The Development of the Traffic Conflicts Technique

An approach to the study of road accidents

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"Traffic, like God, football and politics, belongs to that select group of subjects which everyone, when the spirit seizes him, instinctively feels that he can speak with overriding authority and conviction."

Prof. John Cohen in Causes and Prevention of Road Accidents by Cohen and Preston, 1968.

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The work contained in this thesis covers the period 1977-1982, and was funded by the Transport and Road Research Laboratory. I was the senior research worker on both contracts during which the reliability and validity studies were conducted.

The original idea for a training package for conflict studies came from Mr. S. J. Older of the TRRL, although the responsibility for the design and execution of the studies leading up to its production, and for the package itself, was mine. The original films were taken by Mr. B. R. Spicer, also of TRRL, although I was responsible for editing the incidents that comprise the film accompanying the training manual.

Dr. G. Grayson of TRRL read through the first draft of this thesis and I am most grateful for his constructive criticisms.

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PUBLICATIONS ARISING

LIGHTBURN, A. and HOWARTH, C. I. (1979) A study of observer variability and reliability in the detection and grading of traffic conflicts. Proceedings : Second International Workshop, Paris. Transport and Road Research Laboratory Supplementary Report SR557, Crowthorne.

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ABSTRACT

A practical and reliable alternative or supplement to injury accident data is necessary to diagnose dangerous sites and evaluate remedial measures because available accident data is scarce, is lacking in detail about the events preceding the accident and it takes a long time to accumulate statistically reliable data.

The most favoured alternative is the Traffic Conflicts Technique which satisfies most of the requirements of a supplementary measure, but has so far only been successfully validated for rural dual carriageway intersections (Spicer, 1973). To establish the technique it is necessary

a) to ensure that the subjective judgements on which it is based are reliable,

b) to develop the best methods of recording conflicts, and of training and selecting observers, and then

c) to test the validity of the best available technique.

The main part of this thesis reports three studies aimed at each one of these issues.

In the first study intra observer reliability tested

on filmed material varied between rs = 0.30 and 0.91 (0.65 overall for N = 42), but poor observers could be identified. By selecting the best observers an overall reliability figure of up to 0.88 could be obtained. Reliable observers remained reliable or even improved slightly on the second testing. These reliable observers also showed good agreement with expert judges who had viewed the film many times, and by selection a correlation with the criterion values of up to 0.83 could be obtained.

In the second study a new recording method was developed, incorporating factors that experienced observers used to differentiate the grades of severity currently in use. This helped observers by defining the criteria for detection and grading of a conflict more objectively. This increased the overall intra observer reliability from 0.73 to 0.80, and agreement with the criterion values from 0.66 to 0.76. Transfer from laboratory to field led to a drop in the numbers of conflicts reported. From these studies and a survey of the requirements of local authority accident investigation units, a manual and training package was developed giving guidance on training and selecting observers for the purpose of obtaining reliable conflict data, such as that required for validating the technique.

In the third study this package was validated in a study of a sample of eight urban T-junctions. Again the best observers were selected and found to have an overall reliability of 0.88. It was found that, when rear end conflicts were excluded (on the grounds that they led to so few reported injury accidents while occurring in large numbers), there was a high correlation between accidents per vehicle and conflicts per vehicle (rs = 0.79, $p<0.025$), accounting for 62% of the variance. This compares very favourably with the maximum possible percentage (77%) which could be expected given the reliability (rs = 0.88) of the observers.

Although a validity correlation of 0.79 is very satisfactory and the method of obtaining the data is reasonably economical, an attempt was made to find a still more economical alternative to accident statistics. The most obvious of these are subjective judgements or a combination of these with traffic flow. Traffic flow data for different manoeuvres at each of the eight T-junction sites were obtained and various groups of people were asked to judge the subjective risk of these sites from scale maps and photographs or directly on-site. Judgements from maps and photographs tended to be negatively correlated with accidents. The best subjective estimate (driving instructors judging on-site) correlated 0.44. An attempt to improve on these by combining the traffic flows and judged risk of the different manoeuvres at each site failed to produce a higher correlation. None of these correlations were significant, but the failure of any one of several different correlations to be higher than 0.46 suggests very strongly that these simpler methods are very unlikely to have the validity of the full conflicts technique.

However, the present study has validated the Traffic Conflicts Technique only for urban T-junctions (the commonest of all accident sites). It could, therefore, only be used for evaluating the effects of small changes in the layout of such junctions. It could be used to evaluate more radical changes eg. T-junction converted to a mini roundabout, provided the conflict to accident ratios of the different layouts were known. In this study the conflict to accident ratio was 125:1 for vehicles turning right out of the minor road. For the T-junctions as a whole it was 275:1 while Older and Spicer (1976) found a ratio of 2000:1 for rural dual carriageway intersections. By obtaining more information of this kind, the utility of the Traffic Conflicts Technique could be greatly extended.

CHAPTER 1

INTRODUCTION

1. The Problem.

There is no lack of statistical information about the numbers of injury accidents* on the roads and the deaths and injuries associated with them. Much of the work aimed at discovering factors that contribute to accidents begin by quoting the official figures. In the past, the approach to the problem was mainly epidemiological. That is, the approach was simply to analyse the official accident statistics in the hope that explanations could be found within them, and counter-measures developed from them. Those workers in this field with a medically-oriented approach have particularly favoured this line due to its efficiency in identifying the factors causally associated with a disease which have led to the successful development of methods of prevention.

The statistical data on road accidents show that in 1979, for the fourth consecutive year since the falls during and just after the fuel crisis of 1973/4, road deaths nationally increased. There was, however, a welcome drop in 1980 and again in 1981 and 1982 to a level which was the lowest since 1958. This is especially surprising because the numbers of licensed road motor vehicles has been steadily rising over the last 10 years.

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*unless otherwise stated, all references to accidents implies "injury accidents"

However, casualties in the second half of 1982 were higher than in the corresponding half of the previous year, and suggests that the downward trend that began in 1979 may well have come to an end. In the period July to November 1982, fatal and serious casualties were 5% higher than the corresponding period in the previous year.

The total cost of road accidents to the community is assessed each year by the Department of Transport and was estimated to be about £2,180m. in 1982. The average costs of accidents and casualties on which the total cost is based are shown below (Table 1).

ACCIDENT COSTS	£
Fatal accident	149,200
Serious injury accident	7,900
Slight injury accident	1,080
All injury accidents	6,060
Damage only accidents	460
CASUALTY COSTS	
Fatal casualty	132,700
Seriously injured casualty	5,610
Slightly injured casualty	130
Average, all casualties	3,840

Source: Road Accidents in Great Britain, 1982.

Table 1 : Average costs per accident and casualty in Great Britain in 1982.

The accident costs are higher than the corresponding costs attributed to casualties because there is, on average, more than one casualty per accident, and because some accident costs, such as damage to vehicles, cannot be attributed to particular casualties. The "seriously injured" category is a wide one, ranging from, for example, an injury requiring an overnight stay in hospital to the most severe disability. The average cost of a serious casualty (£5,610), therefore hides a very wide cost range, from a larger number of relatively minor injuries to a much smaller number of very severe injuries with repercussions lasting many years.

2. Limitations of accident statistics

In Great Britain only those accidents that result in personal injury to occupants of vehicles or to pedestrians are required to be reported. No accident where only damage to the vehicles is incurred need be reported so long as those involved exchange names, addresses and insurance companies. Consequently the number of accidents appearing on official statistics is an underestimation of the number of incidents, including damage only, that occur. Dawson (1967) reported that insurance companies know of about 6 damage only accidents to every injury accident. Spicer, Wheeler and Older (1980) filmed a site for 21 hours per day over a nine month period and also recorded a ratio of non-injury to injury accidents of about 6:1. Faulkner (1968) carried out a debris stduy at roundabouts and estimated that the accident rate was about 10 times the reported injury accident rate.

Absent from many reports of an accident is an accurate, objective description of events which preceded and led up to the collision. Attempts to discover what happened are often not profitable because the participants are frequently concerned with proving their own innocence or are inhibited in their evidence due to the possibility of legal action. Some are so confused and shocked by the whole affair that they are themselves not certain of exactly what happened.

The paucity of accidents in an absolute sense at any given location means that a number of years accident statistics must be available to provide an adequate number for analysis. It has been established that, except for highway sites with exceptionally high accident rates, a period roughly of the order of three years is required to accumulate statistically reliable data samples (Michaels, 1966). During this time the site parameters pertaining to the accident may have altered and this in itself may have been enough to influence the type and/or severity of accidents occurring. Accidents are multi-factor events, each factor being dependent upon a number of others. Consequently a large amount of data must be available before analysis can reveal the relative importance of any one or a combination of those factors.

The direct observation of accidents is, for most workers in the field of road accidents, beyond reasonable expectation, and can yield only very small amounts of data. However, this method has been successfully employed by Kanaya at al (1973) and, according to Kanaya, by Cornell Aeronautical Laboratory (1969). The paucity of accidents generally has led to investigation of alternative indirect methods of evaluation by the use of "accident surrogates". These can be defined as

> "events which are not accidents, but which are related to, and predictors of, accidents, and which are common enough to be readily observed." (Grayson and Howarth,1981).

3. Alternative measures of accident potential

Candidates for which data is quick and easy to collect are:

3.1 traffic flow

3.2 subjective assessments of risk

A third alternative, and the most favoured by accident investigators, is

3.3 traffic conflicts

although these require considerably more resources, in both financial and human terms. The potential value of each is assessed below, from available literature on the subject.

3.1 Traffic flows

Traffic flow data are cheap, easy and quick to collect, and the reliability of the data is likely to be high because of the relative simplicity of the data collection exercise.

Studies of traffic flow and accidents specifically at junctions have not been extensive. The derivation of the underlying relationship between the two has proved a complex and difficult problem. Satterthwaite (1981) gives an excellent review of research into the relationship. He concludes that

> "Results (at junctions) have not been very consistent and it would seem that more research is desirable."

The problem of deducing a relationship between accidents and traffic flow at junctions is complicated because more than one traffic volume measure is required and it is not always clear which is the most appropriate combination. The main measures of flow to be considered are: total inflow, and the sum and product (or square root of the product) of intersecting flows.

Mathewson and Brenner (1957) and Breunig and Bone (1959) suggested that the total of all flows entering the junction may predict accidents because this gives a measure of the number of opportunities of being involved in an accident. However, for uncontrolled junctions there does not seem to be a very strong case for its use. McDonald (1953) and Thorson (1967) both found that accident risks did not vary much between heavily trafficked intersections, even though the flows at them varied widely. Neither total inflow, nor summing the intersecting flows takes account of dissimilar flows on the major and minor roads. More recent studies, such as those reported below, use the product of flows in order to take account of differential flows on the major and minor roads.

Spicer (1971) found no significant relationship between the product of flows (major road flows x appropriate crossing flow) and the number of accidents by time of day and carriageway at a rural dual carriageway intersection. However, in a later study at a second rural dual carriageway intersection, Spicer (1972) found the product of flows calculated by time of day and injury accidents for the same time periods correlated significantly (rs = 0.95). To reconcile the two apparently paradoxical results, Spicer said that the accident rate may increase initially with flow up to a certain level, and then at high flows (such as those found in the first study), the accident rate becomes independent of flow, because increased congestion may reduce vehicle speeds and therefore the severity of any accident that may occur (and hence the likelihood of its being reported). A point to note also is that these two studies correlated flows and accidents within single sites by time periods only. In a later study using data from six different sites all of the same layout (rural dual carriageway intersections), Spicer (1973) found no statistically significant relationship (rs = 0.15).

At heavily trafficked uncontrolled rural three-way junctions, Bennett (1966) and Colgate and Tanner (1967) found that injury accidents varied approximately with the square root of the product of the two flows concerned.

From these studies it would appear that the product (or square root of the product) is likely to be the most promising predictor of accident risk. An investigation into the usefulness of this alternative is made in Section D (Chapter 10).

3.2 Subjective assessments of risk

The second suggested alternative is subjective assessments of risk. Apart from the study by Watts and Quimby (1980) reported below, there have been no other investigations into the potential of this method for assessing accident risk.

Watts and Quimby (1980) found a weak but significant correlation (rs = 0.37) between objective risk (injury accidents) and subjective assessments of risk by drivers over a route which contained a wide variety of hazardous locations (N = 45) to be evaluated eg. sharp bends, brows, junctions. At some locations eg. a rural crossroads controlled by traffic lights, there were wide discrepancies between the subjective and objective risk levels. Using this method at a number of sites of the same layout it may be possible to identify those sites where drivers may be incorrectly assessing the potential risk. If this is so then it may be possible for accident investigators to pinpoint those features at the under rated sites that may be responsible for the false sense of security given. This method therefore needs to be tested at a number of sites of the same layout and a comparison with objective risk made. A study to test subjective assessments of risk as a viable alternative is reported in Section D (Chapter 10).

3.3 Traffic conflicts

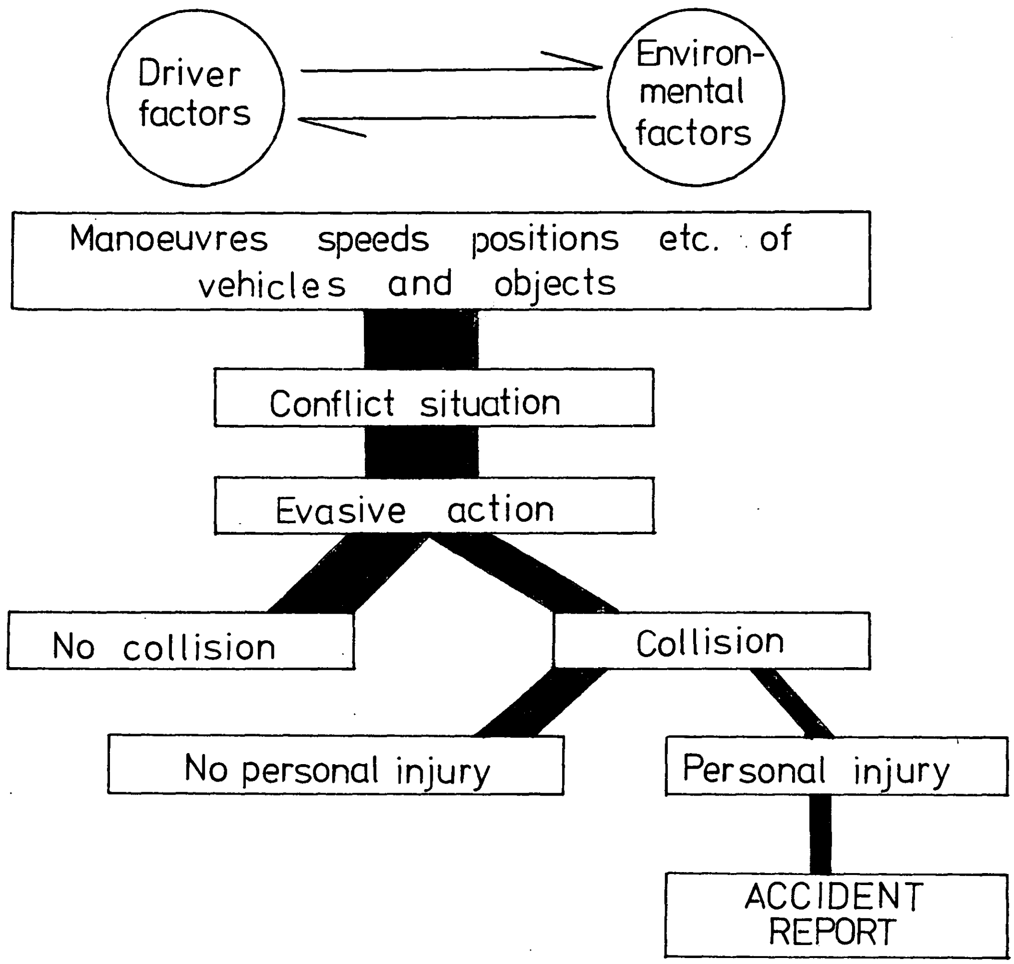
The most favoured alternative is the Traffic Conflicts Technique which satisfies most of the requirements of a supplementary measure, but the data collection period is longer and more expensive than either of the other two alternatives. However, the reliability of the subjective judgements on which it is based must be established and the best methods of recording conflicts and of training and selecting observers must be developed before testing the validity of the best available technique. The following chapter (Chapter 2) examines the concept of a conflict and the development of the technique so far. The criterion for detection of a conflict, namely the illumination of brake lights, is critically discussed. An outline of the thesis, which is mainly concerned with investigating the reliability and validity of the Traffic Conflicts Technique and comparing it with traffic flows and subjective assessments of risk as alternative measures of accident potential, concludes Chapter 2.

CHAPTER 2

CONFLICTS AS AN ALTERNATIVE MEASURE OF ACCIDENT POTENTIAL

1. The concept of a conflict

The idea of expanding on what an accident is so as to make more incidents available for analysis is appealing. The driving task has been seen as a continuum of events ranging from those with no danger of collision, through events where the possibility of an accident increases but was successfully avoided, to those where an actual injury accident occurs because evasive action, where taken, was taken too late. Russam and Sabey (1972) described the sequence of events leading up to an injury accident, and illustrated it in the form of a flow diagram (Figure 1).



Source : Russam and Sabey, 1972

Figure 1 : Sequence of events leading to an injury accident

It is in the area where the possibility of an accident increases but is successfully avoided that information about the deficiencies of a system can be obtained. These events, where there is a possibility of an accident but where a collision does not occur because one or other of the involved parties takes avoiding action, are called "near accidents" (Forbes, 1957) or conflicts.

2. The historical development of the technique.

The earliest studies that can be found in the literature referring to conflicts were by Greenshields et al (1947) and Homberger (1951). Their aim was to assess what proportion of drivers at intersections gave priority to vehicles approaching from the right by measuring vehicle positioning and speed from time lapse film. However, much of the subsequent work in the '50s and early '60s was carried out with a sample of drivers, and studies were conducted by observers from within the vehicle by watching for errors. These errors were variously referred to as critical incidents, near accidents, risks, and vulnerabilities and the definitions varied accordingly. For example, McFarland and Mosely (1954) defined a critical incident as

> "any observable type of driver activity which is sufficiently complete in itself to permit description and inference. To be critical, situations must have developed in such a way that they leave little doubt that an accident

is impending."

They used the near accident as a measure of driver error by in-vehicle observation of the incorrect and dangerous driving behaviour of short haul bus drivers. While they concluded that the observation of driving errors could be a useful indication of accident liability, the results were not conclusive. The main criticism against the study was that both the definition and the errors selected for recording were highly subjective. A second study involved long distance lorry and bus drivers, where the observers recorded near accidents rather than the more frequent driver errors. One hundred and fourteen near accidents were recorded, although no attempt was made to show that, for any particular drivers, there was any association with recorded accidents.

Forbes (1957) gathered reports of near accidents defined as

"accidents that almost happened".

The drivers in this study were largely people interested in or working with traffic. The sample of near accidents and drivers was therefore not a representative cross-section, but the study was only reported as a pilot. The multi-factorial aspect of near accidents was demonstrated in that the results indicated the importance of numerous combinations of human and physical factors, two to seven or more factors being of importance in most of the near accidents reported.

In a series of papers by Quenault (1966, 1967a, 1967b, 1968), Quenault, Golby and Prior (1968), Quenault and Harvey (1971) and Quenault and Parker (1973), near accidents and "risks" were used, with other factors, to measure driver behaviour. In each report, classification of subjects into four groups took place as a result of a test drive. A near accident was defined in these reports as an action by a subject which forced him or another driver to take avoiding action or to carry out an emergency stop. A risk was any action on the part of the subject which could have led to a near accident or accident. The classification of these events was the responsibility of an observer in the test car thus again making use of subjective measures. These errors were grouped into perceptual, judgemental or skill failures and were supposed to correlate well with the overall likelihood of a driver having an accident. Quenault qualifies his definition of a risk situation by adding that an accident or near accident would have occurred if certain elements which were outside the control of the subject had been different (Quenault and Harvey, 1971).

Quenault's "risk" can be compared with what Goeller

(1969) refers to as a "vulnerability". This is a wider measure than McFarland and Mosely's (1954) "critical incident" and is possibly more closely related to the driver errors which they studied with inner-city bus drivers. Goeller (1969), in his model of the traffic safety system, also uses the "confrontation" which is an imminent but not inevitable collision. It is this that is comparable with the near accident and critical incident.

It was not until the late '60s that behavioural measures were made of the population at large. These were the forerunners of the modern conflict study in which conflicts between vehicles are recorded by external observers. The initial work was reported in Perkins and Harris (1967, 1968) and in Harris and Perkins (1968). The work was carried out at the General Motors Research Laboratories and came out of a brief they were given to see if, by observation, it could be shown that General Motors cars performed differently from other manufacturers cars. The definition of what Perkins and Harris call a traffic conflict is broad being

"any potential accident situation".

It is thus similar to Quenault's "risk" and Goeller's "vulnerability" but also includes the near accidents defined more rigidly.

The Traffic Conflicts Technique, as it subsequently became known, was devised after such systems as continuous monitoring of sites with cameras and the study of near misses had both been rejected.

There were two categories of traffic conflict used by Perkins and Harris:-

i) evasive action taken by a driver confronted with an impending accident situation and

ii) traffic law violation based on the uniform traffic code.

Five types of conflict were defined (right hand rule of the road applies):

left turn conflicts,

weave conflicts,

cross traffic conflicts,

red light violation

rear end incidents

Illustrations of these conflict situations are shown diagrammatically in Figures 2a-d (the red light violation cannot be illustrated).

