UNIVERSITY OF LUND

LUND INSTITUTE OF TECHNOLOGY
DEPARTMENT OF TRAFFIC PLANNING AND ENGINEERING

RELATIONS BETWEEN CONFLICTS AND TRAFFIC ACCIDENTS

LUND 1975

CHRISTER HYDÉN

TRAFIKTEKNIK
TEKNISKA HÖGSKOLAN I LUND
FACK 725
S-220 07 LUND SWEDEN

DEPARTMENT OF TRAFFIC PLANNING AND ENGINEERING
LUND INSTITUTE OF TECHNOLOGY

RELATIONS BETWEEN CONFLICTS AND TRAFFIC ACCIDENTS

LUND 1975

CHRISTER HYDÉN

CONTENTS

PREFACE

The following is a progress report on a research project, sponsored by the Transport Research Delegation.

Project manager has been civ ing Christer Hydén, who is also responsible for this report.

Programs for computor analysis of the material were written by civ ing Göran Möller.

Per Öfverbeck and Anders Linebergh were consulted for the statistical analysis of the material.

The project is partly based on earlier works by Lövemark and Hydén and others at the research group of PLANFOR, which was previously connected with the University of Lund.

Lund 1975.05.17

Gösta Lindhagen	Christer Hydén
professor, research manager	civ ing, project manager

1. BACKGROUND

1.1 General

During the last years traffic-planning in Sweden has been characterized by decreased investments in new roads, at the same time as road traffic has continued to increase.

Rather than on new constructions, resources have been directed to measures in the existing traffic system, partly point by point, partly through area regulation.

To get the best possible benefit out of these measures, methods are required for identifying conditions in the existing system with best possible accuracy, as well as for predicting such changes in these conditions as will follow from the measures adopted.

In the sector of traffic safety there is a great need for new methods aimed at a more efficient use of the available resources. To meet this demand we need a method to identify the conditions in the existing network as well as a method to predict these changes in these conditions that will follow from different changes in the network. However the complete interaction that exists between "the man" - the vehicle and the road will continue to render such forecasts a difficult task. For that reason a method for immediate evaluation of realized changes is required as a complement to the methods mentioned. Hereby experiences from steps taken can be utilized in a continuous feed-back. Several attempts have been made to find suitable methods that fulfil the above-mentioned conditions.

1.2 Different methods of determining accident risks

In order to determine accident risks in existing traffic systems in urban areas, actual accident data has been used in different ways. A common procedure is to rank the intersections in the network according to number of accidents occurred and then to distribute available resources on this basis.
Sometimes, accident frequencies have been related to some measure of traffic "production" of the intersections. The object of the frequency measures mentioned is to rank individual intersections.
In other cases, the object has rather been to measure the accident risk for different types of intersections. This makes it possible to get a better understanding of the effects of different details in construction, regulation and other conditions.
By relating actual accident frequencies both to the design of the intersection and to the amount of traffic, attempts have been made to construct accident forecasting models.

To work with actual accidents as a basis has turned out to be associated with vast difficulties. The precision in describing present conditions as well as in the forecast is generally too small to meet reasonable demands. These difficulties are related to the collection and analysis of accident data as well as to the accident frequencies.
This may be illustrated by the following example:

To be able to draw a conclusion from a certain directed measure such as installing traffic lights at an intersection, analysis of accident statistics from several years before and after the installation is required. Even then the validity of the conclusion may well be impartioned by other factors that have occurred. For example the traffic flows in the intersection may have changed considerably in the meantime.

Because of these difficulties with actual accident data, another criteria that better meets with the necessary requirements has been needed for some considerable time.

A common point of origin has been the definition of "dangerous" and "critical" behaviour patterns in different situations in traffic. The resulting models are founded on theories concerning the causes of traffic accidents. A general problem with these models has been the difficulty in validating the methods, that is to establish the relations between the behaviour patterns defined on one hand and actual risk on the other.

Concerning the validation problem, models based on studies of conflicts (near-accidents) seem more promising. With these, attempts are made to separate such critical situations which in a direct continuation may cause an accident. The basic idea is that if the degrees of seriousness in observed conflicts can be measured, the actual risks involved in these conflicts can be defined. The main difficulty seems to be the measurement of the degree of seriousness.

Internationally, research and development concerning the recording of conflicts in traffic has been going on for hardly 10 years.

1.3 Foreign research regarding the recording of conflicts

At the General Motors (1) a conflict recording technique was developed in 1968, with the purpose of measuring accident risks in intersections. A conflict was defined to occur when a car driver makes an averting manoeuvre such as braking or turning aside in order to avoid what he believes will otherwise result in a collision.

This technique has been used by the Ohio Department of Transportation (2) and the Virginia Department of Highways (3). In these applications, tests were carried out in order to validate the method.

The experiences can be summarized as follows:

1. The results from the studies seem to strengthen the hypothesis that a relationship between accidents and conflicts does exist.

2. With minor modifications, the technique could be applicable to other types of facilities than intersections.

The possibility to predict accident frequencies from conflict studies is thus encouraged by these experiences.

However, the G M technique is associated with certain problems. It is true that the objective criterion for a conflict (such as the lighting of brake -lights) is unambiguous and easy to apply. The conflicts registered, however, do not always fulfil the basic requirement that a conflict should reflect a situation with a certain accident risk. In some cases, brakings which were recorded as conflicts were performed with a wide margin and purely out of caution.

At the TRRL in England (4) a technique has been developed which was also used at the TØI in Oslo (5). In this case, the definition of a conflict is based on the distance between the parties involved in the averting manoeuvre. This technique seems to be importuned by the reliability, that is the precision with which the conflicts can be recorded (by observers).

1.4 Present research at the Department

At the Department of Traffic Engineering in Lund, the development of a conflict recording technique has been proceeding since 1973. The project consists of the following main parts:

1. Definition of the concept of serious conflicts. Documentation.

2. Choice of method of recording. Reliability tests.
3. Validation of the method, that is testing relationships between recorded conflicts and accidents.

In order to validate the method, studies were performed in 50 intersections in Malmö. Such conflicts (accidents) were considered, which took place within 20 m from the intersection (measured from the nearest corner). In all 50 intersections there is a 50 km/h (31 miles/h) speed limit.

1.5 Applications of conflict recordings

A conflict recording technique that admits an adequate description of actual accident risk would have several important fields of application:

1. Detailed description of accident risks in intersections. With the help of such a description improvement schemes for different intersections can be ranked according to privity. The results also form a good basis for planning and design of traffic facilities and their physical environment.
2. Evaluating the effects of safety improvement measures. In this case, the speed of the method is of decisive importance. In principle, the effects can be studied immediately after the alterations. By doing several after-studies, also the time-dependance of the effects may be followed.

