CONFLICT ANALYSIS TECHNIQUES FOR ROAD SAFETY RESEARCH

Contributions to OECD Special Research Group on Pedestrian Safety

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CONTENTS

I. INTRODUCTION

In recent years much attention has been paid in the Netherlands and other countries to developing traffic conflict analysis techniques for road safety research.

A distinction must be made between objective traffic hazards in terms of number of casualties or number of road accidents, where applicable related to the degree of exposure, and the subjective experience of such hazards. SWOV's aim in the first instance is to increase the objective road safety of the various categories of road users.

Within the context of objective road safety, conflicts are often regarded as future substitute criteria of road accidents, in order to establish the extent of traffic dangers. Research results concerning the relationship between traffic conflicts and road accidents are discussed in S. Oppe's article. This shows that the correlation between serious traffic conflicts and the accident hazard is not so great that conflicts can be used as a substitute criterion for road hazards. This means that for the time being the risk of injury and the accident hazard must still be used as the indicator for objective traffic hazards and that reliable road accident records are therefore a primary requirement.

Traffic conflict analyses, however, are important in formulating a theory that may lead to developing means of improving road safety. The relationship between conflicts and accidents is bound up with traffic performance. If conflict observation techniques are to be used in the above sense, a reliable method will have to be developed first. This is the purpose of the research discussed in J.H.Kraay's article.

II. TRAFFIC CONFLICT ANALYSIS, A ROAD SAFETY RESEARCH TECHNIQUE

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Summary

Based on research results, it is ascertained to what extent traffic conflict analysis can be applied as a method of traffic safety research. It appears from the literature that there is no substantial relation between conflicts and accidents. Traffic volumes probably play an important role with regard to this relation. Better results are gained if only serious conflicts are considered. However, research in this field has been made only on a limited scale. In this connection the problem of the reliability of the measurements is of some momentum. It is concluded that a great deal of evaluating research still has to be done before conflict analysis can be applied on a large scale. In specific cases, particularly those in which only very few accidents have been recorded or no accident history is available, the application of technique may be useful. It is suggested applying traffic encounters instead of traffic volumes to measure exposure and using the results of conflicts in combination with other data such as those derived from observations of road-users' behaviour.

1. Introduction

Road safety research puts the emphasis on traffic accidents. Usually, the number of accidents, with various modifications according to type and severity, adjusted or not for traffic or transportation performance, is used as the criterion of road safety or danger. Analysis of road traffic accidents, however, produces a number of difficult problems. The main reason is the comparative infrequency of accidents. Although the total number of road traffic accidents in any country, province or city is often considered unacceptably high, the number on practically any individual road section is too small a basis for research. Consequently, other methods have been sought for detecting dangerous traffic situations and for tracing their causes; vide, inter alia, Pahl (13) and Van Minnen (21). The most promising method so far is that of traffic conflict analysis. Although various causes of accidents can be distinguished, most accidents are due to two or more road users coming into conflict. Even in ostensibly one-sided accidents there may be a conflict, for instance when a vehicle runs off the road to avoid a head-to-tail collision.

2. Traffic conflicts versus accidents

Traffic conflicts are very frequent. But seldom do they lead to road accidents. Especially at intersections an accident can almost invariably be described as uncorrectible conflict. The fact that traffic conflicts are so numerous and also have a presumed relationship with accidents has led to their being researched to trace the cause of road accidents. The principal advantages of using traffic conflicts instead of accidents are:

1. The comparatively large number of traffic conflicts that can be established at a given traffic location. Even if accidents are recorded for a number of years the number occurring at specific locations is often still too small, for instance for black-spot research. Research might still be possible with traffic conflict analysis. Hayward (9) has estimated that the number of conflicts on any one day is equal to the number of accidents per year. Harris & Perkins (7) think there are as many traffic conflicts per hour as there are accidents per year. The discrepancy between these estimates is related both to the definition of an accident (for instance fatal accidents only, accidents involving injury, etc.) and of a conflict.

2. Since traffic conflicts are so numerous, very detailed information about them can be gathered quickly; enough data can be collected in several days or even hours.

3. Since data can be collected so quickly, a homogeneous situation can be studied. Road accident data are often collected for a period of several years. During that time, the traffic flow or the road features have often changed.

4. Pahl also mentions the ethical aspect: there is no need to wait for accidents to happen before the hazards are pointed out.

This impressive list of advantages might suggest a quick change-over to traffic conflict analysis instead of accident analysis. But before taking this step, it will have to be properly ascertained whether the naive notion on which the technique is based is substantiated by research results. It will have to be demonstrated that measures based on traffic conflict analysis do in fact lead to greater safety and not merely to an imagined improvement of road safety. It is, of course, possible to start by using the conflict analysis technique and afterwards to evaluate the consequent measures against a recorded or unrecorded reduction in the accident rate. But a better way might be to examine the relationship between traffic conflicts and road accidents before switching to the conflict analysis technique. This applies to the conflict observation technique used for recording conflicts and also to a more comprehensive conflict analysis technique aimed at tracing the causes of traffic hazards. If this is dropped and an effort is made for instance, simply to improve road safety by reducing the number of conflicts, this implies that use is in fact being made of a wider definition of road safety. An approach in which the widening of this definition is made explicit by including convenience aspects, such as the road user's sense of safety, are found in Oving (23).