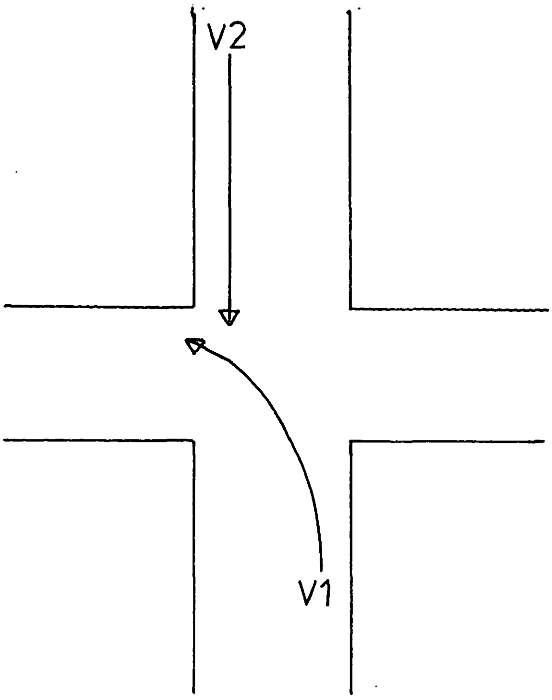


Figure 2a : Left turn conflict

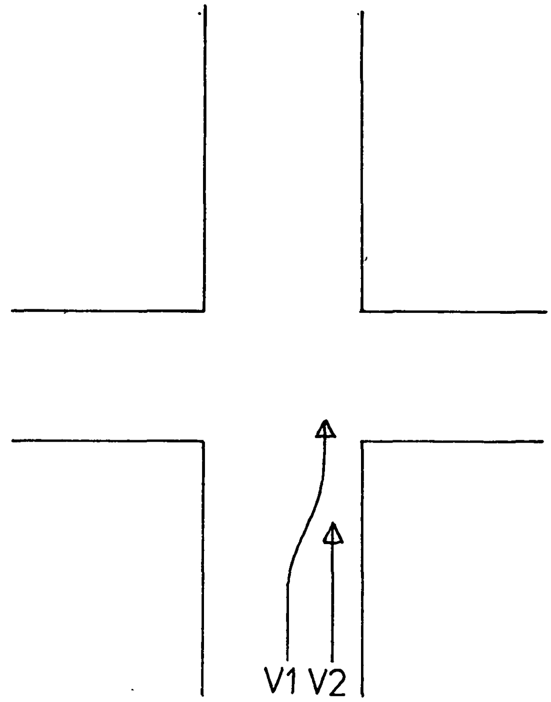


Figure 2b : Weave conflict

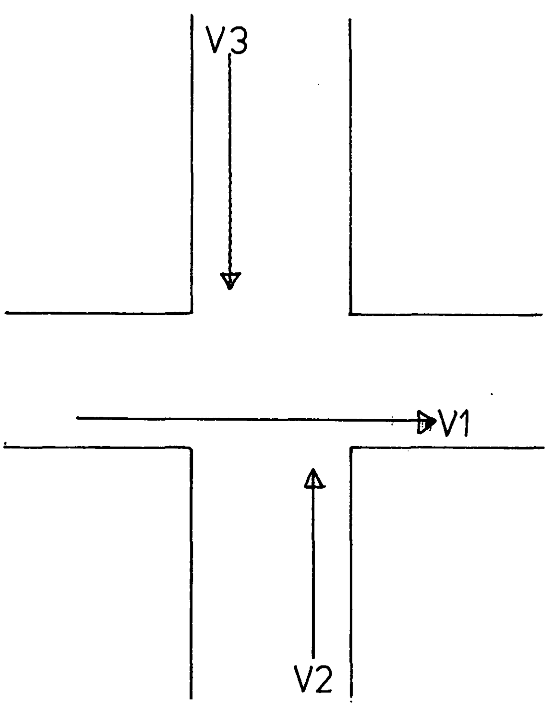


Figure 2c : Cross traffic conflict

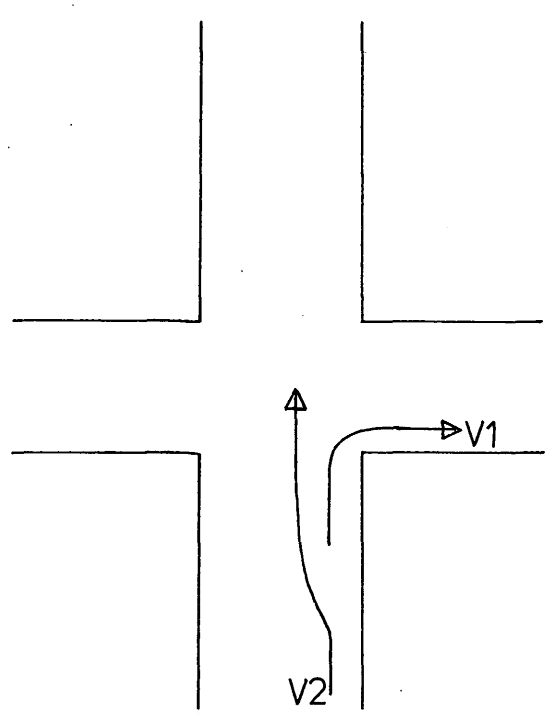


Figure 2d : Rear end conflict

Source : Perkins and Harris, 1967

Figure 2 : Examples of conflicts at crossroads

A left turn conflict (Figure 2a) occurs when one vehicle, V1, turns into a minor road across the path of an oncoming vehicle, V2, causing V2 to brake or swerve. Observations carried out from behind V2 enable an observer to see the brake lights coming on indicating that a conflict has occurred. A weave conflict (Figure 2b) is the result of a vehicle changing lanes. Again, V2 can be observed to brake by illumination of its brake lights. The cross traffic conflict shown in Figure 2c is not the only manoeuvre covered by this category. Left turns by V1 can cause V3 to brake. Perkins and Harris define the rear end conflict shown in Figure 2d as

> "a situation where a vehicle stops unexpectedly and causes a following vehicle to take evasive action".

Some of the five classes of conflict could be further sub-divided. Weave conflicts can result not only from lane changes but also from turns performed out of the wrong lane and turns into the wrong lane. There are a number of varieties of the rear end conflict. Apart from the one illustrated, such a conflict can be the result of a vehicle stopping on the amber signal of a traffic light when being closely followed and being within the permitted distance which allows a vehicle to drive through an amber light legally; alternatively, a cause can be a vehicle slowing or stopping when having priority at an apparently clear intersection. The final version of the rear end conflict is that caused for the second and subsequent vehicles in a stream by the leading vehicle itself becoming involved in a conflict. It would seem that rear end conflicts would not necessarily be confined to intersections but could happen at any point in the road system, including the open road, where a speed difference existed between vehicles. This class differs from other conflicts in that the vehicle which is at fault can itself be the vehicle which is forced to brake due, for example, to following too closely.

The method employed by Perkins and Harris was to study an intersection for three periods from 7am. to 7pm. on a Tuesday, Wednesday and Thursday. During the first two days, brakelights were counted from positions about 100 yards back from the intersection with counts being carried out from one of the two arms being examined every 15 minutes. Vehicle flows were also measured. The final period was carried out with the observers at the intersection watching for, what is described in the report as

> "conflicts defined by traffic movement criteria".

The percentage of brake lights not appearing when vehicles had to stop at signalised intersections was also recorded. They report it to be in the order of 5%.

The work carried out by Perkins and Harris (op cit) was the first to show how conflicts could be classified by manoeuvre of the vehicles involved, but did not make any attempt to classify conflicts by severity. The first study to raise the issue of severity was made by Campbell and King (1970) in the United States. Their classification by manoeuvre was the same as that described by Perkins and Harris (1968). They reported a large number of rear end conflicts at one site caused by vehicles waiting to turn off the main road into the minor road and the vehicles behind these being forced to brake. In the opposite direction such conflicts were the result of vehicles slowing prior to turn right. No accidents involving these configurations had occurred at the site. The authors commented upon the low speeds involved in these conflicts, suggesting that any resulting collisions would be of such a minor nature not to be reported. At the other site, a similar situation of high rear end conflict rates at low speeds again occurred with no reported accidents of the appropriate configuration. Since the authors felt that some of the braking which was recorded as rear end conflicts was for comfort or was purely precautionary as the vehicles were far apart, this class of conflict was considered to be of low severity and was removed from the correlations. They did not, however, attempt to classify the remaining types of conflicts by severity. The first systematic study to include classification by both manoeuvre and severity was made in the United Kingdom by Spicer (1971). He was also the first to show the importance of taking both these factors into account when attempting to validate conflicts with accidents.

Spicer's (1971) report of a pilot study at a rural dual carriageway intersection criticizes the technique used by Perkins and Harris (1967, 1968), commenting that without some grading of the severity of the interaction, the count will be more highly correlated with traffic flows than with accidents. The junction, chosen for its considerable accident history, consisted of a staggered intersection between two minor roads and a dual carriageway, with two gaps in the central reservation. Spicer defined 12 conflict locations. It was noted that at some locations more than one conflict situation could arise. He positioned observers on all four approaches to the junction, moving them around at certain times to equalise reporting bias. In addition, time lapse cine film was taken by a camera mounted on a tower and located about 100 metres south of the junction. When an observer saw a conflict he would record its nature, location and severity on a coding sheet, and also briefly switch on a light which would be recorded on the film. From the film, vehicle speeds and flows were determined. Four days of observation were carried out for 8 hours per day plus one additional afternoon peak period. The accident data used referred to injury accidents only during the previous five years.

Spicer defined the severity grades as shown in Table 2, but only correlated serious conflicts (grades 3-5) with accidents.

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

Source: Spicer, 1971

Table 2 : Classification and description of conflicts.

When serious conflicts (Grades 3-5 only) were correlated with accidents by time of day of their occurrence, a rank correlation coefficient of 0.87 (significant at the 1% level) was obtained. By location, the correlation between these factors was 0.93, also significant at the 1% level. When similar correlations were calculated using all severities of conflicts the coefficients were

0.015 and 0.70 and were not significant.

The development of the Traffic Conflicts Technique as detailed above has now progressed to the stage where the importance of classifying conflicts by manoeuvre and severity is recognised. Using this classification Spicer established the validity of the technique at rural dual carriageways intersections. The author's validation study (reported in Chapter 9) was the first to extend the technique to urban sites, specifically T-junctions.

In all the studies of the population at large mentioned so far, the sole criterion adopted by researchers to identify that a conflict had occurred was the illumination of brake lights. The reliance on this criterion has brought its critics, and at this point it is worth examining the case for and against their use as a standard.

3. The brake light criterion.

It has been said (Allen, Shin and Cooper, 1978) that the use of brake lights as the principal descriptor for the Traffic Conflicts Technique procedure is unsatisfactory. Using brake lights to indicate that a traffic conflict has occurred has several disadvantages:-

1. Braking habits can vary between drivers, some being very cautious and braking in anticipation,

others not braking even when presented with a very hazardous situation. Often the initial reaction of a driver faced with a potential collision is to lift his foot from the accelerator, which in itself causes deceleration.

2. Braking gives only a binary (on-off) piece of information that does not allow further distinction regarding the severity of the situation. For example, a short, sharp application to avoid an imminent collision might be grouped together with an incident where an unnecessary precautionary brake application is made.

3. Decelerating in response to a conflict situation is not necessarily an approprate response. Sometimes acceleration would have avoided the conflict more effectively. Had an acceleration taken place, the incident would not have been counted as a conflict, regardless of how close the conflicting vehicles got (barring an actual collision).

4. By definition, the vehicle with the right of way must apply the brakes for the event to be classed as a conflict. Occasionally conflicts are precipitated by the vehicle with the right of way eg. speeding towards an opposing right turning vehicle without braking. Thus this situation is also excluded.

5. Brake lights may not be working.

6. Brake application does not precede all collisions.

However, their study data (Allen, Shin and Cooper, 1978) do not adequately support their conclusion that enumeration of brake applications is not an acceptable traffic conflict measurement technique. There are several reasons for this:-

a) Their reasons for rejecting the brake application technique was based on data collected on only one approach to one junction. Further, their observations were limited to only one manoeuvre type. Thus their data base was too limited to draw generalisable conclusions.

b) The new measures that Allen et al tested out at the junction did not give any superior correlation coefficients than brake light indicators. As the authors point out, considering the ease of measuring and applying the technique to other types of conflicts, brake applications could be interpreted as having a slightly higher than average rank when compared to the new measures.

c) The authors also admit that the new measures they propose are not applicable for the moving rear end conflict situation. This discrepancy may prove to be a major fallacy in the proposed measures, because rear end conflicts and accidents occur fairly frequently at intersections.

Both brake applications and the new proposed measures have problems associated with them. Ultimately, the integration of several measures may provide a better descriptor.

In any discussion of brake light illumination as the indicator of conflict occurrence, it is necessary to examine the mechanism by which the lights operate. In vehicles fitted with pressure operated brake light switches in the hydraulic system, the switch is designed to be activated (closed) by a fluid pressure of between 30 and 80 psi, depending on the class of vehicle. Private cars have switches operating at the lower end of this range, while commercial vehicles operate near the upper limit. It can be shown that the retardation at which the lights would be illuminated is less than 0.1g. An alternative system for operating the brake lights involves the use of a microswitch in the brake pedal system. In this case, the switch can be activated at even lower retardations. Thus the observation of brake lights can be seen as a highly sensitive measure of a driver's reaction to a situation, providing, of course, that the switch and light bulbs are operational. Estimates put the percentage of non-functional brake lights to be in the order of 4-7% (Perkins and Harris, 1968).

While at present there is no other simple measure giving superior results, it seems that this one is acceptable.

4. Outline of the thesis.

There will be three sections dealing with the fundamental issues of A) reliability of observers B) the development of the Traffic Conflicts Technique Training Package C) the validity of the Traffic Conflicts Technique. Within each section there will be an expansion of the problem, a review of the literature relating to it, then the author's empirical work on the topic. Section D presents empirical data on traffic flows and subjective assessments of risk as alternative measures of accident potential, and compares the results with those of Section C.

Two hypotheses are advanced in this thesis. The first is that conflicts are statistically related to accidents and a corollary of this is that conflicts can be used to supplement accident data so that diagnoses and evaluation of accident locations may be more soundly based. The second is that conflicts predict accidents better than traffic flows and subjective judgements, and also provide more useful information. This thesis examines and compares the three alternatives at urban T-junctions. By applying all three alternatives at the same sites, a direct comparison can be made and the potential usefulness of each method assessed in relation to the others. This thesis reports the first attempt at such a comparison.

T-junctions sites were chosen because they are the most numerous and simplest type of intersection in the road network. Urban sites were chosen because about 60% of injury accidents occur in built up areas. Therefore a method which could result in improved diagnosis and evaluation of remedial measures at these sites should have the most effect in terms of reduced numbers of accidents. Finally, an assessment of the potential applications and uses for the Traffic Conflicts Technique is presented, and work on the further development of the technique suggested.

SECTION A : RELIABILITY

CHAPTER 3

THE ISSUE OF RELIABILITY

1. Introduction

2. Variability and reliability measures
   2.1 Inter observer variability
   2.2 Intra observer reliability
   2.3 Agreement with a criterion value

3. Review of the literature

4. Conclusions drawn from the literature

5. The Local Authority Accident Investigation Unit Survey

6. Aims of the research into observer reliability

1. Introduction

The Traffic Conflicts Technique was developed originally to provide information about operational deficiencies which would supplement or replace the unreliable and incomplete data available from accident reports. One of the early requirements was to develop a recording technique that described the full history and outcome of the event, and that was relatively easy for observers to apply. The accuracy on which estimates of the number and severity of conflicts depends is to a great extent connected to the reliability of the observers applying the technique. To date, many studies have been carried out on the number, type and place of occurrence of conflicts, but very few make more than a fleeting reference to one of the most important variables in these types of study -- namely the observer himself. Campbell and King (1970) acknowledged that variability may exist but dismissed it when they said that

> "conflicts recorded for the same location by any two individuals may vary over short periods of time, but if the conflict definitions are adhered to, this variation will be minor".

Even if the definition of a conflict and the categories for its classification were well defined and mutually exclusive -- a situation which so far has not been reached -- accuracy is still reliant on the subjective assessment of people to quantify a complex set of manoeuvres which build up and are resolved very quickly. In a real life situation with no advantage of the "action replay", we are dependent on the ability of the observers to remember faithfully those events and record them accurately. Much of the success or otherwise of a study will depend on the training and consistency of these observers, particularly where results obtained from a conflict study are to be correlated with known accident data for validation purposes. It is axiomatic that some period of training is necessary to ensure that the observers are conversant with all the measures and manoeuvres, and are confident in their use of the recording forms. Researchers into the Traffic Conflicts Technique appear to have largely treated training simply as a means to an end, rather than as a variable worthy of study in its own right. Almost all reported studies of reliability are preliminary to a study of conflicts in the field. Reliability studies have usually concentrated on measuring consistency between observers during or after conflict studies, but have rarely been used as a method of either selecting the best subjects prior to their observing in the field, or as a means of assessing or improving the level of reliability in working observers.

2. Variability and reliability measures

There are three measures to be considered. These are

2.1 Inter (between) observer variability,

2.2 Intra (within) observer reliability, and

2.3 Agreement with a criterion value

These are the most common measures used in reports of reliability in the literature. The inter observer variability is sometimes referred to as "external" variability and intra observer reliability as "internal" reliability. Agreement with a criterion value is also termed "accuracy". The semantics may vary but the results found differ only in level of agreement found and methods used to obtain them. It is entirely possible that subjects may differ within and between themselves with respect to a) detection and b) grading of conflicts independently and thus the two aspects should be separated. They are not, of course, totally independent, since a conflict must be detected before it can be graded, but the allocation of a grade for a specific conflict may differ between observers. Furthermore an individual may have high intra-observer reliability ie. be consistently detecting and grading incidents in the same way when seen on two separate occasions, but this may not be in accordance with the criterion value. A group of observers may even have low variance among themselves ie. have a high consensus, particularly with respect to the grade allocated, but this again may differ from the criterion value.

The most important measures are intra-observer reliability and agreement with a criterion value, since what is required is an observer who is both consistent and accurate. Where a trainee is compared with an experienced observer, "inter-observer variability" and "agreement with a criterion value" are synonymous. A further discussion of the three measures in turn and some of the factors influencing them, and their implications follows, and then there is a review of their use in the literature.

2.1 Inter observer variability

It may be possible that there are differences in the way drivers and non drivers detect and grade conflicts according to severity. Experienced drivers may dismiss minor conflicts as "normal" driving and fail to record them. Non drivers may be freer of preconceived ideas of what constitutes a hazardous situation and therefore may be more objective. On the other hand, drivers may be better at anticipating potential hazards, and may be able to see a conflict building. They will therefore have more time to follow and remember the event and thus record it more accurately. This possibility is largely ignored in the literature, but requires investigation.

Such a source of potential bias is likely to have quite a different effect on the data collected, and may present a skewed distribution that is totally unrepresentative of conflicts that occur. The problem of bias could theoretically be dealt with by estimating bias for each observer (assuming that it is a constant) and applying a correction factor to their results. This method is extemely difficult and also time consuming. The best practical solution would be to recognise that bias may exist, to attempt to identify those individuals in whom bias is a problem to the extent of adversely affecting the results, and to eliminate them from observation work. Training of the remainder, who would then be more of an homogenous group, could then proceed in a standardised way, with a greater likelihood of consistent results being obtained. While initially more would have to be trained than were ultimately required, the payoff would be worthwhile in that data would be more reliable. This would be of most benefit to those involved in the application of conflict studies in the local authority accident units, who require accurate data for the diagnosis and evaluation of accident sites, and who are the target population for the production of a training package.

2.2 Intra-observer reliability.

There are few factors that may affect this measure, provided that subjects are clear about the deciding criteria both for detecting and grading conflicts. One problem that is inherent in the design of such studies is that subjects may recall their response to a situation when it is presented for a second or subsequent time. One of the ways to overcome this is to have a large number of situations and to vary the order of presentation.

It is suggested that this measure and the one to be discussed next, namely comparison with a pre-set criterion grade, are the most important. Which of the two is more so is debatable. A subject who is internally consistent may completely disagree with the pre-set criterion grade. This is likely to be due to bias as discussed in the previous section, and could theoretically be dealt with by applying a correction factor. A subject who has good agreement with a criterion set of values on one occasion may not on another. This will ultimately affect both measures and implies lack of motivation or application. Neither type of subject is ideal.

2.3 Agreement with a criterion value

Subjects may exhibit a high level of consensus among themselves about whether a conflict has occurred and what grade it is, but it is necessary to establish that this consensus is in agreement with a pre-set criterion. This criterion can be set either by an experienced observer alongside the trainee at a site, or from video/film taken simultaneously and assessed at a later stage or the events may be fabricated to give examples of particular types of conflict and recorded on video/film. There are disadvantages associated with both these methods and they will be discussed more fully in the review of the literature.

A method that has not been used in any previous studies but would logically appear to be useful in training and its evaluation, and by which all three measures could be assessed is that of real incidents recorded on film with a criterion allocated to each. The data from subjects observing and grading the incidents on the first showing could be used to measure correlation with a criterion, and successive showings would give data whereby intra observer reliability could be assessed for each individual. The aims of training to ensure that subjects use the same criteria to detect and grade conflicts according to severity would therefore be satisfied.

The literature review that follows will concentrate on the methods of testing reliability that have been used, and the measures that have been applied to the data, since all researchers have found observers reliable to a greater or lesser extent. The question of what is a satisfactory level of performance by observers following training seems unresolved by researchers in this area. Clearly it should be as close to 100% as possible, but this figure seems unrealistic, especially in the light of current findings.

