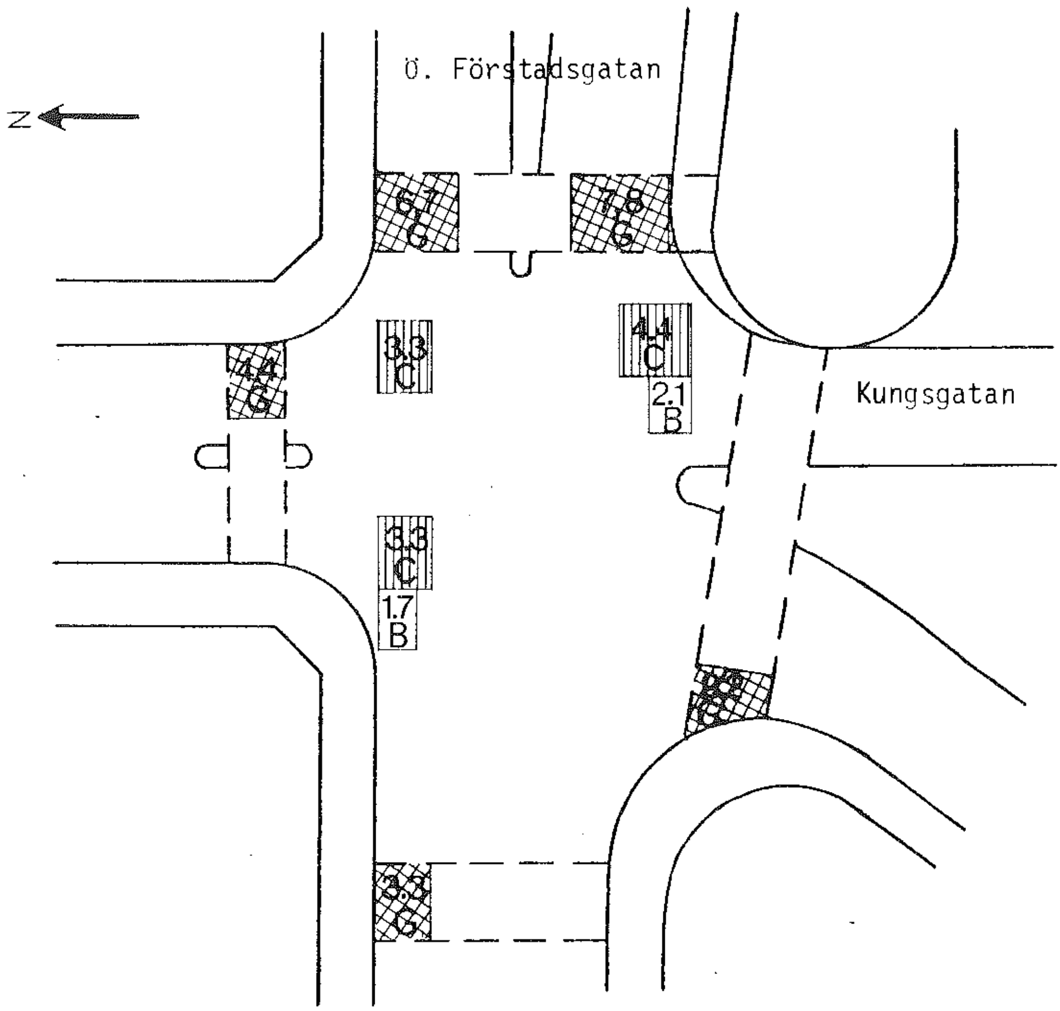
A P P E N D I X 1

Example of standardized risk description using conflict studies.