Another problem is that of putting acquired knowledge into general terms in order to make measures applicable on a larger scale. It is often very difficult to put knowledge of accidents in specific situations into more general terms. It is more difficult still to try and reach general conclusions from a knowledge of conflicts without adequate knowledge of the correlation between road accidents and traffic conflicts.

3. Definitions of conflict

The basic idea behind the use of traffic conflict analysis instead of road accidents is the attempt to expand the range of research: from accidents to potential accidents, with the view that conflicts are potential accidents. The definition of a potential accident is determined by the definition of a traffic conflict. Depending on this, the range of research is extended to a greater or less extent. The widest definition is obtained by referring to a potential accident if two or more road users are in such close proximity as might influence their movements. The choice of this definition practically changes road accident research to traffic density research. And little of the original purpose is left. Limiting the range will give a definition closer and closer to that of an actual road accident.
The point of departure for most conflict studies is the wide definition given in research by Harris and Perkins (7, 14, 15): "A traffic conflict occurs whenever one driver takes evasive action - brakes/weaves - to avoid a collision" (7, pa. 27).
The terms given in the literature on conflict analysis can be arranged as follows, in a scale from accidents to densities: accident - near-miss - serious conflict - conflict - encounter - proximity - presence. Many cases scored by Harris and Perkins as conflicts can thus be described better as encounters (a term introduced by Kraay), or even as proximity, such as precautionary braking at an intersection. Their investigations therefore show that there is not only a correlation between the number of road accidents and the number of traffic conflicts, but also between the number of conflicts

and the traffic density. The immediate question therefore is whether density would not suffice. The momentum of traffic density in the relation between conflicts and accidents is mentioned in hardly any research. No data on the degree of this correlation are given by Harris and Perkins. Heany (10), after analysing their data arrives at the rather low correlation of $r = .48$[1)] between all traffic conflicts and road accidents. This means in fact that only $(.48)^2 \times 100\% = 23\%$ of the variance in accidents can be explained with the help of conflicts. Baker (2), using this same definition of a conflict and collecting data on 392 intersections, does not reach a higher correlation: $r = .458$. At specific locations, such as non-signal controlled intersections and especially at T-junctions, he finds higher values: mostly in conflicts between intersecting traffic flows.
Cooper (4) also finds a correlation between traffic conflicts and road accidents of $r = .45$. In his research the correlation between conflicts and densities is substantial too.
Campbell & King (3) used the same definition as Harris and Perkins, but at first they found no correlation between conflicts and accidents. After eliminating head-to-tail collisions, the conflicts regarded as least serious, they did find a significant correlation ($r_{sp} = 80$), but for only six pairs of numbers. Paddock (12) also based his results on the same wide definition of a traffic conflict. This

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The following notations are used:
r = Pearson Product-Moment correlation
r_{sp} = Spearman rank correlation
R^2 = Squared Multiple Correlation.

research used not only various types of conflicts but also various density characteristics for accident prediction. Data were collected for 922 traffic points, with disappointing results. The correlation was less than R^2 = .30 and for some subgroups did not exceed R^2 = .36. Better results are sometimes found for certain types of traffic conflict. Pugh & Halpin (17), using the same classification as Harris and Perkins, find closer correlations for conflicts relating to cutting in on vehicles ahead or head-to-tail conflicts than for conflicts with traffic turning off left or intersecting. These results are not always identical. Campbell & King, in fact, found it was the head-to-tail conflicts that caused a lower correlation. In Baker's research the higher values were provided mainly by conflicts with intersecting traffic. Both Pugh & Halpin and Baker find that correlations vary with the type of intersection.

Spicer (18, 19, 20) finds high correlations by paying attention to specific locations within a given intersection. In a Swedish project (16) the conflicts are classified, inter alia, by types of road users.

Spicer attributes the meagre results to the wide definition of a traffic conflict. In his research he retains the same definition, but also divides observed conflicts into categories of severity, from precautionary braking or lane changing to serious collision (See Table 1). He, too, finds disappointing results if the research comprises all conflicts. Much better accident predictors appear to be serious conflicts (classification 3 to 5). He finds a correlation between accidents and serious conflicts of $r_{sp} = -93$. It should be noted that there are only six measurements, made at a single intersection, and that this is a rank correlation (the pm-correlation is $r = .80$).

Better results are also found in Sweden by using serious conflicts. They only studied accidents involving pedestrians. It was found, among other things, that at zebra crossings without signal-control there were more conflicts between pedestrians and vehicles driving into the street than between pedestrians and those leaving the street (See Figure 1). This corresponds to the comparable accident statistics, but cannot be inferred from the density statistics (one can reasonably expect as many vehicles to enter the street as leave it).