3. Review of the literature

The first study to be reported (Hyden, 1977) was concerned with the trade-off between reliability and length of training. It gave inter observer reliability data but no analysis and compared data from the observers with a criterion but only used a very crude analysis. The method used by Hyden (op cit) to test observer reliability was by comparing data obtained from five observers working the same intersection, but independently of each other, with simultaneous video-recording. Hyden's method of assessment was based on summing the total observers error for each conflict in turn, and comparing these errors for all conflicts to a possible correct score eg. 8 scorable conflicts rated by 5 observers gives a possible all correct score of 40. If each observer makes one error in detection, then the rate is 5/40 ie. 12.5%. Included in his video tapes were two situations that the experimenters did not consider a conflict, making a total of 10 situations, 8 of which were scorable conflicts. The two non-conflicts were not included in the possible all correct score which would then have been 50 (10 conflicts x 5 observers) even though one observer scored both as conflicts, giving one of them a grade 1 severity and the other a Grade 3 severity rating. The results are shown in Table 3.

	Evaluation from video tapes	Observers A	E	H	J	M	Error	Possible
	1	1	1	2	1	-	1	5
	3	3	3	3	3	-	1	5
	-	-	1	-	-	-	1	
	3	3	3	3	3	3	0	5
	4	4	4	4	4	4	0	5
	-	-	3	-	-	-	1	
	1	-	-	1	1	1	2	5
	1	1	1	1	1	1	0	5
	4	4	4	4	2	4	0	5
	2	2	2	1	2	2	0	5
Total	8	7	9	8	8	6	6	40
Errors/observer*		1	3	0	0	2	6/40	= 15%

Table 3 : Results of Hyden's observer reliability study. (Hyden, 1977)

Hyden concluded that

> "In spite of the relatively small scale of these tests, they indicate quite strongly that the reliability of the observers is quite high when the training period is at least 3-4 days." Hyden, 1976.

In fact, these data highlight the two distinct and separate problems involved in training observers to record conflicts. Firstly there is the problem of detection of conflicts from non-conflict situations, and secondly there is the problem of the correct classification be severity. Hyden acknowledged the former but not the latter in his analysis. The author calculated that the percentage of correctly identified events (hits plus correct rejections) was 88% and incorrectly identified events totalled 12% (misses and false alarms). Only two subjects, H and J, identified all events correctly as conflicts or non-conflicts, but neither correctly classified all the conflicts by severity.

Older and Shippey (1977a) report two studies of observer reliability. In the first, two independent teams recorded conflicts simultaneously, and as they happened at two sites. An agreement level of 80% was obtained between the two groups over all events classed as conflicts, and of 85% when considering only serious conflicts. However, the study only concerned 58 conflicts in total. In the second study, two observers independently graded events recorded on film taken at one site over six days, and then made a combined assessment. Of the 899 events mutually agreed as conflicts, 76% were identified by both observers, and they both gave 70% of these conflicts the same severity grading. Thus the two aspects of detection and classification by severity were acknowledged in this study.

On the subject of the length of the training period, Merilinna (1977) reports that

> "Conformity of observations between individual observers was found insufficient if their training for observing conflicts was very short (only about half a day) .... However, it was also noticed that a longer training period would improve conformity of observations."

He used a simple system to estimate whether the observers needed more training. Before a new observer could start, he was compared with an experienced observer. Both counted the same conflicts during 10 half hour periods at a junction during one day (to get a large variety of traffic volumes). When the correlation coefficient, R.observed > or = 0.975, then the new observer could start working. It is not clear from the paper whether this figure refers only to detections or to both detection and correct classification by severity. If the observers did not reach this level of proficiency, then they were deemed not be be sufficiently reliable, and they had to undergo more practice until they were able to achieve this standard. This is the only study in the literature that sets a standard to be achieved before potential observers could participate in conflict studies. Even so, the threshold value of r = 0.975 against another observer seems very high. It can only be assumed that this was conflict detection (event/non-event) rather than correct detection and classification be severity.

While the criterion against which Hyden's observers were judged was evaluation from video tapes at a later date, Merilinna's criterion was an experienced observer recording simultaneously. Both methods have disadvantages. Evaluation of the videod events may be biased by prior analysis of the subjects recorded conflicts. There will always be a delay in time while the video tapes are analysed, and the benefit of slow motion and replay will usually mean more events are recorded. Realistically, observers stationed together, as in Merilinna's study would very likely bias each others judgement and recording of conflicts. Even without verbal collaboration, if the experienced observer wrote down a conflict, then the trainee would see and do likewise. If the experienced observer did not record a conflict that the trainee would have done if he had been alone, then he might also ignore it.

One of the most thorough investigations into between observer reliability was carried out by Guttinger and Kraay (1976) in a study of conflicts between pedestrians and vehicular traffic. This was an experimental study as the events to be evaluated were fabricated by stooges of the researchers and recorded on video tape. Their definition of conflicts involved the use of "sudden" and "non-sudden" motor reactions. The criterion of sudden was determined empirically. Ten observers (Group I) scored 27 video recorded events on a 7-point scale ranging from more to less sudden. Subsequent discussion resulted in a detailed list of criteria that could be used to identify three types of reactions -- "sudden", "in-between" and "non-sudden". The same observers then evaluated the 27 events again using the 3-point scale and the list of criteria that had been arrived at by discussion. A second group (Group II) then did the task, after having 30 mins. in which to familiarise themselves with the list of criteria, scoring the 27 events three times each in a random sequence. Five basic types of traffic situation were selected. The following results were obtained (see over):

1) Pedestrian reactions
   - a) External reliability - reliability between obs's
     - i) Group I, with discussion, r = 0.91
     - ii) Group II, without discussion,
       - Trial 1, r = 0.87
       - Trial 2, r = 0.87
       - Trial 3, r = 0.86
   - b) Internal repeatability - reliability of the same observer between different sessions
     - Group II only r = 0.95

2) Traffic reactions
   - a) External reliability
     - i) Group I, r = 0.86
     - ii) Group II, Trial 1, r = 0.75
       - Trial 2, r = 0.75
       - Trial 3, r = 0.79
   - b) Internal repeatability
     - Group II only r = 0.85

Table 4 : Results of Guttinger and Kraay's (1976) reliability study

They made the point that they did not select the observers in any way, but merely recruited the first 20 students who applied. Two turned out to be very poor observers, and they had a significant effect on the correlations. It is interesting to compare the results of Group I (who had the opportunity for discussion) with those of Group II (who did not). Group I had greater agreement between observers than Group II for both pedestrian and traffic reactions. Guttinger reports in a later paper (Guttinger, 1977) that, in a subsequent experiment, observers had to pass a selection procedure before being chosen for training, and the correlation for external reliability was 0.94 (pedestrian reactions) and 0.93 (traffic reactions). These results clearly show the importance of selecting the right quality of observers. However, it is not really surprising that the reliability figures were so high, because it was the observers who set the criteria for evaluating the events. In most other studies, the researcher sets the criteria and attempts to train the observers to apply them.

Finally, Malaterre and Muhlrad (1977) report on two experiments on the reliability of two groups of observers over a period of four months, with additional training in between the two testing sessions. Each group comprised only two observers and the two groups worked simultaneously on the same junction. Comparisons were made between the rate of detection of conflicts of the two groups in June and again in October of the same year after discussion and further training, when the detection rates reached "very similar levels". They did not, however, report on the classification of detected conflicts by their observers. They commented that one of the problems is the determination of the correct amount of training -- enough to acquaint the observers with all the categories and to calibrate their judgement, but not long enough at a stretch to cause fatigue or boredom. They expressed the view that training films would be of great use as they would allow intra observer repeatability over a period of time to be investigated, something else that they themselves did not do.

4. Conclusions drawn from the literature

No systematic experimental study of intra observer reliability has been attempted with vehicle-vehicle conflicts. The only report found was on pedestrian-vehicle interactions and the events to be evaluated were fabricated, and obviously so. There is a lack of quantitative evidence of both inter and intra observer reliability, and the inference is that levels of reliability found are accepted as adequate whatever they may be. There is a wide variety of length and content of training methods described in the literature, and the aims and purpose of the training are frequently not clear. One aspect of these analyses that appears to have been missed is that it is not inter observer variability of groups of subjects or trainee observers that is important. It is the reliability of **individuals.** Therefore intra observer reliability and comparison with a criterion are the two measures of consequence. If these are high, then it follows automatically that variability between observers will be low. The measure of inter observer variability can mask a wide variety of competence, and low inter observer variability does not necessarily mean that the observers will have a high level of agreement with criterion values for the same incidents. By examining the two measures of consequence, namely intra observer reliability and comparison with a criterion, for individuals, the best can be chosen for future field studies, and the worst discarded.

The purpose of any training should be two pronged, and should be to ensure that all observers are using the same criteria to

a) detect when a conflict has occurred, and

b) classify it according to severity.

These are the elements that are open to subjective judgement. From the satisfaction of these two aims, detailed information on the more objective factors such as manoeuvres and types of vehicle involved in the conflict should follow. By standardising the training methods and using the results to select suitably reliable observers, then the variance due to this factor could be minimised and reduced to a tolerable level for data collection uniformly. Standardisaton implies the need for a set of guidelines which would lay down procedures that clearly explain the criteria, and which could be used to monitor understanding and progress. However, the extent of this need in the ultimate users of the technique, namely the Local Authority Accident Investigation Units, who were already showing great interest in using the technique in diagnosis and evaluation despite doubts about its validity in the literature, was unknown at that time, so a survey was carried out.

5. The Local Authority Accident Investigation Unit Survey

Local authorities are aware that the effect of Section 8 of the Road Traffic Act, 1974, was to replace the former permissive powers to promote road safety with a statutory duty to carry out a programme of measures to promote road safety, including undertaking studies into accidents. Thus the Accident Investigation Units came into being. A major survey of all these units in England and Wales (N = 85, response rate 100%) carried out and analysed by the author (Lightburn, Routledge and Howarth, 1977) revealed that most (67.1%) used part time casual enumerators but only for general observation work and not for conflict studies because they did not consider that they could achieve the high standards of detection and classification required. Consequently, because the full time personnel considered that only they themselves were sufficiently highly trained in accident studies to record conflicts accurately, such studies were carried out only infrequently due to lack of time. The respondents were agreed, however, that if an appropriate number drawn from this relatively unskilled pool could be shown to be capable of reaching a satisfactory standard of accuracy quickly and easily, more conflict studies would be conducted, as they were considered a valuable source of information. Thus, conflict studies were already in use as a diagnostic and evaluative tool at over half the authorities, but the furtherance of their use was being restricted by concern over the reliability of the results if the data was collected by any other than those with a theoretical background in accident investigation. This indicated a concern in the ultimate users of the technique that was not readily apparent in the research fraternity, who regularly used part time casual observers, but who carried out few, if any, tests on their reliability. This justified research into the issue of reliability with the aim of producing a training package which could show how enumerators could be trained to record conflict observers, and ways of measuring their performance.

6. Aims of the research into observer reliability

With the production of a training package specifically designed for local authority accident investigation units in mind, two studies were planned. The first (Chapter 4: A study of reliability) was an experimental study using real traffic incidents recorded on film to train subjects and measure reliability in the laboratory. No systematic experimental study of intra observer reliability had previously been attempted with vehicle-vehicle conflicts.

The second study (Chapter 5 : Attempts to improve reliability and ease of training) was an extension of this to see whether a new method of recording, incorporating factors that experienced observers used to differentiate the grades of severity currently in use would help observers by defining the criteria for detection and grading more objectively. Also under investigation was whether the technique learnt and applied in a laboratory setting could adequately be applied to real-life observing without significant loss of accuracy as measured by a drop in the detection rate.

After these studies have been presented, there is a summary of the results of both studies and their implications for a package to train observers in the Traffic Conflicts Technique (Chapter 6).

The results have been used to formulate a package, consisting of a manual and associated film, and the development and contents of the package are set out in Section B (Chapter 7): The Development of the Traffic Conflicts Technique Training Package (The Training Manual is reproduced in the Appendix).

CHAPTER 4

A STUDY OF RELIABILITY

1. Introduction

2. Method

3. Results
   3.1 Inter observer variability
   3.2 Intra subject reliability
   3.3 Agreement with the criterion grades

4. Conclusions

1. Introduction

Observers must be conversant with the measures used to record traffic conflicts in order to reduce as much as possibl;e the subjective elements of

a) detection of conflicts from non-conflicts, and

b) severity classification.

It is essential that when observers detect a conflict and classify it by severity they do so reliably (as measured by intra observer correlation coefficients) and accurately (as measured by the level of agreement with the pre-set criterion value). The ability of casual enumerators (defined as people having no professional training or association with transport studies) to record conflicts was seriously doubted by the ultimate users of the technique in practical application, namely the Local Authority Accident Investigation Units. A survey of all these units in England and Wales (Lightburn, Routledge and Howarth, 1977) had revealed that none had ever used casual enumerators for conflict studies for this reason. This meant that few conflict studies were ever carried out, despite the general recognition of the value of conflict data for accident diagnosis and evaluation.

Researchers into the Traffic Conflicts Technique also tended to limit their observers to people working with them or with close association with transport studies. They seldom ran reliability tests and there had been no systematic experimental study of intra observer reliability on vehicle-vehicle conflicts. Training was either done with fabricated material (for pedestrian-vehicle interactions) or on-site (vehicle-vehicle conflicts). The latter meant that there was no possibility of reviewing an incident and in this situation no measures of intra observer reliability could be taken, and this aspect of an observer remained virtually unknown for vehicle-vehicle conflicts. Furthermore, there is no control over the number or type of conflicts which the observer may see when being trained on-site, and it may take a considerable length of time before all possible types and severities can be seen. A new method was therefore devised by the author which was used to measure the ability of the subjects to detect conflicts from non-conflicts, their accuracy in classifying it according to severity and their reliability in doing both of these tasks. If it could be shown that casual enumerators, having no previous professional experience in transportation could detect and classify conflicts reliably and accurately, then the ultimate aim was to use the training method devised and used here to formulate a set of guidelines in the form of a training and evaluaiton package for local authority accident investigation units to train their own observers in the Traffic Conflicts Technique.

2. Method

A quantity of 16mm. silent, colour films taken by the Transport and Road Research Laboratory at three different locations were edited to produce 72 separate pieces of film. Each piece was approximately 25-30 seconds in length, and 59 presented conflicts of varying manoeuvres and severities (but only one conflict per piece of film), while 13 displayed ordinary traffic manoeuvres with no conflicts. Interspersed with the clips were 90 second sections of blank film, to enable the observers to record the events of each clip. The 72 clips were made up into 6 films, two of each location so that the order of presentation could be varied. The conflict on each clip was viewed several times by a number of experts in the Traffic Conflicts Technique, including members of the Transport and Road Research Laboratory, and agreement was reached on the classification of each event by severity grade. These grades became the criterion values against which grades allocated by observers were compared. No attempt was made to select subjects in any way. This was a deliberate policy in order to assess limits of variability in different subjects. All subjects were students and there were 42 in all, approximately half male and half female. Which subjects held a driving licence was noted. About an hour was spent in training and there was opportunity for practice.

The method of recording used was the same as Spicer (1971, 1972, 1973) classifying conflicts by severity in grades 0-4, equivalent to Spicers 1, 2, 2+, 3, 4 categories (Figure 3). If they did not think there was a conflict on the piece of film they saw, then they were told to write "No conflict" and put down their confidence in their observation. Naturally, no severity grade could be awarded.

GRADE	DEFINITION	✓
0	Precautionary or anticipatory braking eg. for vehicle waiting to emerge from a side road. Precautionary or anticipatory lane change where the lane ahead is clear. Perception of a hazard but without the possibility of a collision.ie. the way ahead is clear.	
1	Controlled braking to avoid a collision with a vehicle blocking the way ahead (even momentarily) but with ample time for the manoevre. <u>Or</u> lane change <u>without</u> braking to avoid vehicle blocking the way ahead.	
2	Longer period of controlled braking or less time to execute the manoeuvre ie. harsher or prolonged braking. Braking <u>plus</u> lane change to avoid collision with vehicle blocking the way ahead.	
3	Extended period of braking or little time to execute manoeuvre (identified by skid marks, dipping of front of vehicle on braking etc.) No possibility exists for vehicle to change lanes because other lane(s) occupied or not available. Having to come to a complete stop due to the way ahead being completely blocked.	
4	Emergency braking and/or violent swerving resulting in a very near miss situation, possibly where the avoiding manoeuvre, hastily executed, involves the vehicle in a second imminent collision situation.	

Figure 3 : Layout of recording sheet for grades method

3. Results

The results will be presented as follows:-

3.1 Inter observer variability

3.2 Intra subject reliability

3.3 Agreement with the criterion values

3.1 Inter observer variability

The following overall coefficients of concordance (Kendalls W) were found for the 42 subjects in the study on each of the three dys of the experiment.

Day 1	W = 0.61
Day 2	W = 0.67
Day 3	W = 0.68

This shows that agreement between subjects increased during the experiment ie. subjects had a higher level of agreement among themselves on the second day when compared to the first, and was highest on the third day (W = 0.68) Although in statistical terms this figure is fairly good, whether it would be acceptable in general observation work is questionable. Comparing the results to other reported studies of observer variability is difficult because of the variety of techniques employed. From Hyden's (1977) data, the author estimated the coefficient of concordance, W to be 0.75 for eight observers. Guttinger and Kraay (1976) report coefficients of around 0.75 with 20 observers for traffic reactions, but it must be remembered that these filmed encounters were not taken from real life but were staged for this purpose, with no "noise" in the form of other traffic.

3.2 Intra subject reliability

There were large differences between subjects. The highest correlation for an individual subject was 0.91, the lowest 0.30 (Spearman Rank Correlation Coefficient, rs). Poor quality subjects greatly influenced all the results and indicated the importance of selecting observers on some criterion.

The correlation for all observers was calculated by converting each r to z (Fisher's transformation) then taking a weighted (each z by the inverse of its sampling variance) average of the z's. This weighted average is given by the formula

$$Zav = \frac{(N1-3)Z1 + (N2-3)Z2 + \ldots\ldots\ldots(Nn-3)Zn}{(N1-3) + (N2-3) + \ldots\ldots(Nn-3)}$$

Zav is then transformed back to an r (Fisher and Yates, 1963).

The correlation between days 1 and 2 was 0.65

(N=42). Between the second and third days of the experiment the correlation coefficient was 0.75 ($p<0.01$ level, $t = 7.15$). Observers therefore improved on the second testing and there was no regression to the mean. The correlation coefficients between the two testings were ranked for each subject and correlated using Spearman's rho, and was found to be 0.80 ($p<0.01$). This meant that the good observers on the first testing were also the good observers on the second testing. The effects of eliminating various percentages of the poorer subjects on their results are shown in Table 5 below, and presented graphically in Figure 4. By selecting the best observers a reliability of up to 0.88 could be obtained.

Eliminate lowest %	N	DAYS 1-2	DAYS 1-3	DAYS 2-3
0	0	0.65	0.67	0.75
10	4	0.66	0.69	0.77
20	8	0.68	0.70	0.78
30	13	0.71	0.72	0.80
40	17	0.73	0.73	0.81
50	21	0.74	0.75	0.82
60	25	0.76	0.76	0.83
70	29	0.78	0.77	0.85
80	34	0.80	0.78	0.86
90	38	0.83	0.81	0.88

Table 5 : Effects on the intra observer correlation coefficients of eliminating various percentages of observers

It is necessary to assess whether there is adequate justification for selecting out the poorer subjects early in the proceedings. To this end, it was necessary to look at the effect on the correlation coefficient on Day 3 of eliminating various percentages of subjects according to their results on Day 2. In other words, the data from the same subjects who would have been eliminated at each point after Day 2 were inspected again after Day 3. The effect on the intra subject correlation coefficients is shown in Figure 5. This can be compared with Figure 4. By superimposing the two it can be seen that there is very little difference between the two graphs indicating that those subjects who perform poorly on Day 2 also do so on Day 3 relative to other subjects and can be excluded without any significant loss.