Intersection: Östra Förstadsgatan - Kungsgatan

The conflict studies were carried out 1974 and 1975, total 11,5 hours (69 conflicts)

ACCIDENT RISK CALCULETED WITH USE OF WEIGHED CONFLICTS

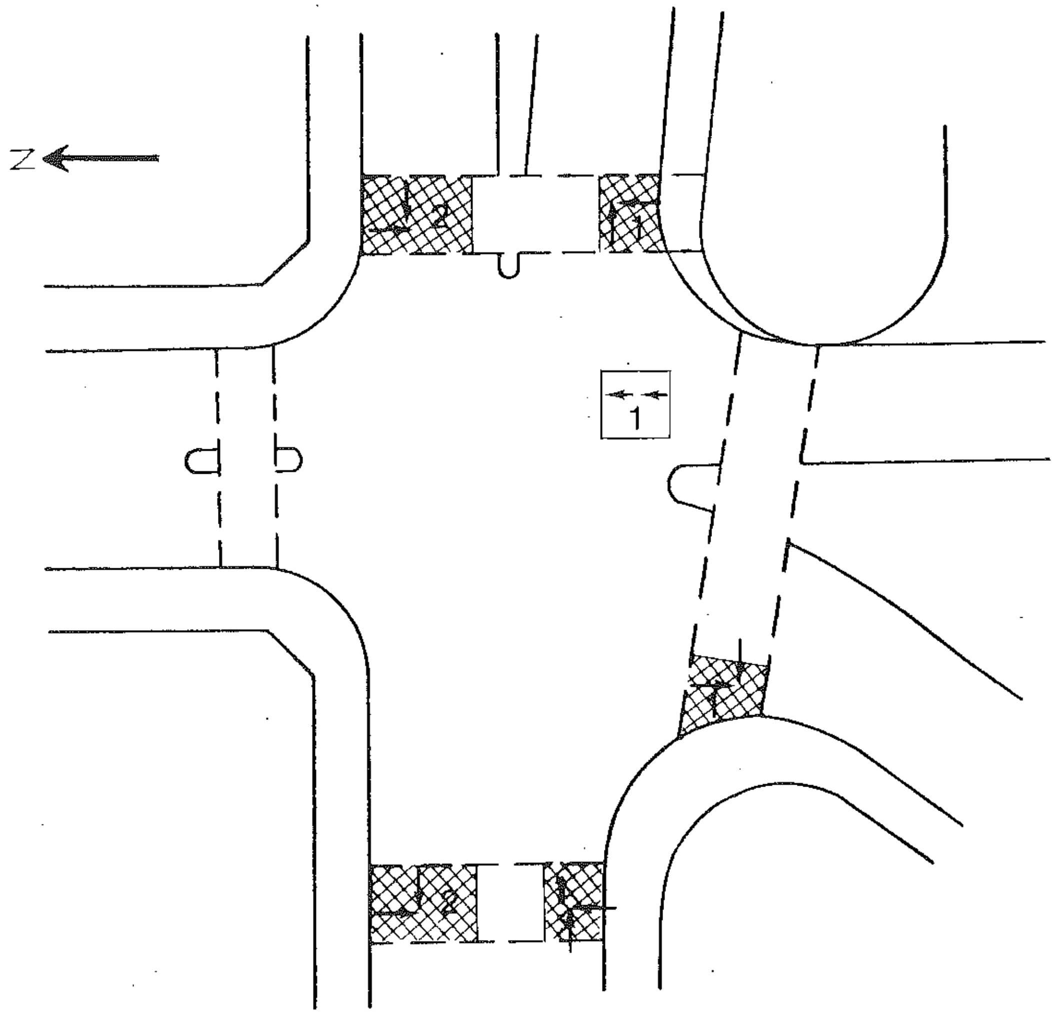


Symbol explanation:

G = Risk for pedestrians
C = Risk for bicyclists
B = Risk for car drivers

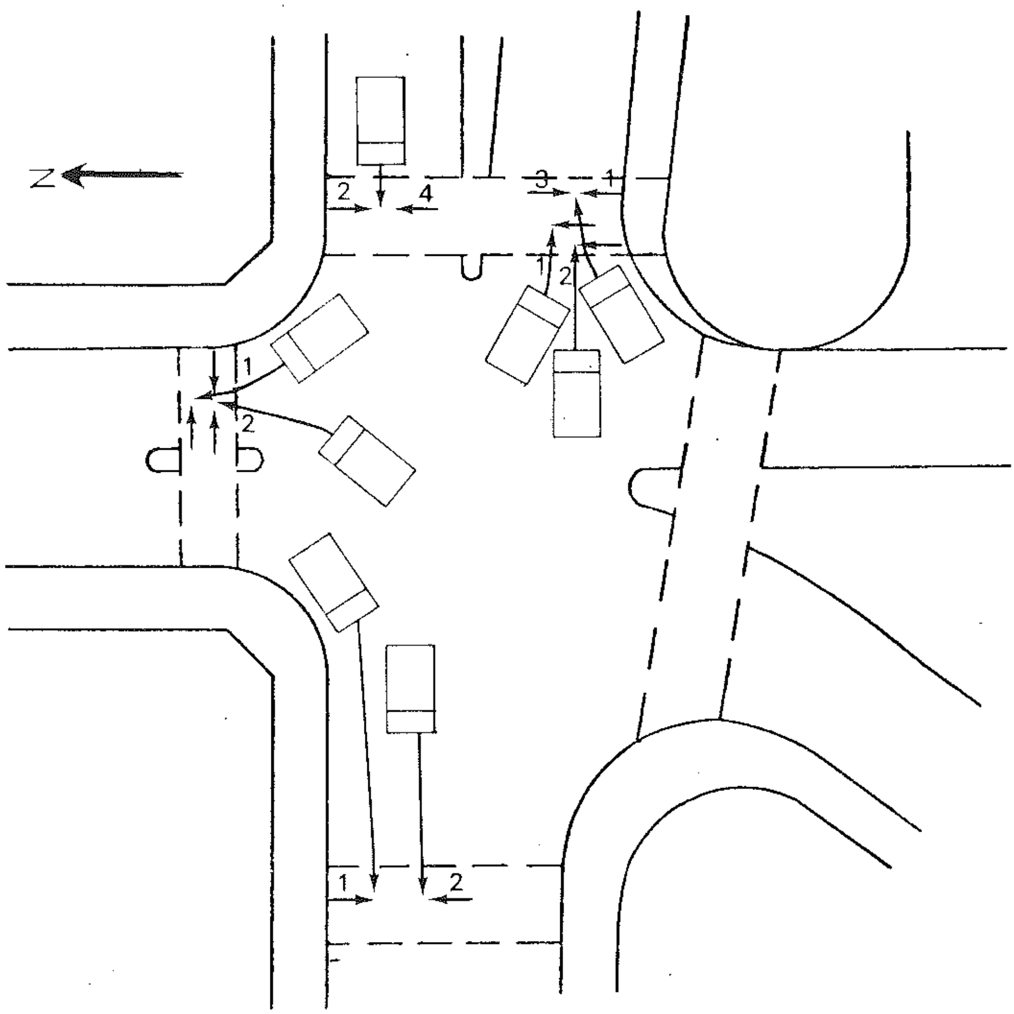
The values give the relative accident risk