4. Validity and reliability

The fact that it is mainly the number of serious conflicts which is related to the number of accidents indicates that every conflict must not be regarded as a potential accident. The ratio between serious and slight conflicts is apparently not constant. This leads to the question whether such a constant ratio does exist between serious conflicts and accidents. In other words, even if a correlation is found between serious conflicts and accidents, this does not necessarily mean that traffic conflict analysis is warranted instead of accident analysis. This would require more than correlation. For an explanatory factor it may suffice if a significant correlation is demonstrated with the criterion. For instance, it is wise to wear safety belts if a correlation is demonstrated between wearing one and the (decrease in) the risk of being killed. In the case of the traffic conflict technique, however, we are not particularly interested in a potential correlation between serious conflicts and road accidents, but in the degree of correlation. If we regard reduction of the number of accidents as the criterion of road safety research and the relevant measures, then we seek in the traffic conflict technique for a substitute criterion variable instead of an explanatory variable. And for such a substitute criterion, an important question is how well it replaces the real criterion. Technically speaking, it is not a question of whether the correlation between serious conflicts and accidents differs from zero, which is verified in most cases, but how close the correlation is to unity. This is known as the validity question: how well is the criterion replaced. Amundsen (1), for instance, wrongly says, with reference to a correlation significantly differing from zero between accidents and conflicts, that this means that "situations which result in conflicts also result in accidents of the same type".

From Figure 2 , a figure taken from Baker (2), it can be seen, for instance, how many "incorrect positives" (c), how many "incorrect negatives" (a) and how many correct positives (b) would be obtained if conflicts were used instead of accidents in order to indicate the 30% (i.e. 20) locations with the most accidents. The correlation here is r = .653, meaning that nearly 60% of the variance in the number of accidents is not explained by the conflicts. Although the results are hopeful, this does show that an effort must be made to increase the validity of the conflict method. Using "serious conflicts" instead of "conflicts" seems to be a move in the right direction. Perkins and Harris's criticism of this method concerns the subjectivity of the scoring technique. Applying braking lights and changing lanes can readily be measured. Measuring the severity of a conflict demands an opinion from the observer. His opinion will be partly governed by his idiosyncracies; one observer will tend to deem a situation serious quicker than another. Hence, analysis of the same situation may lead to big differences in scoring. This is the problem of the reliability of the technique: a measurement is reliable if the error in measuring is slight. A big error in measuring the seriousness of the conflicts may make the validity of the conflicts disappointing as a substitute criterion of accidents.

Güttinger (5) had evaluers classify traffic situations as dangerous, not so dangerous or safe. His investigations examined how well a particular evaluer's scores could be reproduced by the same evaluer, and also how closely the scores of different evaluers corresponded. Kraay (11) uses for this the terms "internal" and "external reliability". The results of Güttinger's research suggest that training is needed, but that a reasonably high degree of reliability can then probably be obtained. Recent Swedish research announcements show that the reliability of scoring by observers after training is fairly high. But this reliability research was only on a very limited scale.

Finnish research (6), using a wide definition of conflict, produced internal reliability of r = .95 and external reliability of r = .88. Research in Rotterdam (22) gave a correlation of r = .91 between a first and a second series of traffic conflict measurements. If conflicts with pedestrians are eliminated, the correlation is only r = .75. This would suggest that a conflict is clearer to indicate if pedestrians are involved than if only other road users are taken. Little is known about the influence of external factors such as weather conditions, time of day, etc. on the reliability of measurements. It would be advisable to examine reliability for the greatest possible variation in situations.

Problems of scoring reliability have led to more objective scoring techniques being sought. In Sweden, the seriousness is determined by measuring the distance between the road users involved in the traffic conflict. This can readily be found with film or video systems. If the distance is less than one metre, this is classified as a serious conflict. Hayward (9) has the criticism that this distance alone is not a standard of severity: the seriousness of a conflict also depends on the speed of those involved and the angle between their paths. He therefore measures the time that would have elapsed from the conflict-avoiding action until the accident that would have occurred without it. He uses some very effective equipment for his investigations: a circulating-tape video-recorder linked to a film camera which can record on command the last twenty seconds of the video picture on film. He speaks of a "near-miss traffic event" if the time up to the accident is less than 0.5 second. A fairly arbitrary value, based on reaction-time data. How good the technique is for accident prediction is not known.

The announcement mentioned above show that Swedish research now uses a time criterion, too, instead of a distance criterion. A (notional) limit of 1.5 seconds has been chosen for a serious conflict.