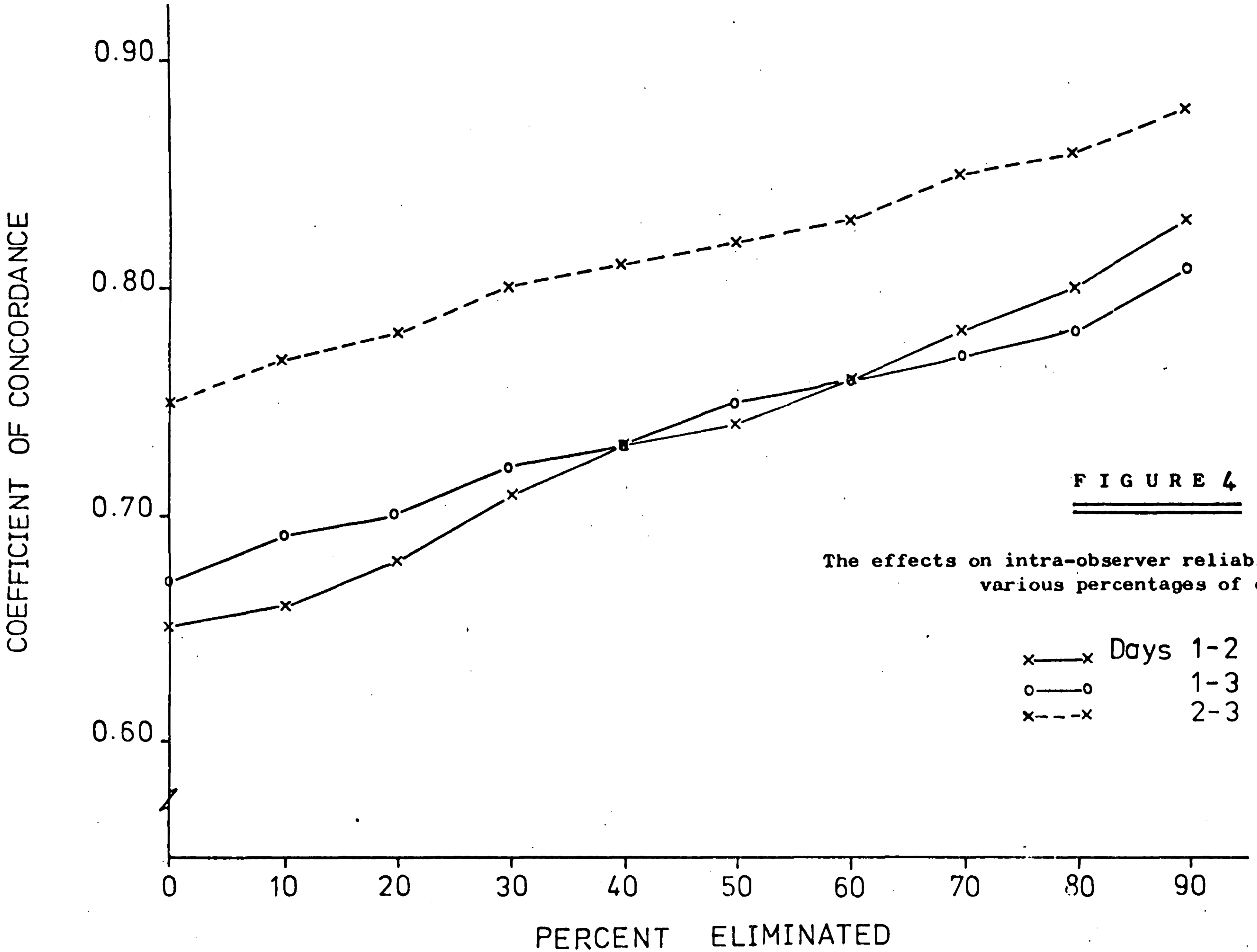


FIGURE 4

The effects on intra-observer reliability of eliminating various percentages of observers.

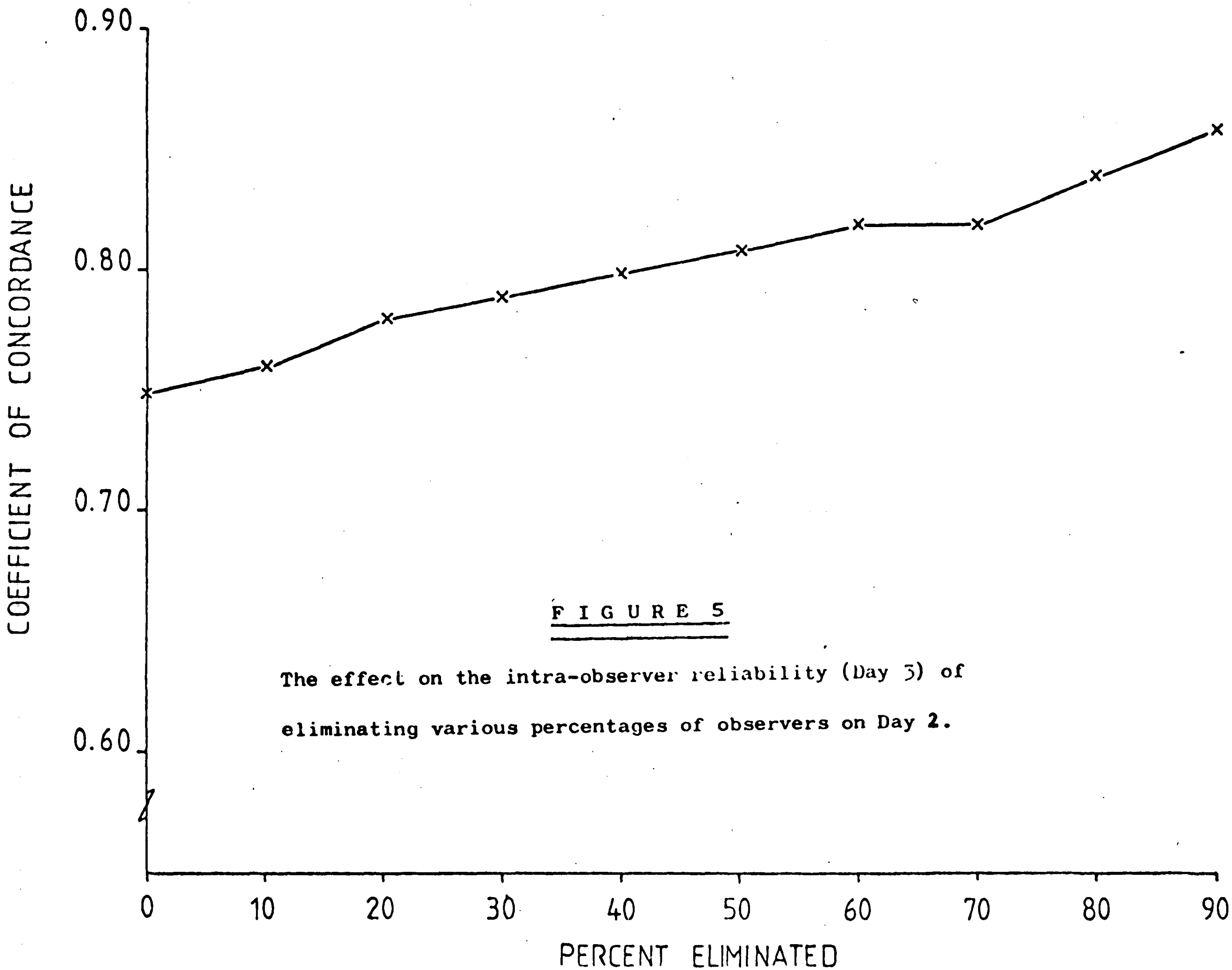


FIGURE 5

The effect on the intra-observer reliability (Day 3) of eliminating various percentages of observers on Day 2.

3.3 Agreement with the criterion values

Each observer's gradings were compared with the pre-set criterion for each day of the experiment. The correlations varied considerably between individuals, and overall showed a trend towards better agreement with the criterion on the third day than on either of the two previous days of the experiment. The effect on the correlation coefficient of eliminating various percentages of the poorer subjects is shown in Table 6, and presented graphically in Figure 6.

Eliminate lowest %	N	DAY 1	DAY 2	DAY 3
0	0	0.60	0.65	0.67
10	4	0.63	0.67	0.68
20	8	0.64	0.68	0.69
30	13	0.66	0.70	0.72
40	17	0.68	0.71	0.73
50	21	0.70	0.72	0.75
60	25	0.71	0.74	0.76
70	29	0.74	0.76	0.78
80	34	0.77	0.79	0.80
90	38	0.79	0.81	0.83

Table 6 : The effects on the correlation coefficient between observers and expert criterion, of eliminating various percentages of observers

The highest overall correlation was obtained on Day 3 and was 0.67, significant beyond 0.001 level (t=5.72, N=42). There was a trend towards increased agreement across the three sessions.

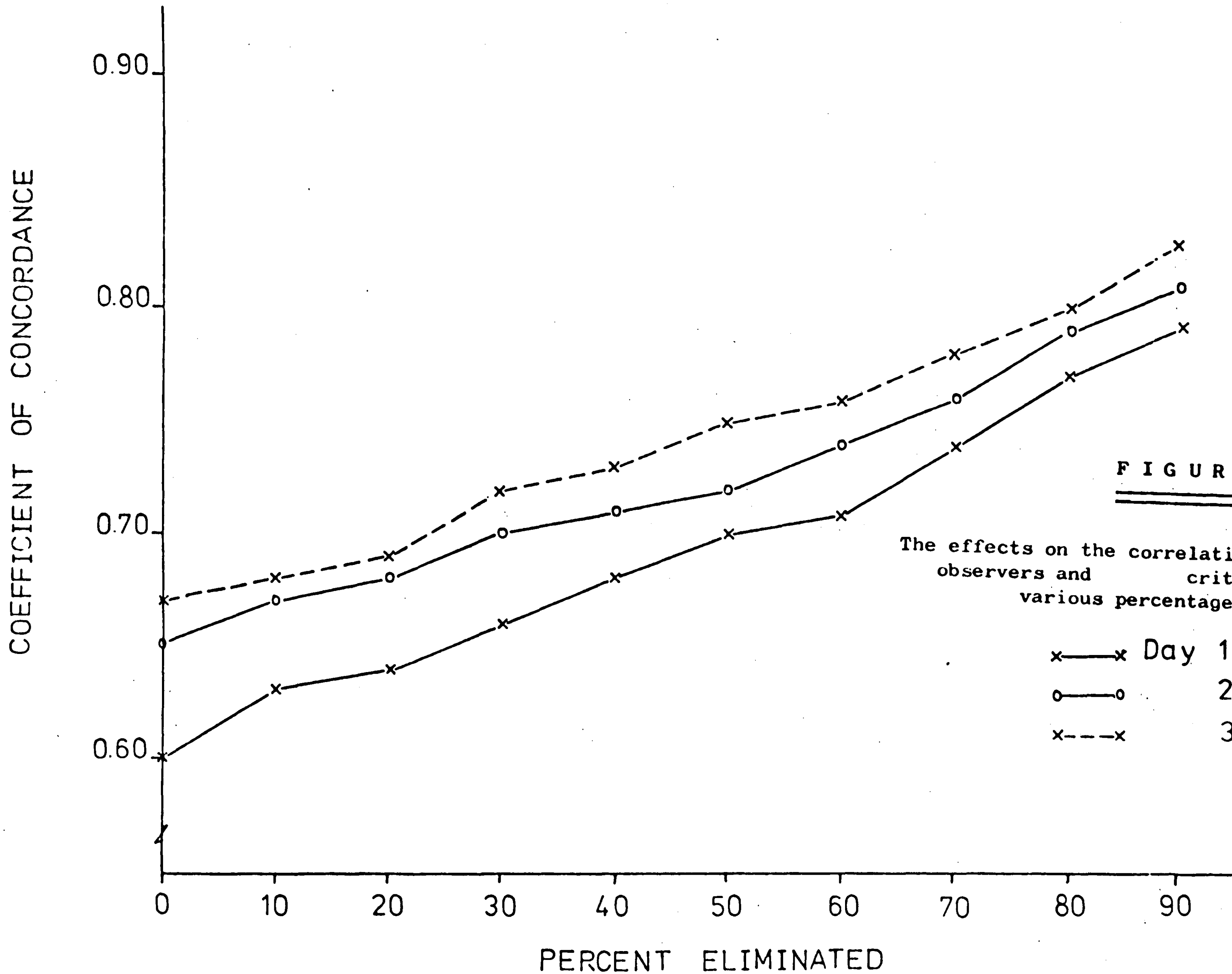


FIGURE 6

The effects on the correlation coefficients between observers and criterion of eliminating various percentages of observers.

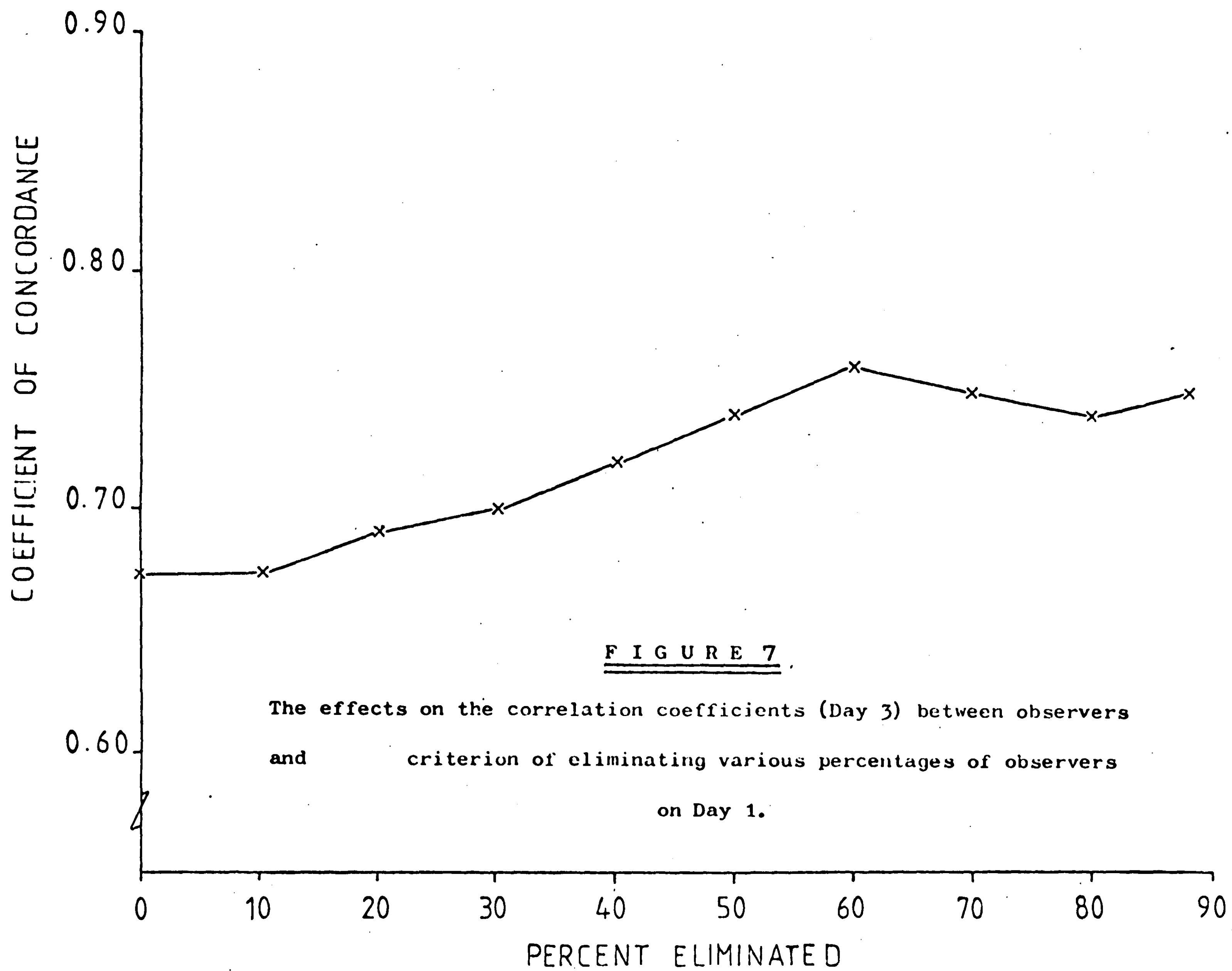


FIGURE 7

The effects on the correlation coefficients (Day 3) between observers and criterion of eliminating various percentages of observers on Day 1.

The effects on the correlation coefficients on Day 3 of excluding the worst subjects on the results of their performance on Day 1 are shown in Figure 7. This can be compared with Figure 6 which shows the effects of excluding various percentages of subjects solely on their results on Day 3. Comparison of the two graphs indicates that some of the subjects do improve, but the worst 60% can be eliminated with no deleterious effects.

By looking at the distribution of allocated grades for each conflict by all the subjects will show where they differed from the criterion, and would also indicate where there was a consensus among subjects, but where this consensus differed from the criterion. The raw data are shown in Tables 30a-f in the Appendix along with the percentage of subjects agreeing with the criterion for each conflict, and summarised in Table 7 below. From these data it was found that non-conflict situations were correctly identified in almost 75% of the pieces of film shown, although at Site 2, 91.4% were correctly identified compared with 76.4% at Site 3 and only 52.2% at Site 1.

Nearly 88% of conflict situations were detected as such, and the classification by severity was as follows.

Grade 0 situations were correctly identified in just under 50% (65.1% at Site 3, and 39.3% at Site 1).

Grade 1 conflicts were correctly identified in 58.3% of their presentations (63.6% at Site 3, 57.4% at Site 2, and 54.0% at Site 1).

Grade 2 conflicts were correctly identified in only 28.0% of their presentations (31.2% at Site 2, 28.3% at Site 3, and 25.4% at Site 1).

Grade 3 conflicts were correctly identified in only 19.7% of their presentations (31.5% at Site 1, and 12.5% at Site 2).

Grade 4 incidents were correctly graded on 52.4% of the presentations.

Criterion grade	Conflicts missed %	Conflicts correctly detected and graded %	Correctly detected but given one grade higher than criterion %	Correctly detected but given one grade lower than criterion %
0	38.1	48.0	10.8	N/A
1	13.1	58.3	14.3	12.5
2	6.8	28.0	5.3	48.2
3	11.7	19.7	4.5	32.5
4	0.0	52.4	N/A	41.3
Weighted average	8.2	49.3	10.1	40.9

Table 7 : Percentage of conflicts detected and graded by criterion grade

Thus it was found that for all film clips, almost half were correctly identified and graded. Only 10% of the incidents were graded one higher than the criterion, but over 40% were graded one lower than the criterion. The conclusion from this is that, while the detection rate is good, the classification by grade when a conflict has been identified needs improvement, especially at criterion grades 2 and above.

The problem here can be divided into four possible causative factors:-

i) definitions of the grades not being mutually exclusive enough, are causing confusion amongst observers.

ii) genuine misinterpretation of the incident due in part to the short and singular nature of the presentation.

iii) a down-grading of the incidents because of the prior knowledge that no accidents occurred in any of the films.

iv) insufficient awareness of the severity of avoidance manoeuvres, possibly due to inadequate guidelines in training.

If iv) is suitably improved, then it is thought that this in turn will help counter the problems involved in i), ii) and iii).

Overall, Site 3 (Films E and F) had the highest number of correct gradings, which corresponded with the subjects anecdotal reports that Site 3 was the easiest, and Site 1 (Films A and B) was the most difficult.

As for the investigation into driver differences, there were no significant differences between drivers and non drivers as to the way each group graded the incidents. As the subjects were all under 25 years of age, and most were between 18 and 21, the amount of experience among the driver group would be quite small, and may account for the result. It is possible that there might be a difference if older subjects were used, where the drivers among them would have a good deal more experience.

4. Conclusions.

The results of this study showed that, even without selection, subjects similar to the casual enumerators used by local authorities can detect the signal events ie. conflicts, from the general "noise" inherent in the traffic system. About 88% of conflicts were correctly detected. Of these, almost half were correctly classified by severity. A further 40% were given a grade below the pre-set criterion. The problem of incorrect grading was partly due to the definitions of the grades not being mutually exclusive. Any classification system used should ideally have categories that are mutually exclusive to eliminate confusion and to optimise accurate definition. Existing definitions are really descriptions of the most typical event indicating a particular severity grade rather than including all possible events that could be similarly classified, and this system clearly needed improving. (A better method of defining the criteria involved in detecting and grading conflicts is investigated in the next chapter).

Intra-subject reliability (N=42) was found to be 0.75 ($p<0.01$). However, the results showed that some subjects appear to show a greater facility for this type of work, as some individuals had higher intra-subject reliability than others (range 0.30-0.91). It was shown that by eliminating poorer quality subjects and keeping only the best observers, a reliability of up to 0.88 can be obtained. If necessary, a threshold value could be set, and only those subjects achieving higher correlations against a criterion accepted for observation work. The implication of this for the proposed training package is that a sample of filmed incidents with pre-set criteria should be included for this purpose. The finding that the good observers remain good or even improve, validates the method employed.

While this section is concerned with the fundamental issue of reliability of observers in the field, this study was quasi-experimental in that the incidents the subjects saw were selected and the same and not equivalent incidents were seen in order to assess reliability. The question that must be asked is what standard of results can be obtained in the field, and whether laboratory training methods can be adequately applied to real-life situations without significant loss of accuracy or drop in the detection rate. It is inevitable that some loss will occur and it will be related to the problem of detecting infrequent and irregular signals generally referred to as vigilance performance.

The pioneer study of vigilance performance was made by Mackworth (1950), and arose from the wartime problem of detecting submarines by airborne radar. He found that correct detection rate in the first half-hour was significantly better than in later periods. Since then, the fall-off in detection after the initial phase has been well established (Broadbent, 1958, Davies and Tune, 1970). A certain minimal rate of information input is necessary for a human operator to function efficiently. If this is not reached in a vigilance situation, it has been suggested (Broadbent, 1963) that the operator's level of arousal is lowered, rendering his performance less efficient, an effect known as vigilance decrement. However, it is unlikely that in the present tasks there is sensory underload below a threshold level of the type experienced in the experimental work on perceptual deprivation that led to the discovery of the vigilance decrement effect. There are differences in watching for conflicts on film in the laboratory and watching for them in the field. For observers recording in the field there is much more background "noise" (both literally and metaphorically) from which to detect the signal event. The method employed in the laboratory study involved subjects watching silent films and assessing whether a conflict had occurred. They then recorded any conflicts they had seen while the action was temporarily suspended. They always knew when the next piece of film was about to be shown and could adjust their concentration accordingly. In the field, observers must sometimes concentrate on the situation for long periods at a stretch, and, even when recording an incident, must be aware that other conflicts may be occurring. However, the field has advantages over film in that the observer has full visibility and are themselves flexible and can observe a wider area for the build up of an incident. Even with a wide-angle lens, visibility through a camera is restricted to a fixed area and by its very nature gives a fore-shortening effect. Real life observing also has the added advantage of sound. The noises of horns and tyres can indicate or confirm what is happening in areas outside the direct field of vision. It is unlikely that observers would be subjected to the sensory underload which might lead to vigilance decrement in the present task, as conflicts occur more frequently and are usually more distinct (higher signal to noise ratio) than those encountered in the experimental work on perceptual deprivation which established this phenomenon.