   The possibility of rapid evaluations can be exploited systematically with the purpose of experimenting with different measures on the facilities and their physical environment.
3. Studies of the causes of accidents.
   The conflict recording can be of great importance in this area through the in depth description of the events preceding the conflict that is obtainable.

This knowledge can be used when planning for improvements in the physical environment and in connection with information and education programs.
For example, driving schools would be able to use video-taped conflict situations in order to point out characteristic accident causes.

4. Building prediction models for accident risks

Conflict recording enables the production of a vast data base in short time, and with full control over the chosen explanatory variables. (Such as traffic flows, physical design, type of regulations, weather and light conditions).

When judging the applicability of the method, it should also be considered that a reduction in the frequency of serious conflicts may be viewed as an improvement in itself, disregarding the effect on accident frequencies. The importance of the frequency of serious conflicts as a quality measure should be penetrated further.

2. METHOD

2.1 Problem statements

The ultimate aim of the project is to investigate whether, in some sense, meaningful relationships can be established between serious conflicts and traffic accidents.

To investigate this, a comparison was made between the number of accidents involving personal injuries and the recorded conflicts. The comparison involves 50 intersections in Malmö, with accident data for the years 1968 - 1974 and with approximately 10 hours of recording per intersection.

The following essential problems can be separated:

1. Definition of serious conflict.
2. Choice of recording technique. Reliability test.
3. Definition of accident. Choice of sample.
4. Choice of statistical methods.

2.2 Definitions

The interaction between road-users when passing an intersection can be described as a series of "elementary incidents". The passages may take place in any relative directions (same, opposite, perpendicular etc.).

1. Undisturbed passage: the road users pass each other with a time lag of such a size that one does not affect the other in any way.
2. Potential conflict: the road users approach the intersection in such a way that they would meet. One or both of the parties involved adjust his speed in ample time to avoid a conflict.

3. Conflict: one or both road users has to brake or turn to avoid a serious conflict.

4. Serious conflict: one or both of the road users must brake or turn suddenly to avoid a collision.

5. Accident: none of the road users discovers the situation until the remaining time of reaction is so small that a collision can not be avoided.

Every "elementary incident" occurs with a certain frequency in every intersection: accidents more rarely and undisturbed passages with a very high frequency.

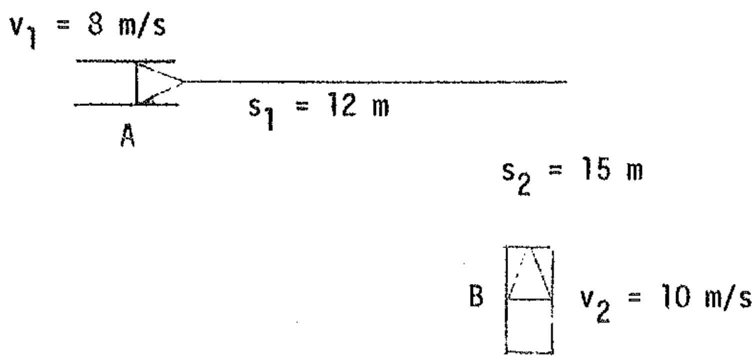
2.3 Definition of serious conflict

Hypothesis: Conflicts, which allow an objective measurement of degree of seriousness, are related to accidents in a certain way.

One way to measure the degree of seriousness is to determine the remaining time to a collision. The following definition has been used in this project:

If two road users approach each other on a collision course, one or both will discover the danger in a certain position and react by breaking or turning. The time to accident (TA) is that time that would have passed from that moment in which one reacts and starts to brake or turn until that moment the collision would have occurred, if both parties had proceeded with speed and direction unchanged.

EXAMPLE:



In the position indicated B has just discovered the danger, reacted and just started to brake.

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

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

TA can vary with some tenths of a second between the two parties, depending on different relative positions at the collision. In such cases the highest TA is selected. If the difference in TA exceeds the margin mentioned, no collision would occur if both proceed with constant speed. With the original definition, such a situation would not be a serious conflict.

Thus, the TA-value is a measure of that remaining time, which is allotted to the road users for avoiding an accident. A high TA-value means that the conflict is not serious, the parties have ample time to decide how to react.

A low TA-value, on the other hand, indicates a situation where an immediate reaction is necessary to avoid a collision. Some road users might consciously lower the TA-value by braking as late as possible, even when they discover the danger much earlier. In such cases the TA-value is a bad measure on the degree of seriousness of the situation.

One might suppose that there exists a threshold value for TA, so that no road users consciously enter a situation where the TA-value is below this threshold. Road users, involved in such situations, have a margin to react which is so small as to demand immediate action in order to avoid an accident. The TA-value is then a measure of the seriousness of the situation. It follows that this threshold value should be a good choice for defining "serious" conflicts.

Serious conflicts arise as a consequence of a disturbance in the interaction between man, vehicle and environment. One of the major "causes" is the design of the traffic environment. The requirements on the perceptual abilities of the road users become too great.

As an example, about 3/4 of all accidents on zebra-crossings in urban intersections occur after the vehicle has passed the intersection. (5)

An accident can be said to occur as a result of a lowering of the TA-value in a serious conflict below a necessary minimum. That minimum, which is needed to avoid an accident, is difficult to establish exactly. The value probably depends on, for example, the speeds just before the conflict arises.

In a first stage, attempts were made to apply the theory of serious conflicts on actual traffic situations. Continuous video recordings were performed in some intersections of various designs. On the basis of these studies, 1,5 sec. was chosen as a threshold value for conflict situations. This leads to the following definition:

A serious conflict situation is at hand when the remaining time to an accident (TA, as previously defined) is less than 1,5 sec.

The studies mentioned showed that it is practical and possible to grade the conflicts in two types:

1. serious conflicts with $TA < 1{,}0$ sec.
2. " " " $1{,}0 \text{ sec.} \leq TA \leq 1{,}5$ sec.

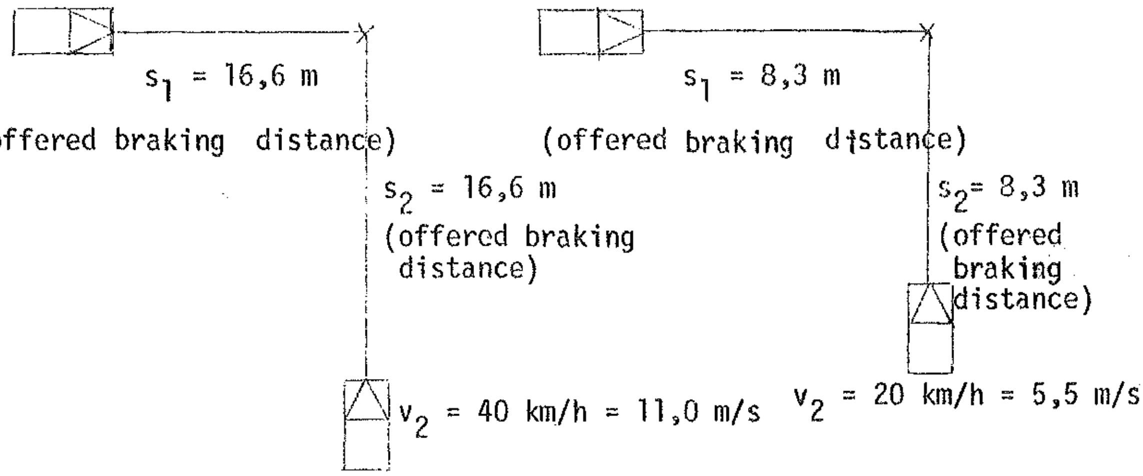
The probability that a serious conflict will result in an accident evidently depends on the road users possibilities to avoid the accident. These possibilities mainly depend on the reaction time offered, but probably also on the speed of the parties involved.