Although training observers or applying more objective techniques can improve the reliability of measuring the severity of conflicts, the question still remains of how well accidents can ultimately be predicted by conflict measurements. Pugh & Halpin calculated, for their 240 intersections, also the correlation between accidents and accidents in various years. For 1970 and 1971 they find a correlation of r = .69; for 1970 and 1972 of r = .62, and for 1971 and 1972 of r = .67. On the assumption that accident prediction based on traffic conflicts is unlikely to be much better than accident prediction based on accidents, the correlation between traffic conflicts and road accidents cannot give values much higher than .65. Even if accident data are collected for a number of years the values will not be very high. Over a three-year period an upper limit of r = .85 is likely. These limitations on research of course apply equally to road accident research and traffic conflict analysis. But they greatly impede evaluation of conflict analysis in terms of accidents. An aspect disregarded in all the research is the possible importance of conflicts or encounters as a criterion of exposure to traffic (See inter alia (24)). It would seem worth while ascertaining whether in some cases

the number of encounters is not a better exposure criterion than the densities that are mostly used. It is conceivable, for instance in the case of controlled traffic flows, that the product of densities widely used at intersections is less suitable for measuring the degree of exposure than the number of actual encounters.
The question that still remains is whether accident prediction is better with many traffic conflicts than with few road accidents (Pahl). Hauer (8) concludes, on the basis of published results and a theoretical model, that traffic conflict analysis can be used when the number of accidents in the research area is too small (say three or four a year) or when the measurement period is short (as is often the case with before and after-studies). He does assume, however, that the conflicts have been recorded representatively for the whole year. Representativity regarding time of day and day of the week might be added. The problems Hauer mentions concerning small numbers of accidents have in fact led to the Delft research (11) being based on traffic conflicts.

To sum up, it can be said that various definitions of a conflict have been given, but that the best results have been achieved with a definition limited to serious conflicts and near-misses. In this, however, the reliability of observations causes problems. A review of what has been done in conflict analysis is given in Table 2.

The conflict analysis technique can be used in specific cases, especially where there are very few accidents. Much evaluating research will be needed, however, before the technique can be used on a large scale. But there are other research techniques, such as behaviour-observations and traffic-flow models, which can be used if accident analysis is impossible. Thus Van Minnen (21) uses a combination of behaviour-observations (right-of-way behaviour) and traffic conflict observations for studying road hazards at intersections. Such a combination of conflict measurements and traffic-flow models might be possible, say on motorways.

If conflict analysis is used in this way, it will amount to research aiming at an hypothesis or theory formulation.

For less specific problems, traffic accident analysis still seems to be the most appropriate method of improving road safety.

Description	Classification
Precautionary braking or lane changing collision very unlikely	Slight 1
Controlled braking or lane changing to avoid collision but with ample time for manoeuvre	2
Rapid deceleration or lane change to avoid collision resulting in "near miss" situation	Serious 3
Very near miss or minor collision occurred	4
Serious collision	5

TABLE 1. Classification of traffic conflicts by severity, by Spicer (18)

Object	All conflicts	Serious conflicts
Total number of conflicts	1,2,4,7,12	1
Type of intersection	2,12,17	
Location on intersection		18
Type of conflict	2,3,7,9,17,21	18
Slow traffic (mainly pedestrians)	6,17	16
Related to black spots	4,12	20
As regards traffic offences	3,6,17,21	

TABLE 2. Review of research into traffic conflicts. (The figures relate to the literature list)

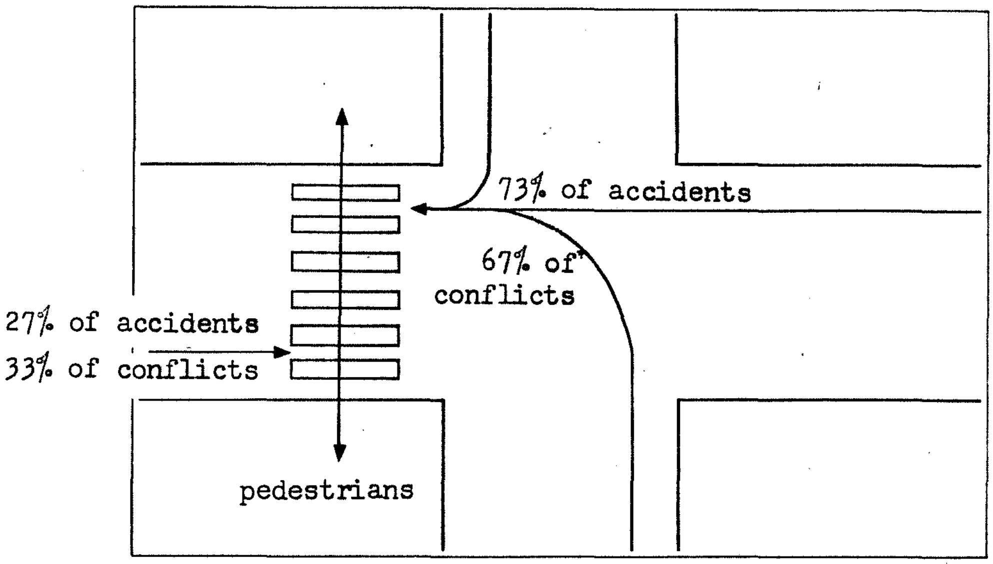

Figure 1

Relation between conflicts and accidents on zebras without signal-control in Sweden.