It is, however, necessary to assess the effect of transfer of training in the laboratory to a field situation, and so a second study was carried out by the author at two selected sites, using a new method of recording which incorporated factors that experienced observers used to differentiate the severity grades and which it was hoped would help observers by defining the criteria for detecting and grading a conflict more objectively.

CHAPTER 5

ATTEMPTS TO IMPROVE RELIABILITY AND EASE OF TRAINING

1. Introduction

The effect of transfer of training from the laboratory to a field situation has not previously been examined in conflict observation studies. This is partly because most training recorded in the literature has been carried out on-site. This has meant that intra observer reliability could not be assessed and incidents about which trainer and trainee disagreed could not be re-examined or re-assessed. Furthermore, a great deal of time could be wasted in waiting for sufficient numbers and types of conflict representative of the site to occur.

The present author carried out an investigation (reported in the previous chapter) to assess reliability and accuracy of subjects in a controlled experimental study in the laboratory using filmed material. This showed that unselected casual enumerators can correctly detect and classify conflicts by severity under test conditions but that selection improves the quality of the observers. The next step is to train a small carefully selected group of observers using the same procedure as used in the previous study, and then to assess the effects of the transfer of training from the laboratory to field.

An investigation was also made into the potential of a new method of recording (the factors method), devised initially at the Transport and Road Research Laboratory and developed further by the author, over the traditional grading method, to see if improvements in the detection and subsequent classification of conflicts by severity could be achieved. The way in which this new method was developed is described below.

2. The factors method of recording

Further consideration was given to Spicer's definitions of severity (Table 2, Chapter 2) by Older (1979). Detailed discussions were held with the observers who were regularly involved in this work which indicated that there was some need to amend the definitions. This was based on the following conclusions

1) Grade 1 events (Definition: precautionary braking or lane changing; collision very unlikely) did not satisfy the agreed general definition of a conflict reached at the First International Traffic Conflicts Workshop in Oslo, 1977. According to that definition a collision must be imminent and therefore Grade 1 events cannot be considered as conflicts.

2) Observers found difficulty in classifying many events which, although more severe than a Grade 2, did not appear to be as severe as the Grade 3

definition implied.

3) The above difficulty led to the adoption by the observers of an intermediate Grade 2+, but it proved difficult to provide a clear verbal definition for this grade in terms similar to the others.

Experienced observers were asked what items they took note of in arriving at their judgement. As had been suspected, although severity of evasive action and ultimate proximity of vehicles were used, there were other factors affecting their judgement. It was finally decided that four factors were considered in classifying the severity of a given conflict. These were

i) the time before the possible collision that the evasive action commenced (T),

ii) the severity or rapidity of the evasive action (S),

iii) the complexity of the evasive action (C),

iv) the minimum ultimate proximity of vehicles involved (P).

The following levels of each factor (Table 8) were found necessary to effectively differentiate the 5 grades of severity that were currently in use (ie. 2, 2+, 3, 4 and 5).

Factor	Levels
T Time before collision	Long Moderate Short
S Severity of evasive action	Light (controlled) Medium (controlled) Heavy (less control) Emergency (uncontrolled)
C Complexity of evasive action	Simple (single action) Complex (more than 1 action)
P Minimum ultimate proximity	Near Near miss Very near miss Minor collision Major collision

Table 8 : Levels of the four factors involved in classifying a conflict by severity

The use of the above factor ratings in defining a particular severity grade is illustrated below in Table 9. This table shows the present severity grade value for appropriate combinations of the four factors. It can be seen that factors T, S and P appear the most important, with factor C making a contribution in only a few cases.

	Factor Time	LONG		MODERATE				SHORT			
	Factor Severity	Lgt	Med	Light		Med	Hvy	Med		Hvy	Emer
	Factor Complexity	-	-	S	C	-	-	S	C	-	-
P	Near	2	2	2	2	2	2+	2	2	2+	3
r	Near miss	2	2+	2	2+	2+	3	2+	3	3	3
o	V. near miss	2+	3	2+	3	3	3	3	3	4	4
x	Minor collision	3	4	3	3	4	4	4	4	4	4
	Major collision	5	5	5	5	5	5	5	5	5	5

Table 9 : Classification of conflict grades by factor rating.

The importance of the different factors depends on the value of all the other factors, hence grade cannot be obtained by simply summing the factors. Table 9 shows the grade judged appropriate for each combination of factors. Note that complexity only changes the grade for near and very near misses.

It was concluded that the use of this factor rating approach would prove useful to observers in aiding classification, but that development was needed in the definition of the factor levels. The author has included in the study of observer reliability the first assessment and comparison of the original grading with the new factors method of classification. Since the reliability of observers is a major question of unknown quantity underlying the technique, a method which helps observers classify conflicts by more objective means has important implications for all users of the technique, in both further research and in use by the accident units of the local authorities. Instead of the researchers or full time personnel carrying out their own conflict studies, casual observers could be recruited and trained. The author used the factors method to train half the observers in the study to be reported here. The other half were trained using the traditional grading method.

3. Method

In response to a newspaper advertisement, 20 people were chosen as subjects by the author and a member of Nottinghamshire County Council's Traffic Division. Those selected were typical of the usual kind of enumerator employed to carry out routine surveys such as origin and destination surveys, seat belt usuage, classified traffic counts of vehicles and pedestrians, bus occupancy and passenger interviews, roadside questionnaires, quantity and duration of parking and so on. The subjects were randomly assigned to two groups. One group was trained to record conflicts with the grading method used in the previous study, and the other used the new factors method described earlier. Some modifications were made to the factor levels by the author to help subjects differentiate between them on more objective criteria. The main change involved definition of the proximity factor which had three levels: near, near miss and very near miss. The levels had not previously been defined objectively, so the author equated the levels to measures of distance: more than 30', 15-30' and less than 15' respectively. On the basis of a pilot study, these were later changed to measures of car length since there were readily available yardsticks in the traffic environment. This proved more reliable and accurate than assessments of distance measured in feet. Thus the three levels of the proximity factor became: more than 2 car lengths, 1-2 car lengths and less than one car length respectively.

The time factor, divided into three levels: long, moderate and short, also initially proved a difficult measure to apply since time in this context is a function of speed and distance, both of which are notoriously subjective components. If the average speed of vehicles passing through a site on the major through route is known then the levels can be equated to approximate distances, and as such will vary between different sites. At urban intersections where the average speeds are usually less than 30mph the distances will be very similar at most locations. The final recording sheet used for the group recording with the factors method is shown in Figure 8. The combination of the four factors can subsequently be used to obtain conflict grades and the conversion of factors to grades has already been illustrated (Table 9).

Factor	Level	✓
1 TIME before possible collision when evasive action commences	i) Long time ii) Moderate time iii) Short time	
2 SEVERITY of the evasive action	i) Light braking and/or swerving ii) Medium braking and/or swerving iii) Heavy braking and/or swerving iv) Emergency braking and/or swerving	
3 TYPE Whether evasive action comprises one or more types	i) Simple - either braking or swerving alone ii) Complex - both braking and swerving	
4 PROXIMITY Distance between conflicting vehicles when evasive action terminated	i) More than 2 car lengths ii) Between 1 and 2 car lengths iii) One car length or loss iv) Minor collision v) Major collision	

Figure 8 : Layout of recording sheet for factors method.

Using this method, two observers might record an event differently, but when the factors are converted to grades, the resultant grade may be the same. For example, if one observer recorded an event as

long, light, simple and 1-2 car lengths"

and another recorded the event as

"moderate, light, complex and more than 2 car lengths"

and yet another as

"short, medium, complex and more than 2 car lengths"

these would all be transposed via Table 9 to Grade 2. In other words, there can be a greater variability between observers but this is taken account of when the factors are reduced to a grade. The dependency among the factors provides redundancy which enhances performance. There is no such flexibility in the grading method.

While Older (1979) speculated that this method would prove useful to observers in aiding classification, this study was the first application of it in practice. Recognition of its usefulness, including the modifications made by the author, has since been ratified (Baguley, 1982). The films used to train observers were composed of the same events used in the previous study, but the total number was reduced from 72 to 60. Some of the more controversial events were omitted. These were the incidents where the grades allocated to it previously were widely distributed, with no clear consensus. Subjects were then taken out to observe on-site with an experienced observer at two different sites.

4. Results

The results are presented in two parts: firstly those concerned with the results of training on the filmed incidents in the laboratory, and secondly the results of the field observations.

4.1 Laboratory training

Only 15 incidents were used to test intra subject reliability, using the Spearman Rank Correlation Coefficient, rs, which was 0.80 for the factor group and 0.73 for the grades group, suggesting some difference between the two. The correlation with the criterion values for the factors and grades groups were rs = 0.76 and 0.66 respectively. In order to test the differences between the groups for significance, the percentage of conflicts and non-conflict events correctly identified by recording method was calculated and is shown in Table 10.

	FACTORS (N=10)	GRADES (N=10)
% conflicts correctly identified	97.3	90.2
% non conflicts correctly identified	85.0	80.0

Table 10 : Percentage of conflict and non-conflict events correctly identified by recording method

The difference between the two groups is significant at the 0.001 level ($X2 = 17.14$). This suggests that detection is not independent of the recording method. In the factors method, subjects may be detecting the conflict and then classifying it. In the grades method, subjects may more consciously be searching for typical behaviour defining a conflict, so that grading effectively precedes detection.

Table 11 below shows the effect on the intra subject correlation coefficients and the correlation between subjects and criteria by recording method, of eliminating various numbers of the poorer observers in this study.

	Intra subject correlation coefficients		Correlation with criteria	
Eliminate lowest...	Factors N = 10	Grades N = 10	Factors N = 10	Grades N = 10
0	0.80	0.73	0.76	0.66
1	0.82	0.75	0.78	0.68
2	0.83	0.77	0.80	0.70
3	0.85	0.79	0.81	0.73
4	0.86	0.80	0.82	0.75
5	0.88	0.82	0.83	0.76
6	0.91	0.83	0.84	0.77
7	0.92	0.86	0.84	0.78
8	0.94	0.89	0.85	0.79
9	0.96	0.89	0.85	0.79

Table 11 : Effects of eliminating various numbers of subjects.

Table 11 can be compared with Tables 5 and 6 which showed the effects of eliminating various percentages of observers from their intra observer correlation coefficients and correlation with the criteria in the Reliability Study. The comparison shows that the intra-observer correlation coefficients are higher overall in the present study (0.80 for the factors group and 0.73 for the grades group compared with 0.65 previously). Similarly the correlation with the criterion values (0.76 for the factors group and 0.66 for the grades group compared with 0.60 previously). These figures compare the results of the observers in each study at the same stage in training. Elimination of observers in the present study brings the correlations to an equivalent level to that reached in the previous study for the grades group and a higher level for the factors group. The factors method produces consistently better results than the grades method.

4.2 Field observations

The main method of analysis was by Venn diagrams, and the raw data appears in this form in the Appendix, Figures 20 and 21. The figures within the circles denote the numbers of conflicts detected by each observer. The numbers of conflicts detected by each observer is compared to the criterion number, and the number of conflicts common to both is shown as a measure of detection.

As it was clearly impossible to have 20 observers at one site together, they were divided into three groups, each group composed of approximately half using the factors method and the rest using the grading method. Observations were taken over the same period on the same day of each week. The results of each group at the two sites have to be considered independently due to the differential numbers of conflicts occurring ie. Site A produced 28 conflicts in Week 1, 8 in Week 2 and 18 in Week 3. Site B produced 18 in Week 1, 25 in Week 2 and 21 in Week 3. Due to the differential numbers of subjects using each method comprising the groups by week, the numbers of events are different for the factors and the grades groups. The percentage of events correctly identified is shown in Table 12 by site and recording method. Clearly there has been a considerable drop in the detection rate from over 90% in training to 63% for the factors group and 53% for the grades group, a difference significant at the 0.01 level ($X2 = 8.26$). The possible reasons for this are examined below.

	Site A	Site B	Sites A + B
Factors	60.0%	65.2%	62.8%
Grades	50.6%	54.5%	52.7%

Table 12: Percentage of events correctly identified by recording method

There were three main problems: linking each event across subjects, the criterion for each being established simultaneously, and the weather. These are elaborated below.

While all the subjects synchronised their watches at the beginning of each observation period, it was apparent that some observers put down the time of the conflict as that when they had finished writing instead of the actual time. Thus there tended to be differences in the recorded times of each event. This was not too much of a problem to overcome so long as each observer had recorded the incident with some details of colour or make of vehicle along with the manoeuvres. But sometimes a run of minor conflicts became indistinguishable and there was difficulty in matching up any one event with those recorded by other observers. Observers also tended to miss some events while writing down a previous one, despite being told to continually watch for other incidents. Simultaneous video-recording would have helped to clear up the discrepancies. Subjects could also have been instructed to record only serious events or alternatively to ignore minor precautionary and rear-end conflicts of which there were a considerable number.

The second reason to account for the drop in the detection rate, concerned the establishment of a criterion for each event simultaneously by an experienced observer. The disadvantages of this method have already been considered when reviewing the literature on reliability studies, although, to avoid subjects copying the experienced observer, he stood behind the subjects. The use of an experienced observer instead of using simultaneous video recording was due to the third problem: the weather.

Although obviously no figure can be attached to it, the intensity of the cold when this study was carried out did nothing to enhance the quality or quantity of the data. On each occasion of the on-site trials, the subjects had to sit for several hours with no shelter in temperatures below 5°C. On one occasion there was sleet for an hour. The weather was unseasonable cold for the time of year (May) and had turned from mild to bitter very suddenly and without due warning, or the whole study would have been postponed. No video or film set up would reliably operate at these temperatures. There was no facility for parking vehicles and observing from these, and it says a great deal for their loyalty that the subjects stayed for the pre-determined observation time. Due to these difficulties the results should be regarded as estimates derived under the severest of conditions and not necessarily representative of transfer from laboratory to field under normal conditions. In fact, they probably represent the worst that could be expected. Overall, it seemed that subjects tended to attend selectively and record a sample of all the conflicts that occurred. However, the serious ones were recorded by most of the subjects, but there were insufficient to analyse further.

5. Conclusions.

Transfer from laboratory to field is likely to cause some deterioration in the quality or quantity of conflicts reported. It was found that the detection rate dropped by about one-third. There was no means of estimating intra observer reliability in the field. How many events are missed may not be so important as long as observers record a representative sample of the distribution and type of all events that occur at a site. Thus, although one observer may differ from another in which events are recorded, both sets of records would be equally representative. However, observers are more likely to record serious conflicts. As these are the ones used most often to validate the Traffic Conflicts Technique because of their assumed closer relationship with accidents, the quantity and quality of this category is likely to be a more accurate reflection of both the number and type of these incidents.

The grading method has acknowledged disadvantages. Almost no matter how fine the classification system is, there are complaints that a certain event falls between two grades. The factor method has the advantage of flexibility. When transposed into grades, several alternative combinations result in the same grade. It thus takes account of minor differences between observers. In fact, it appears that the factor method actually aids in the detection process, since those using this method detected significantly more conflicts from the films and in the on-site observation periods ($p<0.001$ and $p<0.01$ respectively). It was therefore concluded that the factors method should be used instead of the grades method in future studies.

The results of the first reliability study and the above study are summarised in the following chapter, and their implications for the training package discussed.

CHAPTER 6

SUMMARY OF RESULTS OF RESEARCH INTO OBSERVER RELIABILITY PRESENTED IN CHAPTERS 4 AND 5.

SUMMARY

The issue of reliability is a common one wherever methods with a subjective element are to be applied. It is necessary to ensure that any recording technique accurately describes an event. How observers will apply this technique is another matter entirely. It is generally recognised that the level of agreement varies according to what is being measured. If the response is in binary form (Yes/No) then reliability is likely to be high. For example, whether two vehicles are involved in a conflict or not. The severity of the avoiding action is much more subjective. Objective criteria are needed to define a classification system that segregates each category from all of the others. Defining behavioural events in classes that exclude all but what is specified is not an easy task, since most behavioural events are continuums, and the imposition of upper and lower limits is, to a certain extent, arbitrary. Without mutual exclusivity, observers will seldom return identical records of the same behavioural event. While reliability studies of observers have been carried out by workers in this area, reports are few, sketchy and incomplete. Results are frequently only reported as a finding, rather than as a useful tool for selecting or as a means of comparing lengths or methods of training, or to check on improvement due to feedback or experience.

Discussion of methods of measurement used show two in common usage and one other. The first two are inter and intra observer reliability, and the third is comparison with a pre-set criterion. The latter is suggested as being the most useful as it will give information on the first of the two main elements in conflict observation that are open to subjective judgement, namely detection of conflicts from non-conflict events, but it has not previously been used in reliability studies of vehicle- vehicle conflicts. It is also possible to examine observers' severity classification of a conflict against a criterion value, the second main element.

It was discovered that Local Authority Accident Investigation Units already used the Traffic Conflicts Technique to diagnose and evaluate remedial measures, but were concerned that, while traffic engineers could apply the technique because they understood the underlying issues involved, casual enumerators could not be trained to reliably detect and grade conflicts. This prejudice was preventing many conflict studies from being carried out because the traffic engineers in the units could not spare the time to do them themselves. In order to examine whether there was any substance to this prejudice, two studies were carried out. The first was to see if, and if so, how well, subjects drawn from the general population, having no professional interest or association with traffic or road safety, could learn to apply the technique to filmed incidents shown in the laboratory. The second was to test the transfer of training in the laboratory to on-site observing, and the superiority of a new recording method. The studies were carried out with the ultimate aim of using the findings to help in producing a training package suitable for use by local authorities for their casual enumerators.

The first study, the Reliability Study, showed that a group of unselected subjects gave a wide variety of levels of performance, from poor to very good (r_s = 0.30 - 0.91) but that the best subjects can be identified and selected for further training at an early stage. Whereas the detection rate was generally good, the grading of detected conflicts was not so encouraging since only about half the conflict events shown were correctly detected and graded. A further forty percent of the conflicts were correctly detected but given a grade lower than the criterion value. It was concluded that this was partly due to the brevity of training, but that a better way of helping observers to assess and grade the conflicts was required.

In the second study, an alternative method of grading conflicts was introduced and compared with the traditional method. This system is known as the factors method and was first proposed by Older (1979). The results of a small pilot study developed the levels of some of these factors so that they were more objectively defined. There were significant differences between the detection rates of the two groups of subjects both on the films and in the on-site observations ($p<0.001$ and $p<0.01$ respectively) even though the individuals had been assigned to each group randomly. Therefore these differences must be due to the method of recording used. The factors method actually appears to aid in the detection process. It was suggested that, using the factors method, subjects may be detecting the conflict and then classifying it, whereas using the grades method subjects may more consciously be searching for typical behaviour defining a conflict, so that grading effectively precedes detection. The high level of correctly identified incidents that could be expected from casual observers watching filmed events was confirmed with the factors group correctly detecting 97.3% of the conflicts and the grades group detecting 90.2%.

When the subjects were asked to apply their laboratory training to a field situation, the detection rate dropped by about a third. The reasons for this were partly methodological and partly environmental. The former concerns the difficulties found in matching conflicts recorded by several subjects at a site simultaneously. For the few severe conflicts this proved relatively simple, but subjects seemed to be "sampling" the lower and more frequent grades of conflict. The way to overcome this difficulty would be to have simultaneous video recording to check against subjects reports at a later date, or to ask them to concentrate on the more serious events only. The sampling occurred mostly with the minor precautionary and rear end conflicts and these seldom result in accidents.

The results of the two studies confirmed that subjects similar to the enumerators used by local authorities can detect conflicts shown on films from non-conflicts to a high degree, but that this ability may be reduced when training is transferred to on-site observing. Problems arise when grading of the incident is required, but the factors method of recording seems to overcome some of the problems associated with the traditional grading method. The former is more flexible in that it allows for some slight variation between subjects without affecting the ultimate grade awarded, and also seems a useful aid to the observers in detection as well as classification by defining the factors to be considered.

It had been established by a survey of Local Authority Accident Investigation Units that a need and desire for a training package existed, and the above studies have shown that their enumerators could be selected and trained to detect and grade conflicts to an acceptable level using the factors method. The next step would be to prepare a training package based on the training used and the results of the studies carried out in Chapters 4 and 5. The development of this training package is described in Section B, (Chapter 7) and the manual reproduced in the Appendix.

SECTION B : THE DEVELOPMENT OF THE TRAFFIC CONFLICTS TECHNIQUE TRAINING PACKAGE

CHAPTER 7

THE TRAINING PACKAGE

1. Introduction

2. Review of the literature

3. The theory of report writing

4. Structure of the manual
   - 4.1 Rationale for conflict studies
   - 4.2 Designing a conflict study
   - 4.3 Training observers
     - 4.3.1 The introductory training manual
     - 4.3.2 The training film
     - 4.3.3 On-site trial observations
   - 4.4 Executing a conflict study
   - 4.5 Film and video techniques

5. Conclusions

1. Introduction

From the results of the reliability and transfer of training studies, the author prepared a manual and training film which is now on trial at a number of local authorities. The following chapter describes its development. The manual is reproduced in the Appendix.

In order to determine what should be included in the training package, a small number of local authority accident investigation units were visited to further assess their current use and applications of conflict studies one year after the initial survey (The Local Authority Accident Investigation Unit Survey described in Chapter 3). It was also important to gather opinions on the form in which the relevant information should be presented, as it seemed sensible that the format as well as the contents should be influenced by the target population.

Seven authorities were chosen, all favourably disposed towards conflict studies which they had made some use of in the past. They therefore had some knowledge of the technique in use, and would likely be acquainted with the problems of training and recording.