The reason why this is so is inherit in the very definition of serious conflicts. While the distance to the "collision point", for a certain TA-value, is in direct proportion to speed, the braking distance is proportional to speed squared.

The following example illuminates this point:

Case 1. TA = 1,5 sec
v_1 = 40 km/h = 11,0 m/s

Case 2. TA = 1,5 sec
v_1 = 20 km/h = 5,5 m/s



Actual braking distance = 15,0 m

(dry bitumen, level section)

Actual braking distance = 3,7 m

(dry bitumen, level section)

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

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

The example above shows that the relation between actual and offered braking distance is considerably less in Case 2, where both cars keep lower speeds. In this case, the spatial margin is relatively bigger and hence the probability, that the conflict will develop into an accident is likely to be smaller. A description of the speeds for those involved in a conflict can be obtained in different ways. One possibility is to classify every intersection studied according to some criteria of speed standard, another to classify each conflict according to the speeds of the vehicles immediately prior to the conflict.

In the conflict studies that have been carried out so far attempts have been made to classify the conflicts according to both TA-value and actual speeds.

Four classes of conflicts were selected:

Class 1: Speed $\leq$ 35 km/h (22 miles/h) 1,0 sec. $\leq$ TA $\leq$ 1,5 sec.
(Speed of all vehicles involved)

Class 2: Speed $\leq$ 35 km/h TA $<$ 1,0 sec.

Class 3: Speed $\geq$ 35 km/h 1,0 sec. $\leq$ TA $\leq$ 1,5 sec.
(Speed of any vehicle involved)

Class 4: Speed $\geq$ 35 km/h TA $<$ 1,0 sec.

Tests of conflict observers have shown that it is possible to train the judgement of speeds so that a difference, as measured between different observers, of less than $\pm$ 5 km/h (3,1 miles/h) is obtainable.

As a consequence, the speeds were classified according to principally continuous scale in the second stage of the conflict studies. However, this classification of speeds has not been used in the analysis performed so far.

2.4 Technique of recording serious conflict situations

2.4.1 General

The recording technique to be selected must fulfil certain requirements on practicality and reliability. Film- and videotechniques give a high reliability for conflict recording. By determining speeds and relative distance of the parties involved, TA-values can be obtained with a high accuracy.

However, the method has some difinite disadvantages:

1. Using one camera only a part of the intersection can be studied at one time.

2. In many intersections, some considerable work would be required in order to find suitable camera positions (if they exist), and to obtain permissions for using these positions.

For the reasons mentioned, this method was rejected. Recording with the aid of observers, for direct observations and placed in the intersection lack the disadvantages mentioned. At the same time, this method required a thorough training of the observers and a control of their ability to select serious conflicts according to the objective criteria.

2.4.2 Training of observers

In order to train the observers conflict situations were collected and documented with the help of video recording. This technique has great advantages when compared with film technique for the same purpose. The list of material is reduced, since the video-tapes can be re-used. Further, video admits a direct sound recording which contributes to a more realistic performance. The recordings were made by a portable SONY-equipment for use with either batteries or AC-power.

In city traffic, road users often find themselves in a situation where they unknowingly have to estimate the time that remains to a potential accident. In an absolute majority of these situations, they estimate this time with enough accuracy to avoid the TA-value from falling below the critical threshold.

The ability of road users to estimate time lags indirectly is fundamental for our belief that persons can be trained to judge conflicts according to the objective criteria.

According to experience the training should be planned so that the observers first of all are taught to make an indirect estimate of the degree of seriousness, in the same way as road users. By comparing the TA-values for recorded conflicts with the subjectively experienced degree of seriousness the objective time limits for serious conflicts can be separated with acceptable accuracy. The accuracy mainly depends on the intensity of the training. The training of observers hitherto undertaken shows that, as a complement, these should also be aware of the technique behind the calculation of TA-values. In that case, they will also be able to make a correct estimate of situations where, for example, a car brakes suddenly without being compelled by circumstances.

2.4.3 Tests of observers

Before the observers participate in the conflictdata collection at a field site, their reliability (i.e. their ability to select serious conflicts) has to be tested. Tests of the external reliability of the observers have been performed, meaning that estimates of the same situations were compared, between the observers as well as with the objectively defined criteria.

These tests were carried out in the following way:

Several observers were placed on the same spot and were given the task of recording the conflicts between the same traffic flows. The same conflicts were simultaneously recorded on video tape. The tapes were then examined, whereby all conflicts were registered and compared with the records of the different observers.

The conflicts, registered by the observers, could be identified since these were instructed to note the kinds of road users involved (car, pedestrian etc.) and their direction of travel. Also, the observers noted the time when the conflict ocurred. Time was also recorded contineously at the video tape.

A test of the external reliability of five observers was carried out in May 1974. The results were as follows (TABLE 1):

Any test of the internal reliability of the observers has not been considered necessary for the field studies carried out as of yet. With internal reliability we mean the ability to maintain the same way of estimating serious conflicts during a longer period of time.

The reason why the internal reliability has not been tested is the relatively short durability of each field study period (at most six weeks).

During May 1975, nine observers which had been trained on different occasions (Nov - 74, April - 75, May - 75) were tested simultaneously. These tests, illustrating the internal reliability together with the external, is accounted for in TABLE 2.

In TABLE 3 there is a comparison between the number of conflicts per minute in field studies carried out 1974 and 1975 at both occasions in April and May. In identical studies 1974 and 1975 (between 1130 and 1300) there is a difference of only 6 % according to the number of conflicts per minute recorded.

The difference, when comparing 1600 - 1830 for the two years, is 24 %. This is mainly due to the fact that there was two observers in the 1975 studies but only one 1974.

The results of the reliability tests must be considered satisfactory, what concerns the ability of the observers do discern whether a conflict is serious or not according to definition.