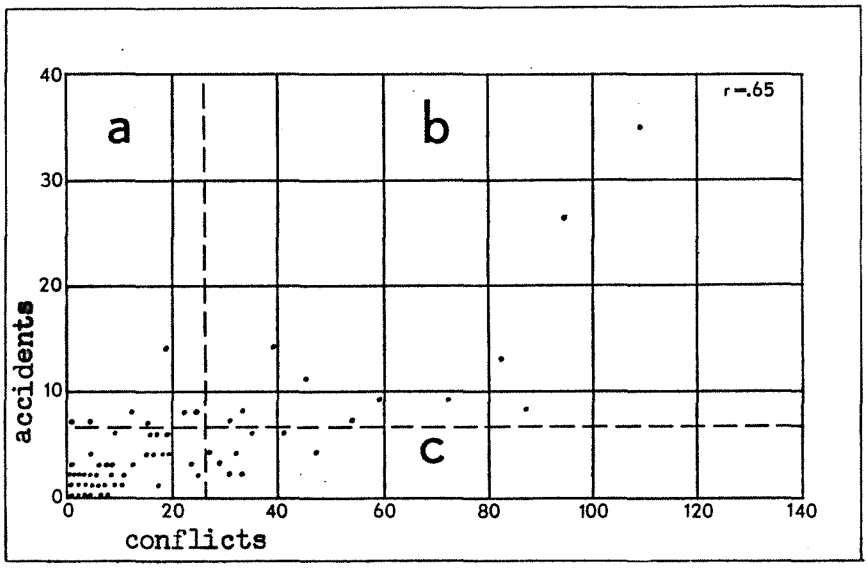

Figure 1

Number of incorrect positives (c) and incorrect negatives (a) in choice of 30% intersections with the highest number of conflicts instead of accidents (Baker (2)).

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II. A CONFLICT OBSERVATION TECHNIQUE FOR ROAD SAFETY IN RESIDENTIAL AREAS (PROGRESS REPORT ON A SWOV RESEARCH PROJECT)

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Summary

Researchers suspect that infra-structural measures have more influence on road safety than the more conventional legal measures, traffic regulations, initiatives in the field of instruction, training and campaigns.

The Institute for Road Safety Research SWOV has commissioned the Netherlands Institute for Preventive Medicine TNO to develop a conflict observation technique in order to determine the effects of various lay_outs of residential environments on traffic safety. The proposed pilot study in the town of Delft is a very useful instrument for gaining experience in handling techniques other than road accident analyses.

The examination concerns the Buitenhof district of Delft, consisting of two areas.

The Gillis area was designed on the principle that the entire residential area, including the streets, can be used by children at play and that it should provide the possibility of various other social activities.

On the other hand, the Fledderus area was planned on conventional lines, which implies that neat green beds (not to walk on), footpaths, streets and curbs have been laid out.

Several problems pertaining to the reliability of the conflict observation technique are dealt with in this article.

1. Introduction

Efforts have been made for many years to reduce the number of traffic conflicts and the consequent road accidents between pedestrians and wheeled traffic. They have resulted in measures of the following kinds:

1. legal regulations (such as the introduction of zebra crossings in November 1961); a right of way for pedestrians who, crossing straight ahead, have precedence over wheeled traffic turning off;
2. initiatives in instruction, training and campaigns;
3. segregation of traffic categories in terms of time (such as control with traffic-signals);
4. physical segregation of traffic categories.

The favourable effect of the first three measures is greatly overrated. The fourth provides the best guarantee of reducing conflicts between pedestrians and other road users.

The main advantage of physically segregating traffic categories is in creating a road users' environment whereby conflicts between pedestrians and other traffic are practically eliminated. It is a clear, comprehensible system determined by its design. In other words, physical (urban) planning determines and encourages certain traffic-behaviour patterns. But such measures have a number of drawbacks, including high cost; lack of space or the structural impossibility of carrying out specific plans; the more difficult accessibility of localities because there are different networks.

It is moreover questionable whether physical segregation of traffic categories is really desirable in the direct residential environment

- in view of the many social functions this environment performs - because strict segregation would impose many limitations on the numerous kinds of activity and contacts for which these environments are normally used. Hence a need has arisen for a new approach to road safety in residential areas, based on traffic integration. The benefits of physical segregation as mentioned above, can also be built into such an integrated system.

Such a blending of uses was taken as the basis for design and renovation of various residential areas in the town of Delft. The urban planners in Delft, in designing the residential environment, were guided by the wish to create an area for overall and varied use by its users without causing conflicts with other users. The same applies to the traffic situation.

The SCAFT group in Sweden, similarly to the planners in Delft, recognise the principle that the environment should be constructed so that a pedestrian's "error" does not promptly lead to a conflict or accident. For some years, research has been going on in Sweden based on the above approach. A number of ideas have been formulated which can be found in The SCAFT Guidelines (SCAFT, 1968).
The SCAFT studies which include a comparison of old areas with areas built according to their new approach, show that the latter are three times as safe for children as the former (10 child accidents a year per 10,000 children, as compared with 30). They therefore claim that the new views on residential environment planning have produced more safe residential areas (See also SWOV, 1975).