OCCURED PERSONAL INJURY ACCIDENTS 1968 - 74



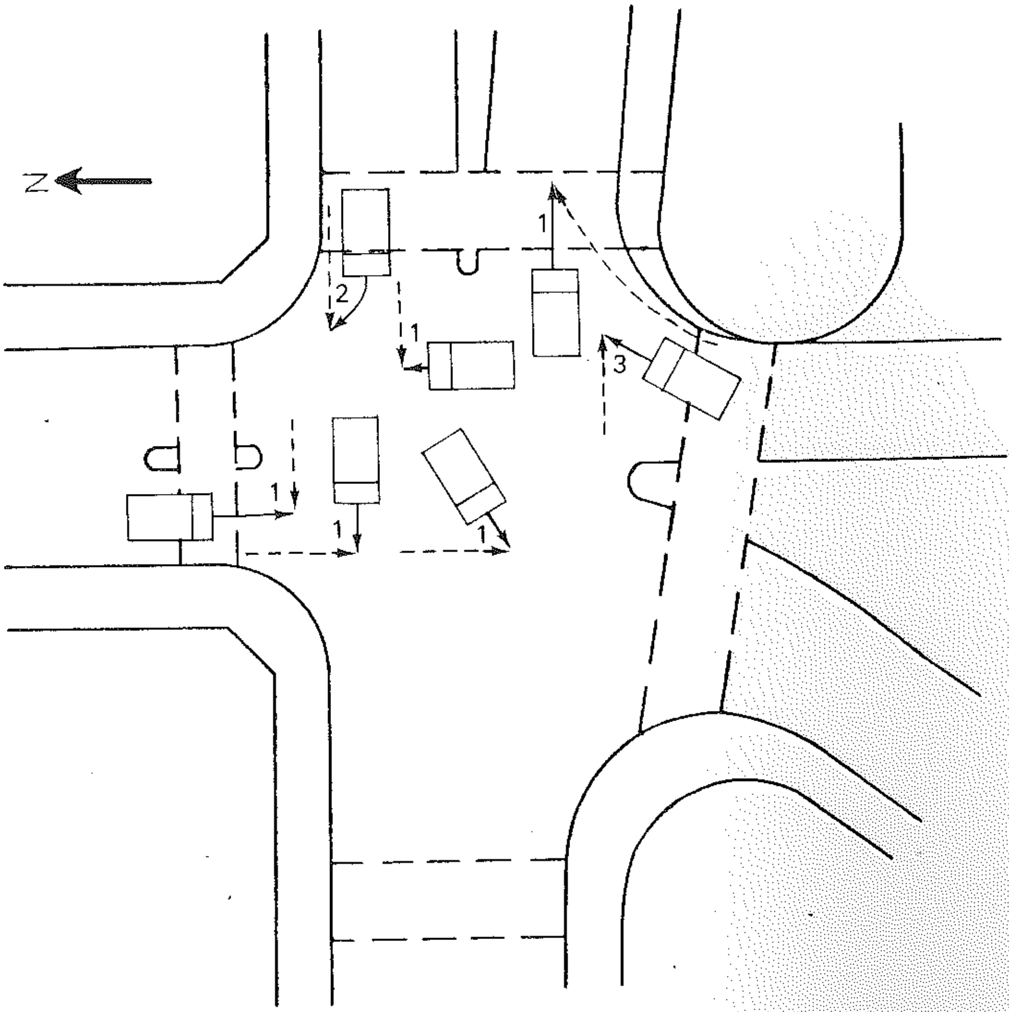
Symbol explanation: See Appendix 1:1

CONFLICTS CAR - PEDESTRIAN



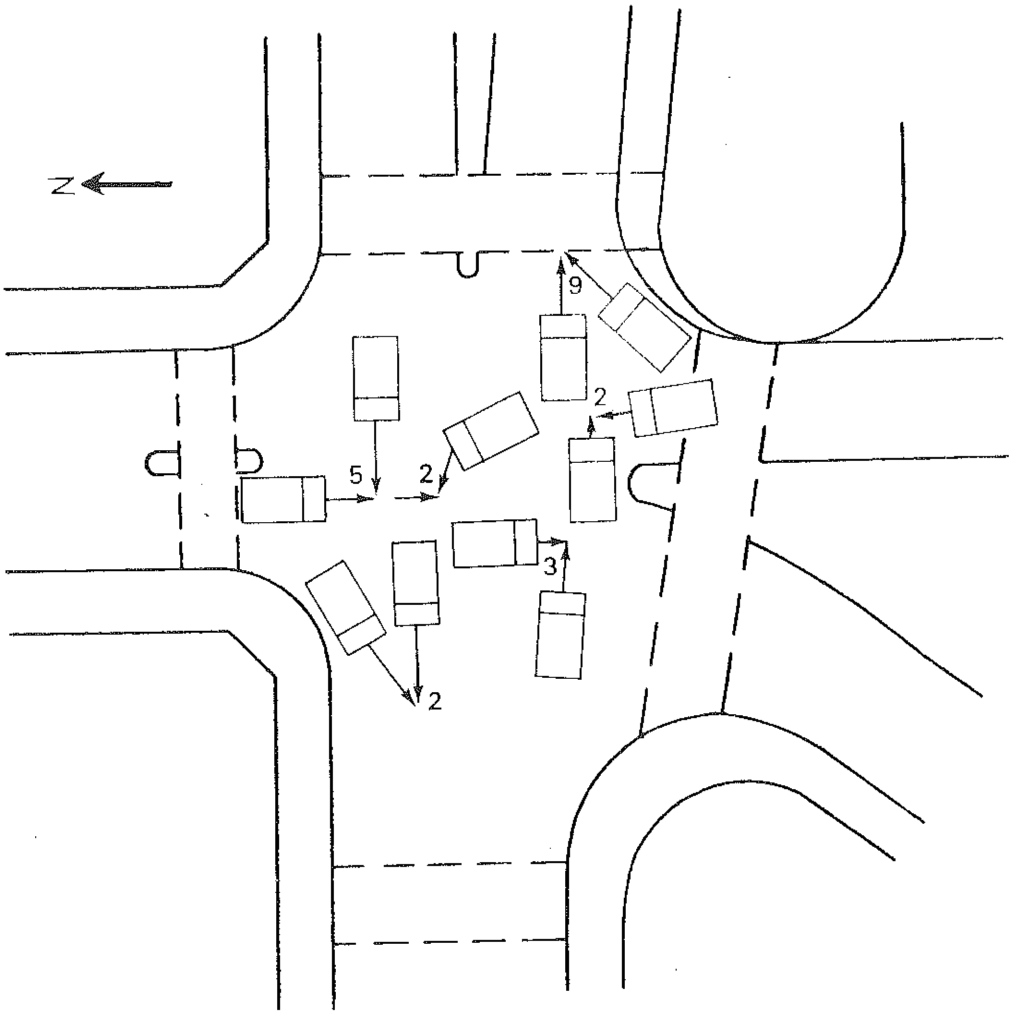
The figures indicate the number of conflicts of respective types