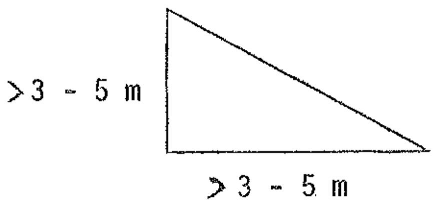
2.5 Data collection

2.5.1 Description of the intersections

For the statistical analysis, the following information was collected concerning design and other technical specifications of the intersections:

1. Type of regulation
   a. No regulation (right-hand rule)
   b. Give-way rule
   c. Signalized intersection

2.	Street width	Number of lanes in each approach
3.	Pedestrian crossings	Presence of zebra crossings in each approach
4.	Sight conditions	a. Good sight in all "corners" of the intersection (A sight triangle with all sides longer than 3 - 5 m = 10 - 15 ft, depending on speed limit)



		b. Bad sight in one or more of the corners of the intersection.
5.	Speed standard (for other than signalized intersections)	a. High speeds. (Average speed in one or both of the intersecting streets is more than 35 km/h = 22 miles/h)
		b. Low speeds (Average speed less than 35 km/h = 22 miles/h in both intersecting streets).

2.5.2 Traffic accidents

There are some obvious problems associated with the definition of "traffic accident" for this purpose, and with the choice of a suitable data collection method. The first condition on the definition selected must concern the representability of the collected data. It is well known that while accidents with very serious consequences are well represented in the police records, accidents with only material damages are not. Of the latter, reporting frequencies of 25 - 50 % have been mentioned, compared to 85 - 90 % for accidents with personal injuries.

Considering accidents with only material damage, the police records are too incomplete to be of use. In spite of the fact that accidents with personal injuries are considerably fewer, the number of police reported accidents with personal injuries was chosen here for definition of "accident". Investigations of the degree of reporting such accidents has not shown the existance of any bias. Therefore, it can reasonably be assumed that the loss is randomly distributed in the sample of selected intersections, especially since these were geographically concentrated to an urban area within Malmö. As a base for the collection of accident data was used a copy of the police record concerning traffic accidents with personal injuries.

2.5.3 Serious conflicts

2.5.3.1 Recording

To record conflicts a form of the type shown in FIGURE 1 was used. The figure also includes an example.

Apart from a direct registration of data concerning type of conflict, movements of the parties involved etcetera, the form also facilitates a brief description of the sequence of events that preceeded the conflict. The intention was that the observer should record only such factors, that he could discern clearly and that in some way contributed in trigging the conflict.

This simple way of recording the conflicts was possible because of the in this connection relatively few conflicts that arouse. At most 10 conflicts per hour were obtained. Besides, the form selected makes possible a rather complicated description of the events. This was considered valuable at that stage in the development project. When using conflict recording for practical applications, a more rational method of registration could be found.

2.5.3.2. Planning the field studies

Field studies for the collection of conflict data were performed in two periods, May - June 1974, and Feb. - May 1975.

During both periods the same 50 intersections in Malmö were studied.

Each intersection was studied in average four hours 1974 and six hours 1975.

The studies were distributed over four time intervals of the day:

1. 9 P.M. - 11.30 P.M.
2. 11.30 P.M. - 1 A.M.
3. 1 A.M. - 4 A.M.
4. 4 A.M. - 6.30 A.M.

All studies 1974 were carried through with only one observer, while these studies during 1975 that considered peak-hour traffic (4 A.M. - 6.30 A.M.) were made by two observers in each intersection.

The experience from peak-hour studies during 1974 shows the difficulties for only one observer to survey the entire intersection. The number of potential conflicts increases steeply during the peak-hours.

2.5.4 Traffic flows

Traffic flows were counted by special personal parallell to the recording of conflicts. The counts were made so as to differentiate between different directions and different types of road users. The purpose of the counts is twofold:

1. Later and if necessary, traffic flows will be included in the statistical analysis of relationships between accidents and conflicts.

2. By relating number of conflicts to various flow measures, you have the foundation for modelling the connections between serious conflicts on one hand and design elements on the other.

An example of the form used for flow counts is shown in FIGURE 2.

Since only one counter would not manage a simultaneous count of all flows, an approximate procedure was chosen: Every count lasts 5 minutes. In heavy traffic, divide the total amount of flows in two or three parts. A minimum condition is that all flows should be counted twice per half hour, i.e. at least during one third of the total time. This procedure yields an error that is acceptable for the purposes mentioned above.

3. RESULTS

The purpose of the statistical analysis was to investigate the dependence on different variables of the number of observed conflicts per accident with personal injuries, and to investigate the relationship between accident and conflict frequencies at different conditions. It seems reasonable to assume that the relation between conflicts and accidents is not a constant but varies with, for example, different means of transport. However, if the method should be of use for practical applications, this relation must not depend on too many variables.

In a first attempt, the material was divided with regards to six parameters. Three of these describe the physical design of the intersection, namely speed standard, traffic islands and sight distances. The other three, means of transport, flow and observation period describe the traffic elements involved. With "means of transport" we mean the type of road user involved in conflicts or accidents. (Car drivers only, car and pedestrian, bicycle or light motorbike). Depending on the direction of the cars involved, if any, the traffic flows were defined as straight or turning. Observation period is related to hour of occurrence of the conflict or accident (9.00 - 16.00 or 16.00 - 18.30).

Accidents, which occurred during the week-end or which took place on an ice-covered pavement were excluded, in order to make the conditions comparable to those of the conflict studies. All in all, 247 accidents and 765 conflicts were investigated.

The tables below show the physical design parameters of the 50 intersections included, together with the number of accidents and conflicts (separated according to means of transport, period of observation and flow).

VARIABLE	PARAMETER VALUE	NUMBER OF INTERSECTIONS
SIGNAL	SIGNAL CONTROL = 0	12
	LOW SPEED INTERSECTION, NO SIGNAL CONTROL = 1	16
	HIGH SPEED INTERSECTION, NO SIGNAL CONTROL = 2	22
TRAFFIC ISLAND	NO TRAFFIC ISLAND = 0	5
	TRAFFIC ISLAND IN ONE OF THE APPROACHES = 1	45
SIGHT CONDITIONS	GOOD SIGHT IN ALL CORNERS = 0	27
	BAD SIGHT IN ANY CORNER = 1	23

		NUMBER OF ACCIDENTS	NUMBER OF CONFLICTS
MEANS OF TRANSPORT	CAR - PEDESTRIAN = 1	127	247
	CAR - BICYCLE = 2	52	109
	CAR - CAR = 3	36	384
	CAR - MOPED = 4	32	25
PERIOD OF OBSERVATION	09.00 - 16.00 = 1	130	345
	16.00 - 18.30 = 2	117	420
FLOW	STRAIGHT ON TRAFFIC = 1	193	518
	TURNING TRAFFIC = 2	54	247

All variables are discrete and the coded numerial values therefore arbitrary. In spite of this, a computer program for step-wise linear regression (BMD 02 R) was used in a first preliminary analysis. As dependent variable was defined the quotient between conflict and accident frequency, with the six previously mentioned descriptive variables as independent. It should be noted that the intension of the regression analysis was only to give an idea of whether a stratification in any of the independent variables would considerably reduce the variance in the dependent variable, in a qualitative sense. The regression analysis can thus be considered an alternative to the AID-method of Morgans and Songqvists. The procedure should work for variables which are binary only. It is more doubtful for multivariate variables, especially if these are measured in a nominal scale only. In this case, all variables except menas of transport and signal are binary.