The only concession to using other than full time staff to carry out conflict studies since the previous survey, was made by one unit whose casual enumerators identified conflict events from films which were then edited out for viewing and classifying by unit staff as a group of conflicts specific to a location. In other words, enumerators were being used as a filter to detect signal events from non-signal events or noise, but not to classify them in any way. At least one or two of the full time staff from each authority had completed the Departmnent of the Environment's Accident Investigation and Prevention Course at RAF Cardington, which is the main training establishment in accident studies for local authority and police personnel. The survey revealed that the accident units considered that there was a gap in the handbook associated with the course (DOE, 1974) with regard to conflict studies. While conflict studies are proposed in the handbook and on the course itself as a useful diagnostic and evaluative tool in accident investigation, there is litle constructive detail on the planning, design and execution of such studies or the selection and training of potential observers.*

The accident units were asked about the type of information required and the format that would be most useful. The conclusions were that the package should

* The organisers of the course subsequently acknowledged this omission and invited the author to lecture on their tri-annual courses from 1981.

comprise a training manual and an associated film, and that information in the manual be included on the rationale for conflict studies and the design and execution of a conflict study. In particular, it should cover the following topics:-

i) recommendations on choice of observation period (time of day, day of week etc)

ii) form design for recording conflicts

iii) numbers of observers required

iv) positioning of observers on site

v) survey duration

vi) film and video as alternatives to observers on-site

vii) use of conflict data with descriptions of accidents

The film would be used for training and assessing potential observers, with advice on its administration as a training aid, and full details of the filmed incidents and their severity to be included in the manual.

A review of the literature on other similar manuals follows, and there is a brief discussion of the theory of report writing with emphasis on the present task, before returning to details of the process of development of the final package, and the theoretical and practical problems involved in its completion.

2. Review of the literature.

The need for such a training aid had been recognised in the literature for some time. Zimmerman, Zimolong and Erke (1977) were the first to mention the potential usefulness of a training manual. It is now available as an English translation (Erke, Gabner, Gsalter and Zimolong, 1980). This is a self instructional manual only (no film) and includes notes on the use of the technique and the definitions of types and severity of conflicts using annotated diagrams, and examples of the recording sheets used. It is however, only for use at traffic light controlled junctions. While giving ample diagrammatic examples of conflicts at these specific locations, it does not recommend the correct answers to the set exercises, only suggesting that the trainees discuss the answers with the training leader. As this may lead to differences in interpretation, the present author decided to include a criterion interpretation of each event on the training film in the manual for standardisation purposes. Neither were there details of its administration or of the planning and execution of a conflict study. It was clearly a document for use only by workers in the area, specifically research workers, and was not suitable for the needs of the local authority accident units. Furthermore, its application to signalised junctions only limits its more general use.

Glauz and Migletz (1980) report work on traffic conflicts in the United States, and since 1977 have been researching and preparing

> "a readily usable procedures manual that clearly and concisely describes the recommended training procedures, data collection methodology, analysis technique, and evaluation methods."

Their programme should now be complete and the final report is soon to be published by the Transportation Research Board, but is not available at the present time. Its aims seem closer to those of the present package although no mention is made of a training film to accompany the manual.

These manuals are not intended to compete with one another for general acceptance. They have been researched in three different countries whose methods, needs and uses for the technique vary. The manuals reflect these requirements respectively. Because of these manuals, however, it is expected that the quality of data gathered and the results will subsequently improve, and that other countries will follow in standardising and documenting their own training methods so that results will be more reliably based. There follows a brief treatise on the aims of reports according to Ward (1977), with reference to the intended package.

3. The theory of report writing.

Ward (1977) suggests that the author of any document should answer certain questions to clarify his aims and intended readership. The questionnaire he suggests is reproduced below together with appropriate answers for the proposed traffic conflicts technique training package.

<u>What is the title of the report</u>?

1) A manual for the selection, training and deployment of personnel for the study of traffic conflicts.

2) The traffic conflicts technique - a guide for its implementation and use.

3) Traffic conflict observation studies - a manual for the training of personnel

4) The traffic conflicts technique training package.

<u>What action do you want this report to trigger off</u>?

1) For the conflict technique to be recognised as a useful supplementary tool in accident investigation.

2) For local authorities who do not already do so to use conflict studies to supplement accident data.

3) For all local authorities to train and evaluate potential observers to the same high standard.

4) For all local authorities to record conflicts in a standardised form.

5) For remedial measures to be based on the results of such studies.

6) For remedial measures to be evaluated by their further use.

What group of people will be the readers?

a) Initially, TRRL personnel.

b) When they consider it is satisfactory, it may be introduced to a selected group of local authorities to evaluate.

c) Eventually by all local authority departments with responsibilities for accident analysis and prevention.

d) A further group are other research workers in this field who might find it useful in training people in the conflict technique for their own investigative purposes.

<u>How many of them are there</u>?

a) At TRRL - Road User Characteristics section.

b) Approximately half a dozen.

c) Local authorities - 53 in England, 32 in Wales, ? in Scotland and Ireland, plus eg. Greater London Council.

d) Research bodies at home and abroad - approximately 20 institutes.

<u>What is their level of knowledge of the subject</u>?

a) Very high, among the forerunners in developing the technique in the UK.

b) and c) Varies between non-interest (few and rare) through approval but non-implementation because of lack of funds available, through actual implementation often using vague,non-standardised training and recording procedures.

A good report should give the reader an insight into a subject which concerns him. It should also give the impression that he can derive benefit from reading it. The benefit associated with the proposed manual can be described in a number of ways:-

i) the manual may increase his knowledge of the subject matter.

ii) he may find that he can use the technique described to aid his efficiency.

Hopefully it can do both.

Basically the proposed manual will serve two types of reader.

I) those who want to grasp the essentials quickly, and

II) those who want to critically assess the theory and reasoning before acting on the recommendations

Neither group should be neglected, since those in the first group might be converted into the second group on the basis of what they read. Group I will only concern themselves with the

Title + contents + summary + conclusions

so these should be able to stand on their own. The title should be informative and should tell the reader what it is about. It should interest the reader sufficiently that he will open it up and look further. The first question in anyone's mind is

"Why should I spend my valuable time reading this?"

To retain interest, the message must be clear, concise, relevant, appropriate and informative. Figure 9 illustrates how the component parts of the manual could be filtered by a reader.

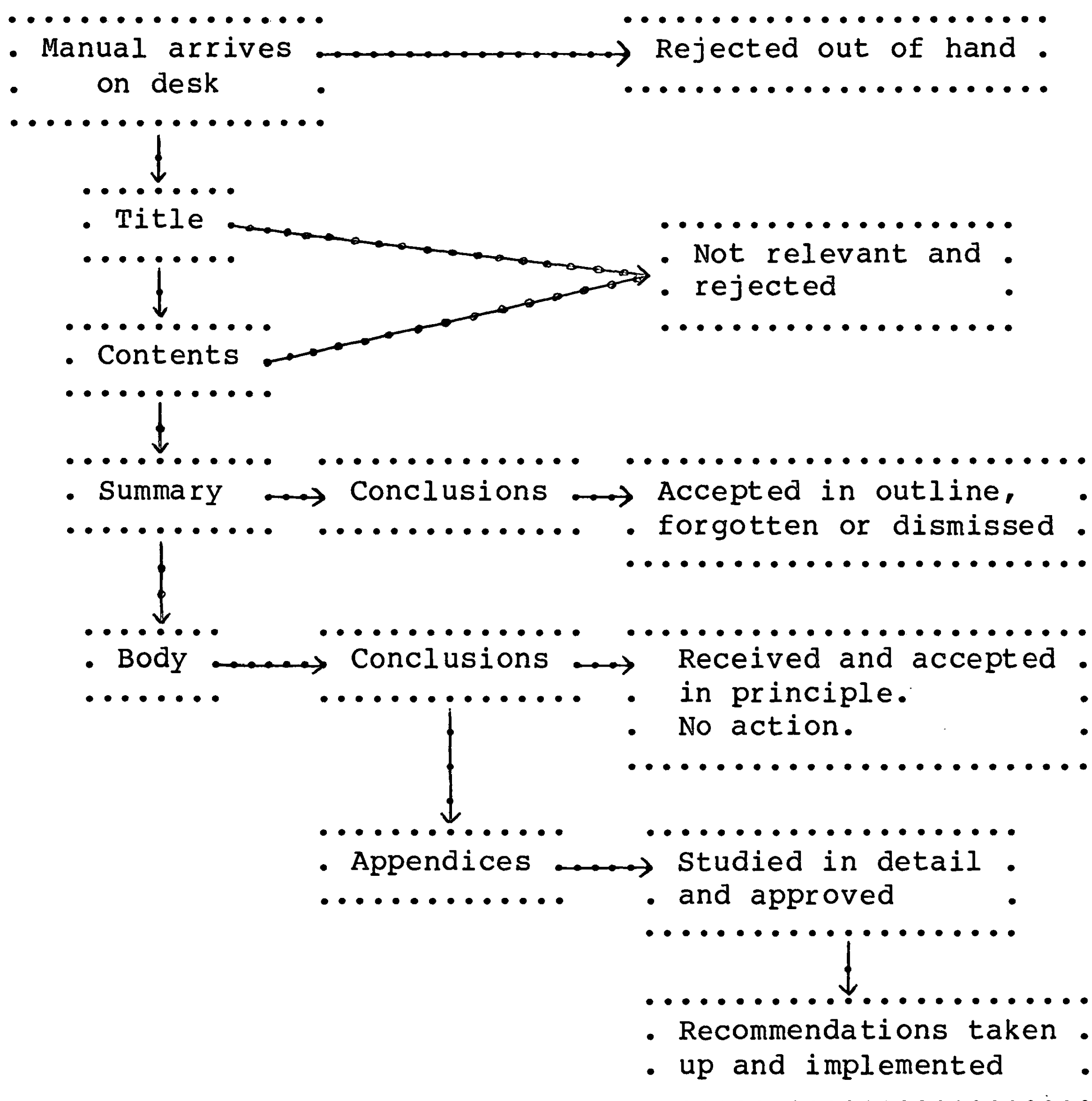


Figure 9 : Flow diagram to illustrate how the component parts of a manual can be filtered by a reader (based on Ward, 1977)

If the reader has got past the title, he will inevitably investigate the contents page to see if it is worth his while reading further. The contents will be his way of assessing the whole's potential value, its structure and what is relevant and what is irrelevant to him. If he is encouraged to dip further, he will probably go to the summary or abstract. For this reason

a) there should be one, and

b) he should be able to find it easily from the contents page.

Usually it is found directly after the contents anyway. This will provide light on the size of the reading task as a whole, and should give a clear but brief account of the order of the proceedings and of the conclusions and recommendations.

It was decided to call it the Traffic Conflicts Technique Training Package, as this covered both the manual and associated film. The main aim of the manual and film were to formalise and standardise a programme for accident unit staff to train their enumerators to record conflicts with a reasonable degree of reliability and accuracy. Reliability in this context is taken to mean intra enumerator consistency. Accuracy implies precise assessment of the two elements of conflict identification, namely detection and classification, when measured against a criterion.

A secondary aim was to place the training and selection of observers into the context of designing and executing conflict studies. Further, while it would be expected that most accident units would not appreciate a long thesis on the state-of-the-art of current research, a short rationale for conflict studies was considered appropriate.

4. Structure of the manual

It was therefore decided to structure the manual in the framework of a logical sequence, beginning with the rationale, going on to the design of a study from choice of site up to selection and training of observers, through to its execution and interpretation of results. For those who might prefer to use film or video techniques as alternatives or supplementary to on-site observers, some notes were included for guidance. These contents covered all the information requested by the accident units. The contents are elaborated in their five component parts below.

4.1 Rationale for conflict studies.

In this short theoretical section, there were four aspects that needed covering. The first concerned the idea that conflicts are "accidents that have been avoided" and that their study will lead to greater understanding of the factors involved in accident generation.

The second aspect covers the need for data supplementary to the unreliable and incomplete statistics available on accidents. This leads on to the third and fourth aspects, namely the advantages and limitations of conflict studies respectively. The former includes the extra information that can be obtained on the events preceding and leading up to a conflict, and their frequency in comparison to accidents. The latter point out that it is still not clear whether conflicts are directly related to accidents, and that subjectivity in recording conflicts, which is the concern of this package, can affect both the quality and quantity of the data collected. The inclusion of both the advantages and limitations of conflicts as a measure of accident potential should help put the value of conflict studies into perspective.

4.2 Designing a conflict study.

It was considered necessary to go through the procedure of design in logical order, beginning with the reasons why conflict studies are likely to be carried out. There are three main reasons:-

1) to supplement existing accident data,

2) to evaluate remedial measures, and

3) to provide a means of assessment in the absence

of an accident history.

The last of these is particularly pertinent to the accident units because of the large proportion of their work that is due directly to public pressure (up to 70%) mostly at sites with few or no reported injury accidents eg. in suburban locations after a single fatality or at new locations such as motorway contraflow sites. Retrieval and scrutiny of relevant accident data is always the first step, but personal inspection of the site is recommended for first hand experience of possible problems.

Caution is advised in the choice of time of both day and year, as well as day of week to coincide with any accidents or reported difficulties wherever possible. The number of observers needed will greatly depend on the layout of the site and the manoeuvres of the vehicles involved, as well as the length of the study, but generally one per approach is sufficient. However, where two or more observers are recording at a site simultaneously from two different approaches, care should be taken to ensure that they do not record the same conflict twice, thereby giving an overestimate of the number of conflicts that occur. This can be resolved by ensuring that they only record within limits of distance or certain vehicle manoeuvres.

The idea of using their own temporary enumerators to carry out conflict studies is put forward as both feasible and practical by using the fully documented training procedures laid down in the manual. The advantage to the traffic engineer is that if an appropriate number of enumerators could be brought up to a satisfactory standard quickly and easily, then they would be freed from this time-consuming occupation. The means of doing this is by using the training scheme together with the film provided as outlined in the manual.

4.3 Training observers

This part forms the bulk of the training manual and is divided into three: the Introductory Training Manual, the Training Film and On-site Trial Observations. Each is divided into three sections: administration, scoring and satisfactory levels of performance.

4.3.1 The introductory training manual.

This concerns initial orientation and familiarisation with the detection of conflicts only. Severity is not introduced at this stage.

i) Administration

This section concerns the administration of the question and answer booklet called the Introductory

Training Manual, which the trainee is given to read, and then answer questions on. In it the definition of a conflict is expounded and explained in words and diagrams, and then examples are given of the situations in which conflicts at intersections can arise (eg. crossroads, T-junctions) and the types of conflict (eg. right turn, rear end) that occur. Each type is illustrated in line drawings and a brief description given. The trainee is then required to complete 10 simple exercises, some showing a diagram of a conflict situation and asking the trainee to explain what type of conflict was illustrated, others requiring the trainee to draw on a layout diagram of an intersection the positions of vehicles involved in, for example, a right turn conflict at a T-junction. During the exercises, the trainee is allowed to look over the examples given and is encouraged to take as long as required to complete them to his satisfaction. This is acceptable since it is understanding rather than memory that is being tested.

ii) Scoring.

A scoring sheet detailing criterion answers is given and the trainee must pass the exercises at a high level.

iii) Satisfactory levels of performance.

As these exercises are fairly simple and straight-forward, and the understanding of these principles is the groundwork on which more complex issues regarding the recording of conflict studies will be based, it is essential that the trainee gets all 10 answers correct before continuing. Any questions which have been incorrectly or incompletely answered can be discussed and any ambiguities sorted out, but a level of less than 70/80% is considered likely to indicate that the trainee will be an unsatisfactory conflict observer.

4.3.2 The training film.

This section concerns the administration, scoring and performance levels of the training film, and introduces the classification of a conflict by severity. A suggested verbal commentary for the instuctor to read to the trainee was included for each piece of film, describing the build up and occurrence of the conflict shown. For the trial pieces of film which the trainee has to evaluate, there is a diagram of the conflict in question detailing the type and colour of the vehicles involved, their manoeuvres before and after the event, the evasive action taken and the grading required. This information is for the benefit of the instructor and in order to assess the answers given by the trainee.

The training film is composed of the following film clips. At the beginning there are 120 seconds of film to enable the instructor to explain the layout of the intersection to the trainee, pointing out road markings and priority through routes and other relavant details. Each clip was prefaced by frames showing the numeral relating to it.

The next three clips show examples of the levels connected with Factor A: how long before the potential accident did the evasive action commence?

Clip no.	Level of Factor A
I	Long
II	Moderate
III	Short

Diagrams of the filmed examples are also available for the trainee to view at the same time.

The next two clips (IV and V) are trials concerning Factor A only for the trainee to answer on a recording sheet.

Clips VI - IX give illustrations of the levels connected with Factor B: how severe or rapid was the evasive action?

Clip no.	Level of Factor B
VI	Light
VII	Medium
VIII	Heavy
IX	Emergency

Diagrams of the filmed examples are also available for the trainee to view at the same time.

The next two clips (X and XI) are trials concerning Factor B only for the trainee to answer on the recording sheet.

Clips XII - XIV illustrate the levels connected with Factor C: was the evasive action simple or complex?

Clip no.	Levels of Factor C
XII	Simple (braking only)
XIII	Simple (swerving only)
XIV	Complex (braking and swerving)

Diagrams of the filmed examples are also available for the trainee to view at the same time.

Clips XV - XVI are for the trainee to assess for Factor C levevls only.

Clips XVII - XIX show examples of the levels associated with Factor D: how close did the conflicting vehicles get?

Clip no.	Levels of Factor D
XVII	Near (2+ car lengths)
XVIII	Near miss (1-2 car lengths)
XIX	Very near miss (<1 car length)

Diagrams of the filmed examples are also available for the trainee to view at the same time.

The next two clips (XX and XXI) are to be assessed by the trainee for Factor D levels only.

Finally, there are six clips (XXII - XXVII) which the trainee has to assess for all four factors.

ii) Scoring

A scoring sheet with the correct answers for all the trails is given in the manual.

iii) Satisfactory levels of performance.

Minor deviations are to be expected but should not be more than one level different from the criterion given in the scoring sheet. Neither should they occur too frequently. The first eight trials where the trainee has to pick just one level of a factor for each clip should be 100% correct. In the six trials where all four factors have to asessed simultaneously, a minimum 75% agreement with the criteria is acceptable (ie. 3 out of 4 factor levels correct), provided that the combination would transpose to the same grade as the criteria. An alternative is therefore to convert the factors to grades, in which case the agreement should be 100%.

4.3.3 On-site trial observations.

In this section, which is again divided into administration, scoring and satisfactory performance levles, it is suggested that a suitable site be chosen and the trainee's transference from training on films be assessed in the field. Simultaneous recording using video or film, or an experienced observer recording simultaneously are advised, so that the two elements of detection and classification by severity can be assessed.

Now that the conflict study has been planned and the observers trained to a satisfactory standard, the study can go ahead.

4.4 Executing a conflict study.

Advice is given on getting observers to the site and the necessity of positioning them so that they can see clearly the events leading up to conflicts but remain inconspicuous. Attention is drawn to the importance of checking the site for road works or other disruptive elements prior to starting to ensure a trouble free study. A major concern of the units was that of survey duration, and discussion and recommendations are included on this.

4.5 Film and video techniques.

Some accident units may decide to use such techniques as alternatives or supplements to observers. Information was requested by them on the advantages and disadvantages of film and video recording, in terms of the cost of the equipment, the benefits and limitations of each type of record and the time taken to obtain them. The main disadvantages of film or video is the expense both of the equipment and the time taken to analyse it. Some records of this type may take several times their real-time to analyse thoroughly. Observers' records may not be quite so complete, but the results are available for inspection and analysis immediately and relatively cheaply.

The complete package (Lightburn, 1981) is now being evaluated by a number of local authority accident units. The time taken to complete the training as laid out in the package will depend on the ability of the trainee to assimilate the ideas presented, but it is not anticipated that it will exceed three hours. It can be completed in one complete session or in several smaller units of time. The whole package or parts of it may be repeated or used occasionally as a refresher course, or to check observers' consistency over a period of time.

5. Conclusions.

Local Authority Accident Investigation Units place a good deal of stress on the small road improvement schemes (DOE, 1975) since these can produce large savings at small outlay and justify high priority in road safety programmes. But to identify the most profitable solutions yielding an economic return on capital invested means careful analysis, a study of problems, and the evaluation of options. In a previous survey of all Local Authority Accident Investigation Units, it was revealed that most thought that the Traffic Conflicts Technique could help identify operational deficiencies and suggest suitable remedial measures. Despite doubts in the research fraternity as to its validity, great interest was shown in applying the technique. At the time, there were no guidelines on the best methods of training observers or of recording, since much of the work was still in the developmental stages. Most authorities used part time enumerators for general observation work other than conflict studies. These people were often part of a pool available at short notice, and had already shown themselves to be accurate and reliable on previous studies. With the aid of this training package it should be possible to convert this relatively unskilled pool into an objective team capable of carrying out conflict studies and obtaining reliable data.

It has been shown that the subjective judgements on which the technique is based are reliable, the best method of recording conflicts has been established, and a manual has been developed to select and train observers in the Traffic Conflicts Technique to a high standard. It is now possible to attempt to test the validity of the technique in the knowledge that its reliability when applied by casual enumerators such as those used by Local Authority Accident Investigation Units is known. Local Authorities are mostly concerned with the accident problem in urban areas, particularly at junctions where 60% of all injury accidents occur. It is therefore necessary to test the technique's validity in these situations, which to date has not been done, in order to establish whether it can be used for supplementing the unreliable and scarce accident data, and for diagnosis and evaluation of minor remedial measures at these locations.