CONFLICTS CAR - BICYCLE



The figures indicate the number of conflicts of respective types

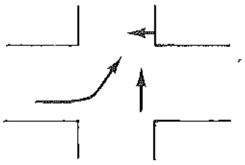
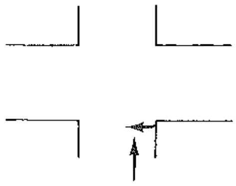
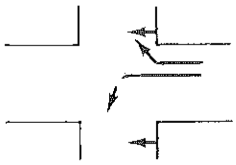
CONFLICTS CAR - CAR



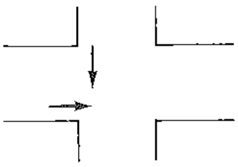
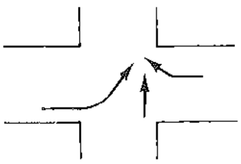
The figures indicate the number of conflicts of respective types

THE DOMINANT CONFLICTS AND THEIR CAUSES

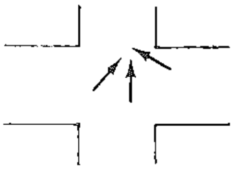
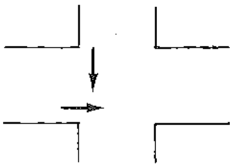
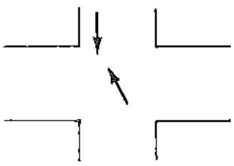
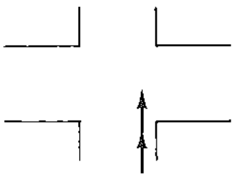
1. Conflicts respective accidents car - pedestrian

	Number of conflicts	Number of accidents	
	13	4	Vehicle/Pedestrian after crossing Vehicle from side or in front of the pedestrian Half of the conflicts occur with left turning cars
	7	3	Vehicle/Pedestrian in front of the intersection Most common: Overtaking in half of the conflicts
	3		Vehicle/Pedestrian Vehicle in back of the pedestrian

2. Conflicts respective accidents car - bicycle

	4	Crossing vehicles
	3	Weaving

3. Conflicts respective accidents car - car

	Number of conflicts	Number of accidents	
	14		**Weaving** Most common cause: Buses that drive out from Kungsgatan right in front of a car, keeping to the right hand rule.
	8		**Crossing vehicles** Most common cause: One or more cars in the intersection that hide or distract.
	5		**Left turning vehicles - meeting vehicles** Most common cause: The turning car has stopped for a secondary pedestrian. Buses drive out in front of the cars.
	3	1	**Rear -end** Most common cause: The car in front stops for a secondary pedestrian.

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