The variable means of transport is multivariate with no meaningful ordering of its values. That such a variable does not enter the regression on an early stage does not necessarily mean that it has no explanatory power, but only that the assumed linear relationship is inefficient.

Because of the high degree of stratification, the number of accidents and conflicts are low for many parameter values. Such cases in which they are zero had to be excluded, due to the construction of the program. More than half of the elementary cases were excluded for that reason. The first regression gave the following result:

Step	Variable introduced	R^2=squared multiple correlation coefficient	Increase of R^2
1	Period of observation	0,0364	0,0364
2	Means of transport	0,0664	0,0300
3	Flow	0,0940	0,0276
4	Sight conditions	0,1030	0,0090
5	Signal	0,1151	0,0127
6	Traffic island	0,1203	0,0045

Since the amounts of conflicts and accidents are small, their quotient often was rather unstable. This is probably one explanation for the low coefficients of correlation. According to the table, no variable increases the coefficient of correlation considerably.

However, one may sense the existence of two groups of variables with different relative importance. Those variables, which describe the physical design of the intersection, seem to be of less significance than the others. Hence, variables of the first type were disregarded in the second regression. The variable "means of transport" was divided in the four cathegories car, bicycle, pedestrian and light motorbike. Each type of vehicle was represented by a dummy-variable, with value = 1 if that vehicle was used and = 0 otherwise. The results were as follows:

Step	R^2 squared multiple correlation coefficient	Increase of R^2
1 Bicycle	0,1100	0,1100
2 Car	0,2119	0,1019
3 Period of observation	0,2483	0,0364
4 Pedestrian	0,2542	0,0058
5 Flow	0,2573	0,0031

The results show that "means of transport" has a relatively large effect. This can also be seen from the summary of the number of conflicts and accidents previously shown. The correlation coefficient (squared) has increased to 0,257.

Because of the definition of conflict used in this study, the quotient between conflict and accident frequencies might also depend on the speed of the road users involved (apart from the effect of different means of transport). To test this, the variables were redefined in order to obtain more homogenous classes with respect to speeds. With these definitions the following results were obtained.

Step	R^2 squared multiple correlation coefficient	Increase of R^2
1 Car	0,3097	0,3097
2 Traffic-class 1	0,5358	0,0262
3 Period of observation	0,5424	0,0065
4 Traffic-class 4	0,5491	0,0068
5 Traffic-class 2	0,5509	0,0018

Class 1 = traffic in low speed intersections and turning traffic in high speed intersections

Class 2 = turning traffic in signalized intersections

Class 3 = traffic straight on in high speed intersections

Class 4 = traffik straight on in low speed intersections

The result of this regression verifies the primary importance of means of transport and speed of the road users involved.

The relatively low coefficient of correlation probably depends on the limited size of the material, as well as on the large random variations in the number of accidents and in the number of conflicts.

Tables 4 and 5 show the number of conflicts and accidents per class of traffic (as above), means of transport and time of observation, 1974 and 1975.

Figure 3 represents the results graphically.

Since "period of observation" does not explain any variation in the accident/conflicts - quotient, the results were pooled with respect to this variable and to year of study (1974 or 1975). From this, a first attempt was made to compute a conversion factor between conflicts and accidents. See table 6.

The table clearly shows the following tendencies:

1. The accident / conflict qoutient increases with increasing speeds (from class 1 to class 4)

2. The qoutient increases with an increasing amount of unprotected road users involved (from car-car to car-pedestrian)

These tendencies agree with the fundamental hypotheses, namely:

1. The importance of speed mainly depends on the time criteria of a serious conflict

2. The means of transport is of importance mainly because only accidents with personal injuries are considered in the comparison.

In order to investigate whether this is the only reason to the variation of the quotient with different means of transport, an attempt shall be made to relate the number of serious conflicts to all accidents with personal or material damages. The problem of obtaining representative accident data for this analysis is very difficult indeed and has not been solved finally at this stage of the project.

In order to strengthen the validation studies, conflicts and accidents shall be compared, firstly with respect to types of conflicts and accidents, and secondly with regards to their primary causes. A classification of accidents according to causes requires a better data base than the police records. Instead, analyses shall be made of the interrogations with those involved in accidents and with the witnesses.

TABLE 1

Test of extern observer reliability

CONFLICT SITUATION NO	TIME OF DAY	CATHEGORY x)	TYPE OF CONFLICT ACCORDING TO EVALUATION OF VIDEOTAPE	TYPE OF CONFLICT ACCORDING TO OBSERVERS					SCORE	
				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	-
									40	6

x) Cathegory: C = car, B = bicycle, P = pedestrian, M = moped

Wrong (%) $\frac{6}{40} \cdot 100 = 15$

TABLE 2

Test of observer reliability

Site No 5 in Malmoe: The intersection Studentgatan - St. Nygatan

Tuesday 1975-06-03, 11.35-13.00, 15.55-18.15

CONFLICT SITUATION NO	TIME OF DAY	CATHEGORY x)	TYPE OF CONFLICT ACCORDING TO EVALUATION OF VIDEOTAPE	TYPE OF CONFLICT ACCORDING TO OBSERVERS							SCORE	
				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	0	-	-	1	-	-	-	-	-	1
4	16.15	C - C	0	-	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
			Sum of conflicts:	5	4	4	4	5	5	5	Sum 35	7

$$\frac{\text{NEGATIVE}}{\text{POSSIBLE}} = \frac{7}{35} = 20\ \%$$

x) Cathegory:

C = car
P = pedestrian
B = bicycle

TABLE 3

Number of conflicts, total and per minute, 1974 resp. 1975

Site 1-20

Site	11.30-13.00				16.00-18.30				11.30-13.00 16.00-18.30	
	Number of conflicts		Time of observation (min)		Number of conflicts		Time of observation (min)		Number of conflicts	
	-74 1/	-75 1/	-74 1/	-75 1/	-74 1/	-75 2/	-74 1/	-75 2/	-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
Sum	40	44	1155	1176	62	76	1872	1872	77	89

Number of conflicts per minute: 11.30-13.00, 1974: 0.035 1/
" " , 1975: 0.037 1/

16.00-18.30 1974: 0.033 1/
" " , 1975: 0.041 2/

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

TABLE 4

Accidents and conflicts per class of traffic, means of transport and time of observation