As far as research into the effects of infrastructural urban road safety measures in other countries is available, the results (which are favourable) vary. Greater clarity is required on this subject. It is known that the potential road safety effect of infrastructural measures in old residential areas in greater than in new ones. There is an idea that sound solutions in new areas can be translated into measures for old ones (in particular, such solutions can be linked up with repaving projects).
But since road accidents do not occur in adequate annual numbers in each area to provide a basis for research, the question emerges of whether alternative techniques can be developed with which opinions can nevertheless be expressed about road safety in residential areas in general.

Based on the above points, a need has grown to develop an observation technique with which a clear picture of road safety in residential areas can be obtained in a short space of time. The lack as yet of a record of all potential solutions in this and other countries is not in fact a drawback to development of an observation technique because this work can run parallel.

2. Object of research

The object of the SWOV research[1] is to develop a conflict observation technique which, as a possible alternative to road accident analysis,

1) This research has been contracted out to the **Netherlands Institute of Preventive Medicine TNO, Leiden.**

can establish the effects of urban planning on road safety. This means that this instrument must be valid for actual accidents. It must also be reliable. The literature shows that such observation techniques all use about the same definition of a "serious traffic conflict" as an alternative criterion to accidents. The following definition is taken from Spicer (1972): "A serious conflict can be defined to occur when, to avoid a collision, a vehicle is caused to decelerate rapidly, swerve violently, or stop, by another vehicle in its path in close proximity to it, leaving no time for normal controlled avoidance behaviour". Though these are all rather vague descriptions, the relevant literature claims that the criteria adopted possess a certain degree of validity for actual accidents.
However, since their validity in the various research projects is not as clear in all cases, it seems advisable firstly to make a specific technique sufficiently reliable - this being the first requirement for a measuring instrument - in order that this will improve its validity (see also S. Oppe's article).
The relative studies in other countries hardly give any information on the reliability of the techniques. The SWOV research therefore has the initial object of developing a reliable technique while, in view of the above remarks on reliability and validity, it should be adapted to the situation in which it is used. It will also be planned on such a wide basis that conflictory encounters other than serious ones can also be ascertained. This will make it possible for relationships between encounters, conflicts and serious conflicts to be analysed.

3. Definitions and procedures

The Dutch research uses as the definition of a (serious) conflict: a sudden, motor-reaction by one (or both) of the road users involved in a traffic situation with respect to the other. As this is ascertained for various distances (10 - 0 metres) between road users, not only serious conflicts but also slight conflicts and encounters can be determined both in absolute figures and relatively to one another.

The definition still comprises the same vagueness as the research in other countries, viz. the term "sudden". As the distinction between "sudden" and "not sudden" (besides the criterion of distance) determines whether a conflict is "serious" or "not serious", an effort has been made to establish this term empirically. Five types of conflict between pedestrians and wheeled traffic are defined; of these five types, each was filmed at least five times, both in actual traffic conditions and in a number of staged conflicts. In total, 27 traffic conflict situations on video tape were used.

Ten observers ranked these 27 situations on a seven-point scale as regards the suddenness of the parties' reactions. After discussions between the project leader and the team of observers a three-point scale was drawn up together with an exact definition of these categories.

Next, a second group of ten observers were clearly instructed on the scoring method. They evaluated the 27 situations three times

each in a random sequence on the three-point scale.
Then the last scores of the first group of observers were compared with those of the second group. It was found that the second group could work well with the definitions of "sudden" arrived at by the first group.
Besides sudden reactions, the observers had to indicate what road users were involved in encounters and the type of traffic situation. The second group scored the video recordings three times in total, each time in a different order to avoid sequential effects. Based on the scores so obtained, the internal reliability (the degree to which the same observer always gave the same situation the same rating) and external reliability (the degree to which different observers gave the same rating to the same situation) were determined.

4. Initial results

As research into a usable conflict observation technique is not yet completed, the initial results can of course only be discussed in general terms. These are as follows:
As regards external reliability the correlations of the first and second groups of observers are fairly good. Internal reliability gives correlations higher than for external reliability.
It is felt that these scores can be improved by better instruction and by training the observers. As three of the ten observers were responsible for reducing the reliabilities, good observer selection will make the observation technique more reliable. As far as figures

shows that American research indicates that about three quarters of all accidents involving children up to 15 years occur in the immediate area of residence within a radius of 500 metres from their own homes. Children are, moreover, the most intensive users of this immediate area.

The children will be followed in their own residential areas by female observers for twenty-minute periods. A record will be made both of conflicts and encounters that may occur with wheeled traffic and also of the complete lack of encounters for instance because the child carries on playing on the grass without crossing the street. Video recordings will also be made as a continuing check on the reliability of the observers' records. In addition, the observers will be selected and trained beforehand, and the shortcomings in the first stage mentioned above will thus be eliminated.

The research is covering both conventional and experimental areas because the described conflict observation technique must be applicable in any urban area with differences in planning and layout.

for reliability tests in other countries are known (e.g. PLANFOR, Sweden), the Dutch figures can be said to have a favourable pattern.