SECTION C : VALIDITY

CHAPTER 8

THE ISSUE OF VALIDITY

1. Introduction

2. Methodological issues
   2.1 Variability of conflict occurrence
   2.2 Variability in research definitions and techniques
   2.3 Variability of the conflict to accident ratio
   2.4 Using injury accident data to validate the technique

3. Review of the literature
   3.1 Conflicts and accidents
   3.2 Conflicts and flow

4. Conclusions drawn from the literature

5. Aims of the validation study

1. Introduction

It has been suggested that a hierachy of traffic events ranging in severity from slight conflicts to fatal accidents exists. This assumption has a certain face validity which has meant that the traffic conflicts technique has been widely accepted, despite the fact that many studies indicate a poor relationship between conflicts and accidents. Validity is most often defined as a measure of association between a predictor and a criterion variable. Before the use of conflict studies can be accepted as valid, it must be shown that events leading to situations where evasive action is taken and an accident successfully averted (the predictor) are similar to those leading directly to accidents (the criterion variable). Despite favourable results in validity studies by some researchers, other studies have found only poor or no correlation between accidents and conflicts. There are a number of methodological issues to be considered.

2. Methodological issues

These have been divided into the following categories,

2.1 Variability of conflict occurrence,

2.2 Variability in research definitions and techniques,

2.3 Variability of the conflict to accident ratio

2.4 Using injury accident data to validate the technique

and the ways in which these may contribute to poor results and how or if each may be improved are discussed below.

2.1 Variability of conflict occurrence.

This refers to the question of consistency of conflicts over time. This is, in effect, the test/retest reliability of two studies carried out on different occasions at the same site. Variability inherent in the occurrence of conflicts may be due to several factors, each or all of which may influence the expected number of conflicts. These include variability from day to day, week to week, one season to another, and these in turn depend on traffic volumes, weather and light conditions.

In theory then, if studies are not carried out on days representative of the site as a whole, then the conflicts obtained will not be sufficiently representative of their long term values. This raises the problem of when to carry out a study and how long the study should be. Thorson and Glennon (1975) considered that the sample sizes needed were so large that it would prevent the practical application of the technique in any circumstances. This conclusion, if true, would have far-reaching consequences. As this very important issue had been reached on the basis of limited empirical data, Hauer (1978) considered it worthy of careful re-examination. He said that the aim of a conflict study is to obtain staisfactory estimates of the "expected conflict rate", where "expected" is generally taken as being closely associated with the notion of "average in the long run". He showed from empirical data that while accuracy of conflict estimates was increased with survey duration. the increase in accuracy per additional survey day over three days was subject to the law of diminishing returns.

Spicer, Wheeler and Older (1980) concur with Hauer's view that, while accuracy increases with survey duration, three days is usually sufficient. They made a study at a semi-urban T-junction of two major roads over a period of six months (8am-6pm) using observers recording time, manoeuvres, type and number of vehicles involved, severity and avoiding action taken. Time lapse filming for 21 hours per day (5am-2am) enabled subsequent checking of conflict occurrences, and conflict and flow counts to be made even when the observers were not present. The study lasted from September, 1977 to May, 1978, and included 15 Tuesdays and three days each for the other days of the week (Monday, Wednesday, Thursday and Friday). Day to day variability in conflict numbers existed but showed no consistent day of week or seasonal effects. During the day, conflict counts varied much as vehicle flow did, with peaks at peak flow time. The conclusion was drawn that a predictor of the long term daily average of conflict numbers, within + or - 10%, could be made from only 2-3 days' counts.

These findings refute Thorson and Glennon's (op cit) argument and have important implications for the application of the technique by the Local Authority Accident Investigation Units. Clearly, for economic reasons, they need a technique that can reliably estimate numbers of conflicts in as short a time as possible. The empirical evidence of Hauer (op cit) and Spicer et al (op cit) has shown that this can be achieved from 3 days observations, within acceptable confidence limits, and this should satisfy the accident units' time/accuracy tradeoff constraints. One of their main applications for conflict studies will be the evaluation of remedial measures, and for these, before and after studies would be undertaken. As long as the predicted difference in expected conflict rates between studies carried out before and after improvements to the system is large (>15%), surveys of modest duration guard sufficiently against the possibility of not observing a reduction in counts when there has been one. When the difference between the expected conflict rates is small, even very long surveys do not offer a guarantee that the after count is lower than the before count. This limitation is inherent in every estimation based on random variables with large variance. The argument for indirect safety measurement eg. by conflict studies, cannot be based on a claim of great estimation accuracy, since this is unattainable. It is based on the simple fact that in some circumstances, indirect measurement is more accurate than any other method currently available.

The study reported in the following chaspter was carried out at urban sites similar to that studied by Spicer et al (op cit) for long term variations in conflict numbers, in a city with a commuter population which is generally acknowledged to have little seasonal variation. Therefore the long term pattern of conflicts should also be revealed from studies of only a few days duration. Where conflict variability becomes more of an issue is at sites with a large seasonal variation in flows eg. in holiday resorts, where accidents in the summer by visiting drivers unfamiliar with a layout, may be totally different from accidents occurring in the winter involving locals. In this situation, there could well be two different distributions of accidents, and hence conflicts, associated with them. One, for example, could be due to inadequate signing causing confusion to visitors, and the other due to higher speeds (because of the lower traffic density in the winter). In this case it would be necessary to examine the two separately, and deal with each on its merits.

2.2 Variability in research definitions and techniques.

The considerable variety of research results can, at least partially, be explained by studying the operational techniques used by different workers in the area. Large differences exist in definitions, severity classifications and methods of recording such that direct comparison between studies is difficult. Diversity of approach during the initial stages of development of any technique is to be encouraged in the hope that eventually there will be convergence on the most satisfactory procedures. However, individual researchers tend to be reluctant to abandon their own methods if these appear to be successful, and consequently it is likely that differences will persist. The great interest in the Traffic Conflicts Technique and the concern about the variety of results being found, resulted in the First International Seminar on Traffic Conflicts. This seminar took place in Oslo in September, 1977, and attracted representatives from most of the world's researchers into the technique. Reprentatives from Great Britain, France, Sweden, West Germay, Finland, Norway, Denmark, Israel, The Netherlands, Canada and the United States attended. This opportunity was used to bring together all current research so that procedures and results could be exchanged and compared. Each country presented a paper outlining the present state and practice of traffic conflicts in their own country. These revealed considerable similarities with some differences. There was considerable debate about the search for a suitable definition of the term "conflict". Defining a potential accident (conflict) when no objectively determined collision has occurred is difficult. Hauer (1977) emphasised this problem when he said

> "The concept of a conflict is intuitive but vague. It is hardly surprising, therefore, that some researchers have adopted slightly different definitions of what a conflict is. There are those who identify a conflict with "evasive action", others who detect its occurrence as a function of the proximity in time of the colliding elements."

and that

> "Failure to converge on a common definition of what constitutes a conflict will effectively preclude the wide practical application of the conflict technique of safety measurement."

Any definition has its limitations, but it should be:-

a) as close as possible to a traffic accident, in terms of distance along the assumed behavioural continuum,

b) be measurable,

c) provide a sufficient number of incidents (greater than that of accidents) to enable the problem to be studied.

Baker and Glauz (1977) of the USA specified in their definition that

> "....the brake light indication or the lane change, as well as the offending vehicle, must be observed before a conflict can be recorded"

which precludes traffic violations and conflicts with stationary objects, since in both these situations there is no offending vehicle. A number of workers have widened their definitions to include other road traffic obstacles eg. pedestrians and stationary objects such as lamp-posts and trees. For example, Zimmerman, Zimolong and Erke (1977) conceived a traffic conflict in West Germany as:-

> "....a hazardous situation in which drivers/pedestrians approach each other in space or time to such an extent that there is an increase in the risk of collision. Indications of a conflict are the critical driving manoeuvres intended to reduce the collision risk:-
>
> -- braking
>
> -- accelerating
>
> -- evasion
>
> --or a combination of these."

They also included traffic violations because conflict situations could have been the result.

The definition of the French team of Malaterre and Muhlrad (1977) stated that

> "A traffic situation is a situation where the interaction of several road users (or of a vehicle and the environment) would result in a collision unless at least one of those involved takes evasive action; it is the success of this action that determines the final result -- conflict or accident. Conflicts have been rated from one to five on an urgency scale designed to give an indication of the closeness between the conflict and an actual collision."

Older and Shippey (1977a) used a similar definition in which a traffic conflict in Great Britain:-

> "....is a situation involving one or more vehicles where there is imminent danger of a collision if the vehicle (or other road user) movements continue unchanged."

Older and Shippey's work additionally included classifying the severity of the evasive action.

These general definitions appear to have led to two different practical interpretations in identifying such situations:-

i) a conflict is identified by the occurrence of an evasive manoeuvre by one or more of the vehicles involved, the manoeuvre being either braking or change of lane.

ii) a conflict is identified by the estimated times of arrival of vehicles at the possible collision point being within a given short time of one another.

The concept of using time to identify the event has been used in Sweden by Hyden (1977). His definition stated that:-

"A serious conflict occurs when two road users are going to collide and the collision should occur within 1.5 seconds if both road users involved had continued with unchanged sppeeds and direction."

Jorgensen (1977) from Denmark observed that:-

"The most useful definition of the serious conflict which we could establish from our data seemed to be one where the set of parameters (accepted gap, main road deceleration) were approximate:-

(<4 seconds , >50 mph. >0 (braking))."

Merilinna (1977) considered that a conflict at an intersection in Finland could be defined as:-

> "a) Evasive action, when a driver with the right-of-way, travelling straight through an intersection, brakes or weaves due to obvious interference by other traffic. Braking is considered to have happened if brake lights are lit. Weaving is considered to have happened if there is a clear change in travel course.
>
> b) Traffic violations
>
> Section a) is further broken down by cause.

i)	Right-of-way conflict	-- from right -- from opposing left turn -- from left
ii)	Rear end conflict (grouped as to movements of first vehicle)	-- to left -- straigt through -- to right
iii)	Pedestrian conflicts	-- driver with right of way has to brake or weave."

Merilinna made no division into severe and other conflicts because "severe" events ie. where the time for braking <1.5 seconds, were allegedly very rare in Finland. He also conducted interviews with professional bus, lorry and taxi drivers, which gave very similar information as the conflicts technique at a lower cost, although, he pointed out, their recommendations could be mis-leading.

As a guide for their observers, the Norwegians

Amundsen and Larsen (1977) made up a table of distances in metres between the vehicle (or vehicles) and pedestrians (Table 13). They used three severity groups -- moderate, dangerous and critical conflicts, but did not classify "unlawful movements" ie. traffic violations, as conflicts.

Severity grade	Traffic	Built up area	Outside built up area
Moderate	Low	3-5m.	5m.
	Heavy	1-3m.	
Dangerous	Low	2-3m.	3-5m.
	Heavy	0.5-1m	
Critical	Low	0-2m.	0-3m.
	Heavy	0-0.5m.	

All measurements in metres.
Source: Amundsen and Larsen, 1977.

Table 13 : Table of distances between vehicle and pedestrian.

Guttinger's (1977) experiments in the suburbs of Delft in the Netherlands concerned conflicts between pedestrians and vehicles only, but he also defined a conflict with respect to the distance between those involved.

> "We defined a serious conflict or near accident as: a sudden motor reaction by a party or both parties involved in a traffic situation towards the other, with a distance of about 1 metre or less between those involved. Two variables are

> important: the motor reaction and the distance. Beside this concept "serious conflict", we distinguished five other possible combinations of the two variables mentioned. For instance:- a **conflict:** a sudden motor reaction by a party or both of the parties involved in a traffic situation towards the other with a distance of about 2 metres or more (maximum 20 metres) between those involveds or a **contact:** a non-sudden motor reaction by a party or both of the parties in a traffic situation towards the other, with a distance of about 2 metres or more (maximum 20 metres) between those involved. All together we called these six types of combination of the two variables (motor reaction and distance) **an encounter:** a motor reaction by a party or both of the parties invovled in a traffic situation towards the other, with a distance of 20 metres or less between those invovled." Guttinger, 1977.

Older and Shippey (1977b) reported on the main plenary session at the conference which centred around the search for a suitable definition. There appeared to be a general consensus of opinion that a traffic conflict could be defined as

> "....An observable situation in which two or more road users approach each other in space and time to such an extent that a collision is imminent if their movements remain unchanged."

This definition excluded traffic violations, situations involving stationary objects and single vehicle accidents. While the author agrees in principal with this definition, it is suggested that it should be amended in order to conform to the requirements suggested for a definition earlier and also to take into consideration highway geometry, so that it would read

> "A detectable and measurable situation, providing a sufficient number of incidents (greater than that of accidents), in which two (or more) vehicles approach each other from different (not the same) directions in space and time to such an extent that a collision, however caused, is inevitable if their velocity and trajectory remain unchanged (except insofar as they are determined by the highway configuration)."

This deals with the situation where the vehicles involved are approaching each other on a bend, for example. This definition excludes traffic violations, single vehicle accidents and incidents involving street furniture by specifying that two (or more) vehicles have to be present. It also excludes rear end conflicts and accidents by specifying that the vehicles have to approach from different, not the same, directions. By stating "vehicles" rather than "road users", pedestrians are excluded. It includes all types of conflict, whether accidental or deliberate, through use of the words "however caused".

While the definition would seem at first glance to be equally applicable to pedestrian-vehicle interactions, with only very minor alterations, there is some doubt as to whether the technique can be applied without considerable modifications. It is possible that an alternative will have to be developed, as the avoiding manoeuvres made by pedestrians to vehicles and vice versa are not directly comparable to those made by vehicles to other vehicles, nor so easily observed and measured (Howarth and Lightburn, 1980).

However, it was concluded that researchers would still agree to differ in the ways used to identify the event (evasion, time gap, distance). Nevertheless, it was hoped that the above definition would help to concentrate and channel future work in this area. Only a calibration study between countries would show if and how these methods result in conflicts being recorded in different categories and the effect this might have on the diagnosis of operational deficiencies at a site. The possibility of such a study was explored at the Second International Traffic Conflicts Technique Workshop held in Paris, May, 1979, at which the author participated. Papers presented showed that there had been developments, but most of these were refinements to techniques already in operation by the individual research groups in each country. The workshop was preceded by a pilot calibration study in Rouen involving teams from the United Kingdom, France, Sweden and Germany (with an American team observing only) using the techniques researched and developed in their own countries. The pilot study indicated that there was a fairly good overlap in the identification of the operational deficiencies at the junctions studied, but that a larger study enabling more sophisticated statistical analysis was required to be able to draw more precise conclusions.

Two subsequent steering group meetings held at Crowthorne, UK, in April 1980, and Lund, Sweden, March 1982 (the author attending the latter) drew up a list of objectives for a more rigorous calibration study, along with a research plan. The aims of the study were to

i) compare the prediction of safety and operational problems identified by each technique and

ii) discuss the implications for the validity of the technique in the light of the results.

This study was carried out in June, 1983 in Malmo, Sweden and was funded by NATO Scientific Affairs Division (Brussels). The results are being analysed but will not be available before completion of this thesis.

2.3 Variability of the conflict to accident ratio

The ratio of conflicts to accidents in different locations within a site is also likely to vary considerably. For example, in a merging situation the conflict to accident ratio is likely to be higher, mainly because many accidents at these sites will be low speed, minor collisions with minimal damage, not injury- producing, and therefore not reported. Accidents at a high speed, urban, unsignalised crossroads, however, are more likely to be serious, and the likelihood of reporting will also be higher. This will result in a lower conflict to accident ratio. Therefore, with the accident reporting system as it is, there must be a variation in collision to reported accident ratios for different manoeuvres. So even if conflicts are directly related to accidents, the conflict to accident rate will also vary. This will also refer to conflict type, since the ratio of rear end conflicts to reported accidents of the same type is likely to be larger than, say, head on conflicts to reported head on accidents. Furthermore, the conflict to accident ratios should be different at signalised and unsignalised sites of the same general layout eg. T-junctions, because traffic lights should effectively preclude certain manoeuvres taking place, except at the beginning of the precluded period where traffic violations may occur. Analysis of these sites should therefore be carried out separately, because the conflict to accident ratios of the same manoeuvre at two sites will not be the same. In the same way, conflicts at sites of different layout will vary in the numbers of conflicts of a particular type eg. right turn conflicts at crossroads will not necessarily occur twice as often as right turn conflicts at T-junctions simply because there are twice as many opportunities. So sites of different layout cannot be combined and should be analysed independently of each other, because the conflict to accident ratio of say right turns at crossroads may be different to that at T-junctions.

It is possible that two (or more) distributions of conflicts exist. The first type, "accidental" conflicts, are those resulting from attentional failure or lack of skill and experience. The second can be described as "confrontations" caused by the driver's deliberate interaction with other traffic. These two types may correlate with different distributions of accidents. While conflicts correlate with serious injury accidents and fatalities, deliberate confrontations may be more closely related to slight injury accidents and those involving damage only. Environmental factors may affect the proportion of conflicts to confrontations occurring at a site. For example, drivers might avoid confrontations when roads are slippery after rain. Where driver interactions (of all types) are observed only in dry weather conditions, they may not be a good predictor of accidents. Similarly, those observed solely under bad weather conditions at sites where there are a lot of deliberate confrontations. Conflicts as observed in the study reported in the next chapter would have included both types, however caused, and in a variety of weather conditions.

The hypothesis of two distributions is an empirical issue but cannot be tested on the current data. If it is considered sufficiently important, it would have to be investigated by further studies. The first of these would be to see whether it is even possible to differentiate the two types of conflict from observation. Since validation of accidents and conflicts in the study reported in Chapter 9 accounts for some 62% of the variance, and that of the most favourable of the reliability measures accounts for 77% of the variance, on which it would be difficult to improve, there is at best only 15% of the theoretical variance unaccounted for. Other factors besides that of the deliberate confrontation hypothesis such as the weather, effect of darkness, condition of the road surface, and approach speeds of vehicles, will all account for some percentage of this missing variance, and are all potentially important. Collectively they may account for much of the missing variance. Individually, each can only account for a very small percentage, and therefore be relatively unimportant.

It is further hypothesized that the introduction of the law compelling all front seat occupants (with certain exceptions) to wear seat belts from January, 1983, might theoretically have changed the existing conflict to accident ratios. However, since it is likely to have affected all levels of accidents more or less equally, then the percentage of the variance accounted for in validation studies may remain unchanged. It will only have altered if the outcome of the law has affected only one level of accidents and left the others unchanged, but this hypothesis can only be resolved empirically by further studies.

2.4 Using injury accident data to validate the technique

Studies attempting to investigate the validity of the Traffic Conflicts Technique have to rely on official accident statistics against which the number and type of conflicts are correlated. Ironically conflict observation techniques are being developed because accidents are often inadequately recorded and occur in insufficient numbers for analysis. The issues of accident data, its completeness and reliability are well documented (eg. Colbourne, 1973; Bull and Roberts, 1973; Grayson, 1979; Hobbs, Grattan and Hobbs, 1979; Lightburn and Howarth, 1980), but in testing the validity of the instrument, accidents are used. It may seem strange to attempt to validate the technique using data gained from the unreliable source which it is intended to replace. Williams (1981) suggested that the only viable alternative is to validate conflicts using accident data gathered by on-the-spot analyses, such as that collected by McKay (1966) and Staughton and Storie (1977). However, this will only provide more details of accidents that are reported. It still does not get around the problem of unreported accidents. The inadequacies of the accident statistics must be accepted. Despite their drawbacks, they are the yardstick against which every alternative must be assessed.

Hauer (1979) believes that the validity of the Traffic Conflicts Technique should be judged in relation to the task at hand, and for many tasks, validity is not an issue. For example, in situations where the operational deficiencies of a system are being sought, the relationship between conflicts and safety may not be of primary concern. A measure implemented at a site which succeeds in reducing conflicts is very likely to improve safety. Operational efficiency is improved and safety most likely enhanced. To know the size of the improvement may not be of crucial importance.

He believed that where the problem of validity is of importance is where conflicts are used to measure safety. He defined the measurement of safety as the expression of a change in the safety of a system (either relative or absolute) in quantitative terms. The measurement of safety in this context is the task of estimating the expected number of accidents and their severity. The validity of the Traffic Conflicts Technique depends on the accuracy of estimates. Where the technique produces estimates of safety which are more accurate than those obtained by reliance on the accident history, then he believed that the technique should be regarded as valid.

3. Review of the literature.

Comparison of the results of studies in the literature is difficult because of the many different methods and definitions used. Researchers have tended to correlate both conflicts and accidents derived by different methods or from different sources. Potential sources of these variations have been dealt with above. This review will concentrate on the results found so far and attempt to analyse why some studies have found good correlations with accidents where others have not. The review ends with a survey of current work on the relationship between conflicts and flow, and the validation study carried out by the author follows.

3.1 Conflicts and accidents.

Perkins and Harris (1968) reported a study which included conflict and accident data for 3 signalised and 2 non-signalised junctions. They commented that

> "a high level of association exists between the traffic conflict and reported accident frequencies"

without stating what order this association reached. A subsequent analysis of their published data by Heany (1969, 1970), however, indicated that the correlation coefficients were of a relatively low order overall (0.48). If the accidents and conflicts on the four approaches to each intersection were considered separately, there were no statistically significant Spearman rank correlation coefficients. Neither were there any significant correlations found by combining data for the signalised and unsignalised junctions. It was not until Heany (op cit) segregated the conflict and accident data at the signalised sites by type of conflict (ie. manoeuvres involved) that significant correlations were found. These are illustrated below (Table 14). Unfortunately Heany does not analyse the data for the unsignalised sites.

Signalised sites only (N = 3).

Type of conflict	Spearman rank correlation coefficient	Significance level
Weave	0.56	5%
Red light violations	0.47	NS
All rear end	0.70	5%
Stop-on-amber and through lane	0.91	1%
Rear end left turn	0.48	NS

Source: Heany, 1969 and 1970.