1974

CLASS 1/	MEANS OF TRANSPORT	PERIOD OF OBSERVATION 2/	NUMBER OF ACCIDENTS	OBS.TIME ACCIDENTS PER MIN. $x\ 10^{-7}$	NUMBER OF ACCIDENTS PER MIN $x\ 10^{7}$	NUMBER OF CONFLICTS	OBS.TIME CONFLICTS (MIN) $x\ 10^{-3}$	NUMBER OF CONFLICTS PER MIN $x\ 10^{3}$	NUMBER OF ACCIDENTS PER MIN/ NUMBER OF CONFLICTS PER MIN $x\ 10^{5}$
1	P	1	14	4.13	3.40	39	6.23	6.26	5.4
2	P	1	6	0.842	7.13	16	1.37	11.7	6.1
3	P	1	40	1.68	23.8	10	2.35	4.26	56.0
4	P	1	7	0.842	8.31	1	1.37	0.73	114.2
1	P	2	13	1.47	8.84	35	5.19	6.74	13.1
2	P	2	6	0.301	19.9	8	1.21	6.61	30.2
3	P	2	32	0.601	53.2	9	1.99	4.52	117.1
4	P	2	8	0.301	26.6	0	1.21	0	-
1	B	1	7	4.13	1.70	11	6.23	1.76	9.6
2	B	1	7	0.842	8.31	4	1.37	2.92	28.6
3	B	1	5	1.68	2.98	8	2.35	3.40	8.7
4	B	1	7	0.842	8.31	4	1.37	2.92	28.6
1	B	2	6	1.47	4.08	9	5.19	1.73	23.5
2	B	2	2	0.301	6.64	4	1.21	3.30	20.1
3	B	2	13	0.601	21.6	11	1.99	5.53	39.1
4	B	2	5	0.301	16.6	2	1.21	1.65	100.6
1	C	1	4	4.13	0.97	31	6.23	4.98	1.9
2	C	1	3	0.842	3.56	5	1.37	3.65	9.8
3	C	1	6	1.68	3.57	25	2.35	10.6	3.3
4	C	1	10	0.842	11.9	12	1.37	8.76	13.6
1	C	2	1	1.47	0.68	35	5.19	6.74	1.0
2	C	2	0	0.301	0	8	1.21	6.61	0
3	C	2	9	0.601	15.0	28	1.99	14.1	10.6
4	C	2	3	0.301	9.97	20	1.21	16.5	6.9

1/ See TABLE 6.

2/ Period of observation 1: 9.00-16.00

Period of observation 2: 16.00-18.30

TABLE 5

Accidents and conflicts per class of traffic, means of transport and time of observation

1975

CLASS 1/	MEANS OF TRANSPORT	PERIOD OF OBSERVATION 2/	NUMBER OF ACCIDENTS	OBS.TIME ACCIDENTS PER MIN. x 10^{-7}	NUMBER OF ACCIDENTS PER MIN x 10^{7}	NUMBER OF CONFLICTS	OBS.TIME CONFLICTS (MIN) x 10^{-3}	NUMBER OF CONFLICTS PER MIN x 10^{3}	NUMBER OF ACCIDENTS PER MIN/ NUMBER OF CONFLICTS PER MIN x 10^{5} 1975	1974
1	P	1	14	3.67	3.81	36	8.36	4.30	8.7	5.4
2	P	1	6	0.842	7.13	17	2.00	8.50	8.4	6.1
3	P	1	31	1.38	22.5	16	3.19	5.01	44.9	56.0
4	P	1	7	0.842	8.31	0	2.00	0	-	114.2
1	P	2	12	1.31	9.16	46	7.13	6.45	14.2	13.1
2	P	2	6	0.301	19.9	16	1.75	9.14	21.8	30.2
3	P	2	22	0.491	44.8	13	2.86	4.55	98.6	117.1
4	P	2	8	0.301	26.6	3	1.75	1.71	154.8	-
1	B	1	6	3.67	1.63	11	8.36	1.32	12.4	9.6
2	B	1	7	0.842	8.31	5	2.00	2.50	33.3	28.6
3	B	1	2	1.38	1.45	3	3.19	0.94	15.5	8.7
4	B	1	7	0.842	8.31	4	2.00	2.00	41.6	28.6
1	B	2	5	1.31	3.82	22	7.13	3.08	12.4	23.5
2	B	2	2	0.301	6.64	6	1.75	3.43	19.3	20.1
3	B	2	10	0.491	20.4	5	2.86	1.75	116.6	39.1
4	B	2	5	0.301	16.6	2	1.75	1.14	145.1	100.6
1	C	1	4	3.67	1.09	53	8.36	6.34	1.7	1.9
2	C	1	3	0.842	3.56	7	2.00	3.50	10.2	9.8
3	C	1	5	1.38	3.62	23	3.19	7.21	5.0	3.3
4	C	1	10	0.842	11.9	17	2.00	8.50	14.0	13.6
1	C	2	1	1.31	0.763	72	7.13	10.1	0.8	1.0
2	C	2	0	0.301	0	5	1.75	2.86	0	0
3	C	2	7	0.491	14.3	49	2.86	17.1	8.3	10.6
4	C	2	3	0.301	9.97	33	1.75	18.9	5.3	6.9

1/ See TABLE 6.

2/ Period of observation 1: 9.00-16.00

Period of observation 2:16.00-18.30

TABLE 6

Number of accidents per minute/number of conflicts per minute for different means of transport and different class of traffic

Class	Car - Car	Bicycle - Car	Pedestrian - Car
1	1,3 (5,191)	11,8 (13,53)	8,3 (27,156)
2	6,6 (3,25)	26,2 (9,19)	11,7 (12,57)
3	5,5 (15,125)	30,4 (18.27)	68,3 (72,48)
4	8,8 (13,82)	55,4 (12,12)	207,7 (15,4)

The quotients have been multiplied with a factor 10^5.
Within parenthesis are shown the number of accidents and the number of conflicts from which the quotients were calculated.

Class 1 = traffic in low speed intersections and turning traffic in high speed intersections

Class 2 = turning traffic in signalized intersections

Class 3 = traffic straight on in high speed intersections

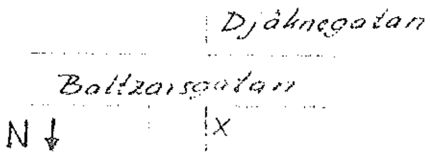
Class 4 = traffic straight on in low speed intersections.