5. Further research

In coming months, this conflict observation technique will be tested under actual conditions. Two residential areas in the town of Delft, very different in urban layout, have been chosen for this purpose.

One was designed on traditional lines, including the conventional segregation of traffic categories (street and pavement) and attractive greenery and beds (not for walking on) and paths. The other was planned on the assumption that the entire residential area can be used and should also provide scope for various activities. In other words, this has grass for walking on, while the conventional pavement - curb - gutter - carriageway has been changed to footpath - mole drain - carriageway, so that children at play and cyclists can use the entire area. Motor traffic faces a number of physical obstacles (blisters on the road surfaces and trees) and psychological obstacles (for instance pavement tiles in the roadway). It might be added that this research deals especially with children's behaviour in traffic. In these areas, the Netherlands Institute of Preventive Medicine TNO had already investigated this same subject (Güttinger et al., 1974). The literature (SWOV, 1974) shows that pedestrian hazards can be localised mainly in built-up areas, chiefly involving the 0 to 9 year and 60 and older age groups. The same study

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ANNEX I: INTEGRATION OF MIXED TRAFFIC IN THE URBAN ENVIRONMENT

The research into "The utility of residential areas" (Güttinger, 1974) examined how children use a new experimental residential area in Delft as compared with one designed on more conventional lines[1]. One of the objects of the project was to find out whether a new design can influence child behaviour so as to ensure more varied use of the area.
Although this evaluating research largely answers this question (in the affirmative), we must realise that besides children as the main users of a residential area, there is another major group, viz. the road users. Conflicts may occur, however, between the various categories of traffic.

Town planners in Delft and elsewhere in designing residential areas have been guided by the principle that such conflicts should be avoided. The planners' objective in Delft was: to create an area for overall and varied use by children without causing conflicts with its other users.

Efforts have been made for many years to reduce the number of conflicts and the consequent accidents between pedestrians and motorists. They have resulted in:

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1) Conventional in this sense means driving on the carriageway and parking along it, walking on the pavement, playing in playgrounds.

1. legal regulations (such as the introduction of zebra crossings in November 1961 ; a right of way for pedestrians over wheeled traffic turning off);
2. initiatives in instruction, training and campaigns;
3. segregation of traffic categories in terms of time (such as traffic control);
4. physical segregation of traffic categories.

The favourable effect of the first three measures is very doubtful. But the fourth provides the best guarantee of reducing conflicts between pedestrians and motorists.

The main advantage of physically segregating traffic categories is in creating a road users' environment whereby conflicts between pedestrians and motorists are practically eliminated. No law enforcement is needed; it is a clear, comprehensible system determined by its design. In other words, physical (urban) planning determines and encourages certain traffic-behaviour patterns.
But such measures have a number of drawbacks:

(a) high cost;

(b) lack of space or the structural impossibility of carrying out specific plans;

(c) the accessibility of the various networks;

(d) the question whether physical segregation of traffic is really desirable in the direct residential environment.

Since strict segregation would impose too many limitations on the numerous kinds of activities and contacts for which these environments are normally used, the need has arisen for a new approach to road safety in residential areas, based on integration of mixed traffic. The benefits of physical segregation as mentioned above can also be built into such an integrated system.

Such a blending of uses was taken as the basis for design and renovation of various residential areas in the town of Delft. In addition there are other almost identical areas with conventional layouts.

The SCAFT group in Sweden, similarly to the planners in Delft, recognise the principle that pedestrian "errors" are of secondary importance in studying pedestrian safety. The main reason why pedestrians are not safe is the traffic environment, which creates situations with a given risk of "errors". The environment should be such that a pedestrian's "error" does not promptly lead to a conflict or accident. For some years, research has been going on in Sweden based on the above approach. A number of ideas have been formulated which can be found in The SCAFT Guidelines (SCAFT, 1968).

These studies, which include a comparison of old areas with areas built according to their new approach, show that the latter are three times as safe for children as the former (10 child accidents a year per 10,000 children, compared with 30). They therefore claim that

the new views on residential environment planning have produced more safe residential areas.
The most susceptible age groups would thus be better protected.

Proceeding on these lines, it can be claimed that residential areas built according to this new approach will present a different traffic-behaviour pattern than the conventional ones.
It is also felt that the differences in traffic behaviour in the experimental residential areas will have a favourable effect on road safety.

The example of the town of Delft concerns the Buitenhof district, consisting of two areas:

Fledderus: designed on conventional lines, including segregation of traffic and attractive greenery and beds (to look at and not for walking on) and paths. The control situation.

Gillis: planned on the assumption that the entire area can be used and should also provide scope for various activities. The experimental situation.

For practical purposes, a further definition is needed.

The residential environment: consists of a number of units existing in both experimental and control situations and differing in detail only.

Use: in the present context this means: driving behaviour, walking and playing behaviour.

As stated above, Gillis was planned on the assumption that the entire area can be used and that it should allow various activities. Consequently, changes are being made in the prevailing standard pattern of a residential environment. This change, or even the disappearance of the existing standard pattern in Gillis explains many hypotheses.