FIGURE 1

FORM FOR RECORDING OF DANGEROUS CONFLICTS

SITE NO: 6
DATE: 750512
TIME: 1600-1830

SITE:



CLIMATE: Cloudy, rain

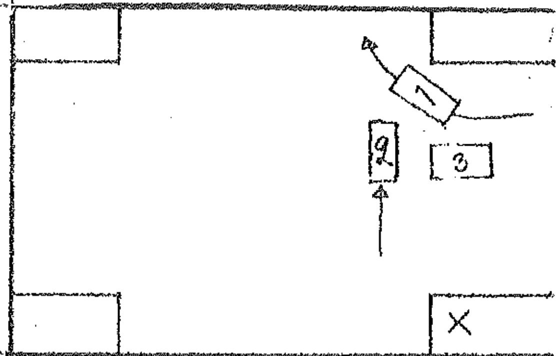
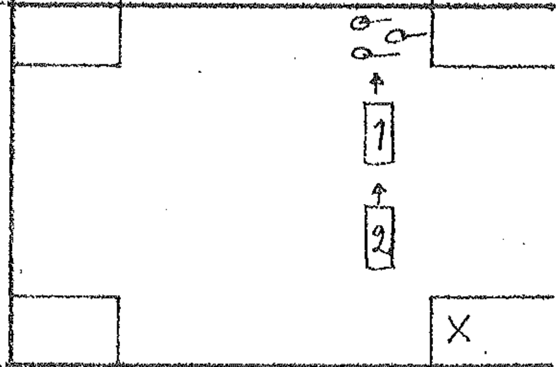
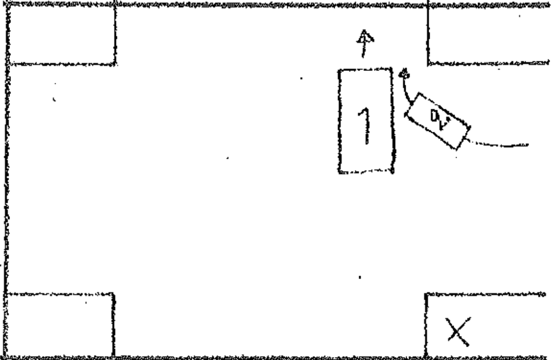
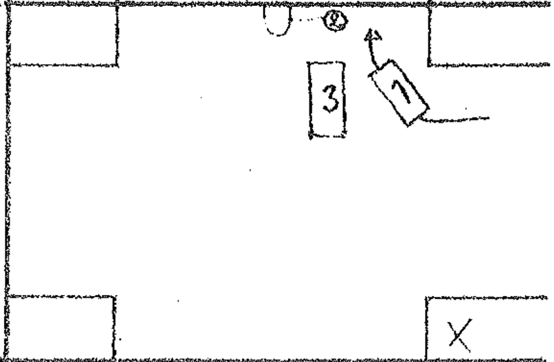
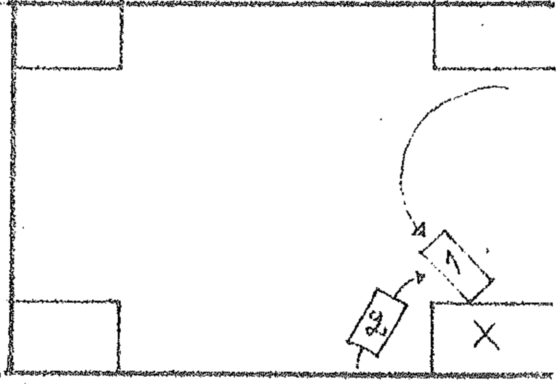
conflict sit no	Description of the conflict situation	Figure of the conflict situation
1 time 1605 speed 30	Class: 2 Primarily involved: B-B Short description of what happened age 1 turned behind 3, which stood in the way of 2. The two cars braked heavily	
2 time 1615 speed 30	Class: 1 Primarily involved: B-B Short description of what happened age 1 brakes to let pedestrian pass. Conflict between 1 and 2, which braked to late.	
3 time 1641 speed 30	Class: 2 Primarily involved: B-B Short description of what happened age 1, lorry, passes the intersection, obviously faster than 2 thought. 2 extremely near driving into one side of the lorry.	
4 time 1651 speed 20	Class: 1 Primarily involved: B-G Short description of what happened age 3 lets 2 pass. 1, which comes round the corner doesn't see 2 until he appears in front of 3. 2 and 1 broke.	
5 time 1704 speed 25	Class: 2 Primarily involved: B-B Short description of what happened age "U-turning car" 1 doesn't succeed in turning and stops across the right roadway. 2 comes around the corner and has to brake because of 1.	