If, to take a concrete example, the conventional pavement - curb - gutter - carriageway is changed to footpath (narrower than a pavement) - mole drain - carriageway, then existing rights and obligations disappear at once: the pedestrian will use the carriageway; traffic will use the path. This may be dangerous, for instance if a car drives along the carriageway at normal speed. Thus action has been taken to counter this with physical obstacles (blisters and trees on the road) and psychological obstacles (for instance pavement tiles in the roadway).

Another example of changing the standard structure is: the entire planted area in Gillis is completely accessible, even off the paths. In Fledderus the planted area (except for the grass) is not intended for walking on, although its quality is the same. Yet a child commits an offence in Fledderus if it walks on the planted area. In Gillis, however, it does not offend the norms.

ANNEX II: THE URBAN ENVIRONMENT AS A "RESIDENTIAL PRECINCT"

(The following observations are taken from "Woonerven", Netherlands Local Authorities Association (VNG), No. 21, The Hague, 1975)

The "alternative" town planning and traffic control measures of recent years for residential areas (accessible to motorised traffic) can be subdivided into full-scale residential precinct layouts and incidental facilities such as simple thresholds, simple elevated entries or exits and localised narrowing of carriageways.

The subject here are the residential areas open to the public that have been (re)integrated as residential precincts. These involve a system of physical and visual facilities including an anti-speeding effect.

Such complete facilities prove impossible at present in many residential areas and streets owing to lack of space and/or money. In view of these limitations, incidental facilities as mentioned above are being designed and carried out, particularly in old, densely populated urban neighbourhoods. There are drawbacks to this type of facility.

The function of a residential precinct differs especially from that of a traditional street in that the same paved area can be and is also used (partly) for various activities such as driving, playing, cycling, walking and parking. Primarily, therefore, it is a place to live in, a meeting point, a playground and pedestrian walk (its precinct function). And, of course, this area accessible to the public opens up the precinct - for wheeled traffic too. But it does not provide for through traffic.

A residential precinct can be defined in greater detail as follows:

(a) it is an area open to public traffic (hence the road traffic regulations apply to it;

(b) it is mostly paved (though it may contain small planted areas open to the public);

(c) it is located in mainly residential neighbourhoods;

(d) it is sometimes a single street or a single square or court, or sometimes a connected group of streets or courts;

(e) walking and playing is allowed everywhere, or at least it is not prohibited;

(f) it is also accessible to motorists, cyclists and moped users;

(g) but it is not intended to be used by motorised through traffic;

(h) it comprises mixed traffic;

(i) there are no conventional, straight curbed pavements;

(j) physical and visual obstacles (narrowed routes, trees, elevations, posts, varied paving) are provided to protect pedestrians and children at play by slowing down motorised road users, especially motorists, when entering and traversing the area.

There is an indissoluble link between the functions of neighbourhood and street, the existence of obstacles to fast driving, special traffic behaviour and special traffic codes. The assumption is that the layout of the area should make wheeled traffic move at the proper speed. The introduction of special codes and the placing of signs indicating this code are the legal outcome of the work of urban planners and traffic experts.

In these areas the residential function predominates (hence the term "residential precinct"). Shops, supermarkets, social and cultural facilities, offices and business firms do not belong in or near the precinct if they would attract or cause excessive motorised traffic. They might also bring too many parked vehicles to it. Too many moving and parked cars - too many mopeds riding round - would spoil the idea of the precincts (which is to provide scope to play and sojourn there pleasantly).

As the above has shown, a primary school, an ordinary shop or a pub in the precinct is not, however, likely to be a drawback.

In order that an area that is or is going to be equipped as a residential precinct can retain its residential character, it will be useful if the local planning authority lays down regulations to this end.

There may, of course, also be excessive motorised traffic and parked vehicles in neighbourhoods where the residential function obviously predominates. The number of homes or residents per hectare plays a part in this because of the traffic they attract or generate. The building density, however, is not the decisive criterion; in the last analysis it is a question of traffic density and excessive parking.

From the viewpoint of clarity to the road user, it seems preferable for a residential precinct to comprise more than a single street or street section.

The optimum size and form of such precincts in general cannot, of course, be indicated, nor how many entrances and exits belong to precincts of a given size. An important point is the (maximum) distance motorists and moped users are prepared to go on driving at a slow enough speed day after day.

An objection to setting up big residential precincts is liable to be that their traffic density will be too great.

Other points meriting attention in deciding the size and form of a residential precinct and the number of entrances and exits include:

(a) the walking distance to tram and bus stops (500 metres would seem to be about the maximum);

(b) the extent to which an area is looked upon by road users as a self-contained unit.

It is also advisable, when planning to (re)arrange a street or complex of streets, to consider the effects a residential precinct will have upon the surrounding area. A broadly based plan has the additional advantage of providing scope for consultation with the residents.

<u>The foregoing requires a new legal formulation.</u>

In the Netherlands, a number of changes and additions to the Road Traffic and Traffic Signs Regulations will shortly become operative.