FIGURE 2 FORM FOR FLOW COUNTS

SITE NR: 6

TIME: 1607 - 1617

RAIN, FAIR WEATHER + 12 °C

1975-05-12

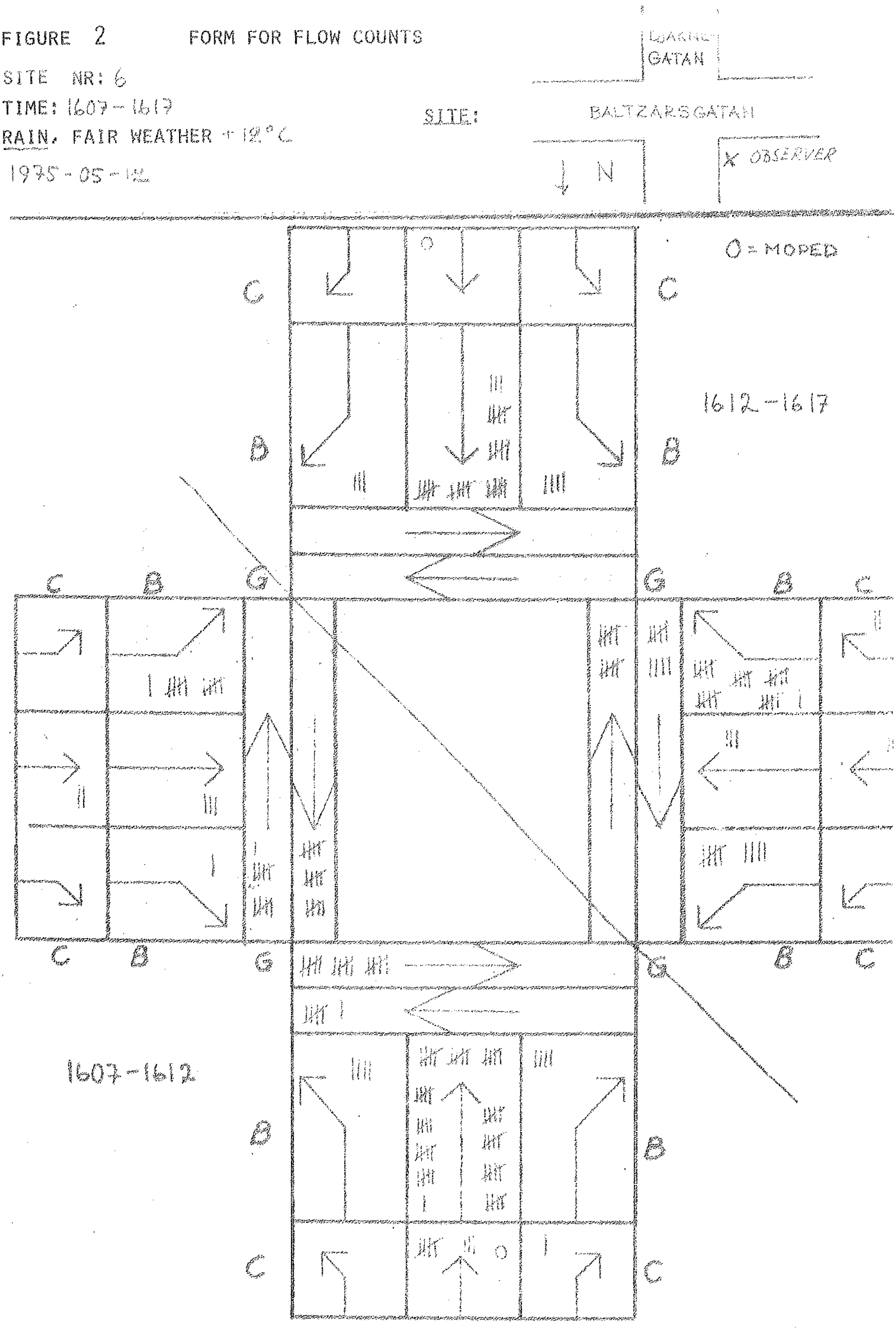


FIGURE 3

Diagram of number of conflicts and number of conflicts per minute, for different traffic classes and different means of transport

1 = traffic in low speed intersections and turning traffic in high speed intersections

2 = turning traffic in signalized intersections

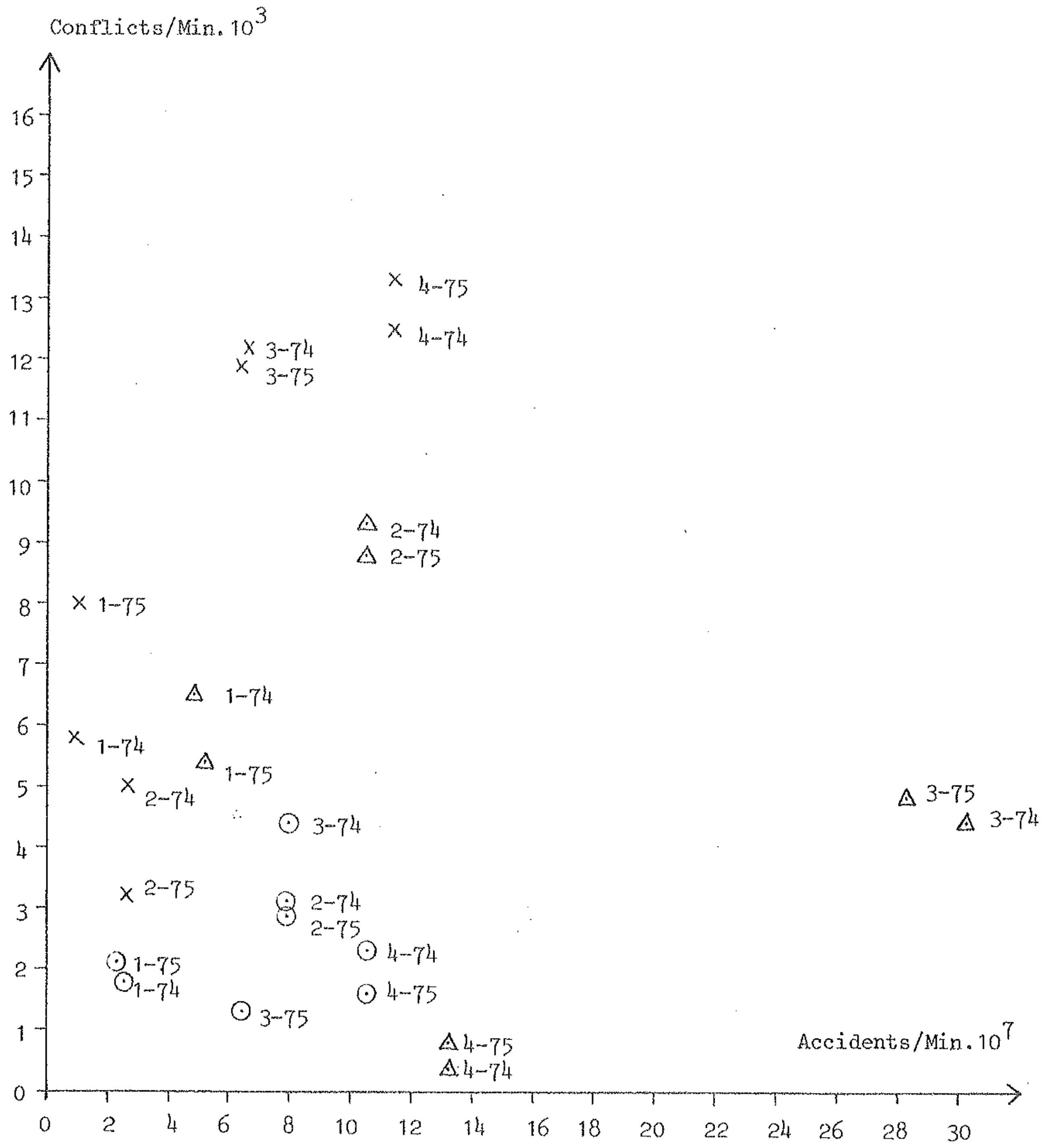
3 = traffic straight on in high speed intersections

4 = traffic straight on in low speed intersections

△ = Car-Pedestrian

⊙ = Car- Bicycle

× = Car-Car



LITTERATURE

1. Perkins, S.R. and Harris, J.I. "Criteria for traffic conflict characteristics study".
General Motors Corporation. Research Publication GMR-610.

Perkins, S.R. and Harris, J.I. "Criteria for traffic conflict characteristics at signalized intersections".
General Motors Corporation. Research Publication GMR-632.

Perkins, S.R. and Harris, J.I. "Traffic conflict characteristics - Accident potential at intersections".
General Motors Corporation. Research Publication GMR-718.

2. Paddock, R.D. "The traffic conflicts technique: An accident prediction method".
Ohio Department of Transportation.

3. Campbell, R.E., Virginia Department of Highways and Ellis-King, L., West Virginia University. "The traffic conflicts technique applied to rural intersections".
Accident Analysis and Prevention. Vol 2 pp 209-221.

4. Spicer, B.R. "A pilot study of traffic conflicts at a rural dual carriageway intersection".
Transport and Road Research Laboratory. RRL Report LR 410.

Spicer, B.R. "A traffic conflict study at an intersection on the Andoversford by-pass".
Transport and Road Research Laboratory. TRRL Report LR 520.

5. Amundsen, F.H. "Nesten ulykker - Utvikling av registreringsmetodikk og analyse av sammenheng med trafikulykker".
Transportökonomisk Institutt, Oslo. TÖI-Report 4413.