Table 14 : Spearman rank correlation coefficients for various types of conflict and associated accidents for Perkins and Harris data.

This confirms the suggestion that there are different conflict to accident ratios for different types of conflict or manoeuvre, and that some conflicts seem to be more productive of accidents than others. The inclusion of rear end conflicts and traffic violations would account in some measure for the non-significant results found when considering each junction separately but without differentiating between conflict types. This study highlights the implications for the technique of structuring the data by manoeuvre or conflict type and by degree of signalisation. However, no attempt at classifying conflicts and subsequently analysing them by severity was made.

Shortly afterwards, Campbell and King (1970), using conflicts per vehicle as their measure and comparing it with accidents per vehicle apparently to make allowance for the large differences in traffic flow which occurred between their day and night studies, reported no significant association between the two measures (r=0.14). They used accident data for only two years prior to the study and admitted that three years data would have been desirable, as well as a larger sample of conflicts. Two rural Y-type intersections were studied by a two person team, one recording conflicts, the other traffic density. Only one approach at each intersection was counted on the first day and two on the second day, so not all conflicts occurring at the sites for the duration of the study were collected. The data that was gathered at study site number one was collected from 7am.-6pm. on a Wednesday and Thursday. A night study was also conducted at this intersection from 8pm.-1am. on a Wednesday and Thursday. Data for site number two was collected on a Tuesday and Wednesday between 7am. and 6pm. The non-significant result raised doubts in the authors' minds about the rear end conflicts that had been included in the correlation. Their doubts reflect those of other researchers, who include the present author, who feel that while this type of conflict occurs very frequency, there are few reported accidents associated with them. This implies that the conflict to accident ratio is very different from that for other manoeuvres and that this type of conflict should be analysed separately. Omitting these from the analysis resulted in a reported correlation coefficient of 0.80, still not significant at the 5% level. They noted how much higher the degree of association now was and concluded that, had more data been available a higher (significant) relationship would have been found. It is suggested by the present author that Campbell and King (op cit) suspected the possible reasons for what they clearly saw as a disappointing result, since they said that

> "Conflicts were noted to vary as to degree of conflict (which could not be recorded) ...."

ie. no attempt to classify conflicts by severity was made, although analysis was carried out by manoeuvre (conflict) type on each of the three approaches.

The importance of manoeuvre type has also been suggested by Baker (1972) who found no correlation between conflicts and accidents until he restricted the comparison to certain types of manoeuvre. No attempt was made to classify the conflicts within each manoeuvre type by severity, which may have accounted for some of the poor correlations. In the states of Washington, Ohio and Virginia, 392 intersections were studied prior to improvement schemes, and 173 sites were studied after construction of the improvements. In addition, one state also applied the technique to non-intersection locations to obtain details of conflicts between single vehicles and the highway geometry. The method employed at the sites in this evaluation involved a one day period of counting for a two person team. One observer counted conflicts while the other recorded traffic volumes. Fifteen minute data samples were taken on each approach to the intersection. The objective evidence in all cases was a brake light indication and/or a lane change effected by the offended driver. The results are summarised in Table 15. It can be seen that more significant results were obtained at unsignalised intersections than at intersections controlled by traffic signals.

	SIGNALISED			UNSIGNALISED			
	T-jnctns	Cross roads	All	T-jnctns	Cross roads	All	All types of intersection
Sample size	14	122	157	94	106	235	392
Weave	-0.207	0.360*	0.402*	0.294*	0.159	0.276*	0.356*
Left turn	-0.128	0.661*	0.615*	0.432*	0.459*	0.453*	0.546*
Cross traffic	-0.170	0.209*	0.136	0.830*	0.602*	0.665*	0.429*
Rear end	0.075	-0.018	-0.017	0.410*	0.213*	0.295*	0.154*
All types	-0.172	0.410*	0.326*	0.837*	0.653*	0.671*	0.458*

*statistically significant at the 5% level.

Source: Baker, 1972.

Table 15 : Correlation coefficients for conflicts and accidents at different classes of intersection.

By differentiating conflicts by type, including a rear end category, Baker found a definite numerical association between accidents and conflicts, although in most cases this association was only weak.

Cooper (1973) reported a study of conflicts at 59 non-signalised intersections in four major Canadian cities. Total accidents plotted against total conflicts for all the intersections gave only a low level correlation (0.453), although comparisons by conflict (or manoeuvre) type eg. weave or right turn, produced better correlations. He also did not classify the conflicts by severity. He concluded that traffic conflicts and accidents were related, but that there were large differences in the conflict to accident ratio for the various manoeuvre types, and that, while the technique did seem beneficial in identifying high accident rates within an intersection, the technique may not be so useful in evaluating the problems of an individual intersection ie. that data on conflicts seemed only to provide information whereby a number of intersections could be ranked in order of safety. He gave an example, by saying that, if an intersection was investigated and found to produce conflicts of mainly the rear end variety, there would be only a nine per cent chance (based on the sample studied) of the same intersection producing mainly rear end accidents. He only studied non-signalised intersections because he considered that signals tended to produce a preponderance of rear end conflicts which are the most difficult to analyse. Despite this and the recognition that Campbell and King (op cit) had omitted rear end conflicts from the analysis, Cooper (op cit) still correlated total accidents against total conflicts including the rear end variety. No attempt was made to classify conflicts by severity. He concluded that an important aspect of the results was that there appeared to be wide differences in

> "the efficiency of the various types of conflicts in their relation to accidents and thus consideration of all conflicts together

suggests an inherent sacrifice in accuracy of prediction."

All the above studies generally concluded that traffic conflicts were related to accidents, but that the level of association was low. The present author is suggesting that this was because the conflicts had not been classified by manoeuvre, site and/or severity and thus that inappropriate types of conflicts were correlated with accidents. The issue of rear end conflicts in particular seems to need further study. In contrast to these uncertain results, a series of studies by Spicer (1971, 1972, 1973) using a grading system seemed to indicate a much stronger association between conflicts and accidents at rural dual carriageway intersections.

Spicer (1971) showed that while simple conflicts (defined as situations involving one or more vehicles taking evasive action) did not correlate closely with reported injury accidents, serious conflicts (defined as situations involving a vehicle in at least a sudden rapid deceleration or lane change to avoid collision) correlated well with reported injury accidents both in location and time of day. (rs = 0.93 and 0.87 respectively). Further data to validate the Traffic Conflicts Technique was collected by Spicer (1972) from a second rural dual carriageway intersection. Correlation between injury accidents and serious conflicts by manoeuvre involved was

0.86, and between injury accidents and serious conflicts by time of day rs = 0.95. By excluding slight conflicts, Spicer would, by definition, eliminate rear end conflicts, although it is likely that at these types of site (rural dual carriageway intersections with adequate slip roads for turning vehicles) that their occurrence would be infrequent in any case.

A further report of six intersections (Spicer, 1973) including the two in the previous studies, gave a correlation coefficient for serious conflicts and injury accidents of 0.97, statistically significant at the 0.1% level. Taking the four new intersections only, the correlation coefficient was 0.90 also significant at the 0.1% level.

3.2 Conflicts and flow.

The simulation model of a non-urban T-junction by Cooper and Ferguson (1976) predicts that the frequency of all conflicts is proportional to the **product** of the flows in the interacting traffic streams, and therefore that conflict rate and flow are related. Wennell et al (1979) in an empirical study at non-urban T-junctions to provide data to input into the simulation model, confirm this and state that for a fixed turning flow, conflict rate increases approximately linearly with major road flow. As far as the relationship between flow and serious conflicts at rural dual carriageway sites is concerned, Spicer (1973) could find no significant correlation between total inflow and serious conflicts (r = 0.20) although no relationship between flow and slight conflicts appears to have been tested. Numbers of serious conflicts tended to increase with increasing flow (measured as crossing flow multiplied by major road flow) but there was a large scatter of values. A decrease in flow may not reflect a decrease in conflicts because it results in increased vehicle speeds. To enable a full assessment of remedial measures, it is necessary to assess each manoeuvre individually in order to determine the factors important in conflict generation. When Spicer (1971) considered conflicts and flow (measured as crossing flow multiplied by major road flow) at each crossing point in the junction separately and calculated correlation coefficients by time of day and position, all were not significant except at one location where vehicles were approaching or leaving the central reserve (significant at the 5% level). This was between flow and all conflicts. He explains this by referring to the large numbers of anticipating actions occurring on entry to the junctions and recorded as conflicts, which are likely to be very flow dependent. However, Spicer (1972) reported a correlation between flow and serious conflicts by time of day of r = 1.0 at a similar rural dual carriageway. He suggested that the effect of flows on conflicts needs further study because of the apparently contradictory results.

At a study of a single T-junction of two main roads over a period of 6 months, Spicer, Wheeler and Older (1980) correlated the total numbers of conflicts and total inflow and the following valuse were found:-

Total inflow and slight conflicts	0.906	(sig. at 2% level)
Total inflow and serious conflicts	0.483	(NS)
Total inflow and all conflicts	0.861	(sig. at 5% level)

The occurrence of slight conflicts appeared to be more dependent on total inflow than serious conflicts. The hypothesis that conflicts at a particular location in the intersection are dependent on the flows meeting at that point was tested by correlating the mean hourly frequency of the main types of conflict (all days) against the square root of the product of flows generating those conflicts. In all cases, the coefficients were significant at the 0.1% level, indicating a very strong relation.

The relationship between conflicts and flow therefore appears to be quite strong but it may be influenced by other factors such as layout, speeds of vehicles, road width and levels of flow itself, but the nature of these influences is still not fully understood. It seems important to investigate and report the relationships between total inflow as well as the product (or square root of the product) of flows for all, slight and serious conflicts at the junctions under study in order to attempt any conclusions regarding the relationship between conflicts and flow. Even so, generalisations between sites eg. of different layout, may not be possible.

4. Conclusions drawn from the literature

It has been argued that the reasons for most of the non significant results of validation studies in the past has been the omission by researchers to classify conflicts by a) manoeuvre (conflict type) and/or b) severity, since correlations of total conflicts and total accidents by a number of workers in this field have proved unproductive. When conflicts are thus classified, good correlations have been found between serious conflicts and accidents by manoeuvre involved at rural dual carriageway intersections (Spicer, 1973).

There is sufficient doubt in the literature to warrant investigation into the effects of separating rear end conflicts from conflicts of other types. Rear end conflicts may be more highly correlated with traffic flow than with accidents. Similarly, signalised and unsignalised sites are better treated separately, as well as sites of different layout, as the opportunities for conflicts (and accidents) at each kind of site will differ. What are needed are conflict to accident ratios for different manoeuvres at various types of junctions, if junctions of different layout are to be compared. It has been argued that low correlations may in part be due to researchers pooling data which should be analysed separately because of the different conflict to accident ratios. Only one study to date has produced conflict to accident ratios (Older and Spicer, 1976), but this was only for rural dual carriageway intersections.

Conflict data for the whole junction should be collected ie. from all approaches in order to get a full picture. Furthermore, conflict studies should be carried out at times to match the accident data, and not simply to suit the researchers.

The relationship between accidents and flows appears to be quite complex and greatly depends on the ratio of major to minor road flows in the junction, as well as on actual levels of flow.

The association between conflicts and the products of flows generating those conflicts appears to be quite strong but again may depend on other factors such as speed, road width, junction layout and, not least of all, on levels of flow themselves.

5. Aims of the validation study

In order to investigate the hypothesis that it is necessary to classify conflicts by manoeuvre (conflict type) and severity to show good correlations between accidents and conflicts, a validation study was designed and carried out at a number of locations.

This study was the first to look at the relationship between conflicts and accidents at T-junctions in urban areas. T-junction sites were chosen as these are the most numerous and simplest type of intersection in the road network. Urban sites were chosen because about 60% of injury accidents occur in built-up areas, so a method such as conflict studies which could result in improved diagnosis and evaluation of remedial facilities at these sites should have the most effect in terms of reduced numbers of accidents.

CHAPTER 9

THE VALIDATION STUDY

1. Introduction

2. Method

3. Results
   - 3.1 Conflicts and accidents for different sites
   - 3.2 Conflicts and accidents for different manoeuvres
   - 3.3 Conflicts and flows for different sites and for different manoeuvres
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5. Conclusions

1. Introduction

Traffic conflict studies carried out in the UK have concentrated on rural dual carriageway intersections (Spicer, 1971,1972,1973). A study to examine the long term variation in conflicts at a single semi-urban T-junction was carried out by Spicer, Older and Wheeler (1980) but concentrated mainly on the relationship between conflicts and flow.

The aim of the study to be reported here was to examine the relationship between accidents and conflicts at strictly urban intersections (specifically T-junctions) in order to establish whether the technique is valid in these locations. Just under 60% of injury accidents occur at junctions in built-up areas, and the largest number of these occur at T-junctions and crossroads. To quote from Russam and Sabey (1972)

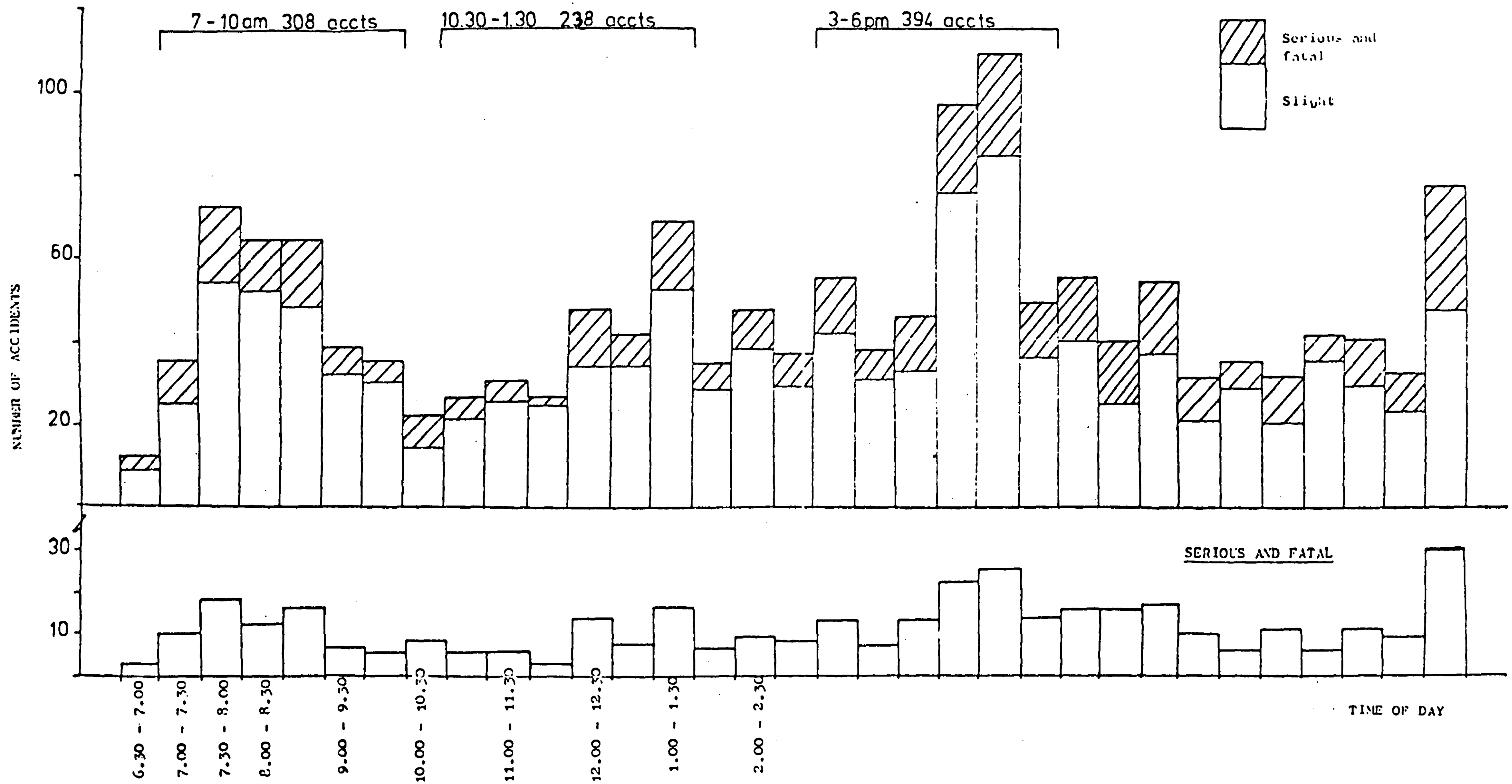
> "While this would be expected since these types of junction are the most numerous in the road network, the magnitude of the numbers serves to put the junction accident problem in perspective. It highlights the need to study situationa at T-junctions ..... especially in urban areas. Any remedial measures whoch can be established for these kinds of junctions ..... will bring about the greatest saving in junction accidents."

Secondary to the main aim was an investigation into the relationship between conflicts and different measures of flow. A novel investigation was planned into the types of vehicles involved in the recorded conflicts (both offender and offended) to see whether some types of vehicle are offended against more often than being the offender eg. motorcycles, or whether long or slow vehicles such as those in the heavy goods category were more likely to offend than be offended against.

2. Method

All accidents for Nottingham City for the years 1978-1981 inclusive were obtained and these are shown by time of day and severity in Figure 10. This shows four peaks in accidents: early morning (7.30am.-9.00am), a similar midday peak (12.00-1.30pm), the evening rush hour peak (4.30-5.30pm), and the last one after 10.30pm. In general, after 10.30pm. a large proportion of road accidents involve drink, so only accident data between 6.30am. up to 10.30pm. (16 hours) was used. In fact, at the 10 sites under investigation, no accidents occurred between 10.30pm. and 6.30am. For Nottingham as a whole, only 5.5% of all fatal, serious and slight accidents for 1978-81 inclusive, occurred between 10.30pm. and 6.30am. In order to get a representative view of the distribution of conflicts, it was decided that observation at each site would cover each weekday for 9 hours per day in three sessions (7.00-10.00am., 10.30-1.30pm. and 3.00-6.00pm). These three periods cover the peaks in the

FIGURE 10 : Numbers of accidents in Nottingham City by time of day and seriousness, 1978-81 inclusive.



accident data and the peak traffic flows as well as some off-peak time either side. The main criteria in choosing the sites were that the T-junctions be in urban locations with places for the observers to sit far enough back from the junctions to see the build up of conflicts, but also still be able to see the junction clearly and be relatively unobtrusive. Eight unsignalised T-junctions were found which fitted these criteria.

For the purposes of this study, the four most important details to record accurately were

a) numbers of conflicts

b) severity

c) manoeuvres of the vehicles involved

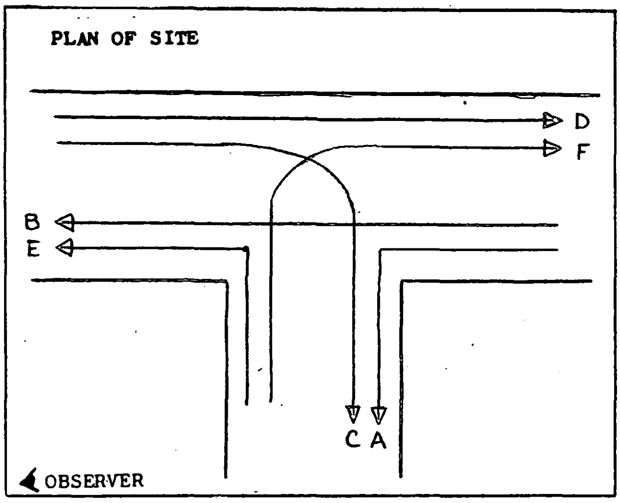
d) types of vehicle involved

The observers were taken through the training procedures as outlined in the Traffic Conflicts Technique Training Package (see Chapter 7). Intra-observer reliability (Spearman) judged at the end of training in relation to the training film, (Fisher and Yates (1963) method of weighted averaging) was 0.88 for all observers (Range 0.84-0.90). Reliabilities were retested on the training film during the data gathering period and at the end. All were similar to the above figures.

The following measures were recorded:-

Vehicle type	(car, HGV, motorcycle, bus)
Manoeuvre	(by letter according to Figure 13)
Time to collision	(long, moderate, short)
Severity of evasive action	(light, medium, heavy, emergency)
Complexity of evasive action	(simple - braking or swerving) complex - braking and swerving)
Ultimate proximity	(near, 2+ car lengths: near miss, 1-2 car lengths: very near miss, <1 car length)
Other vehicles involved	(number from 1-9+)
Classification	(rear end, right turn from minor)
Traffic densities	(by manoeuvre and vehicle type)

A new recording form was designed to shorten the time taken to record all the required data (Figure 11). Previous researchers required observers to draw diagrams of vehicle manoeuvres and positions. As well as taking some time to do, it was difficult to convey accurately what had happened in the phases before, during and after the conflict. In spending time drawing the diagrams, which varied considerably in legibility from one observer to another, other conflicts could easily be missed. By using the above method conflicts could be recorded in seconds in a standardised way, and up to 16 conflicts could be recorded on each top sheet (which showed a plan of the site with manoeuvres labelled as Figure 11) and up to 30 on continuation sheets. This method was a considerable improvement on the drawings method, saving time and ensuring that all relevant details were recorded in a consistent manner.



SITE.................................

DAY..................................

DATE.................................

OBSERVER.............................

WEATHER..............................

....

VEHICLE 1. is the one whose actions cause Vehicle 2 to take avoiding action.

VEHICLE 2. is the one that has to take avoiding action

1 = car/car bodied van 2= light goods 3 = HGV 4 = bus 5 = M/cycle 6 = Pedal cycle

TIME	VEHICLE 1 TYPE	MANOEUVRE	VEHICLE 2 TYPE	MANOEUVRE	TIME TO COLLISION L 1	M 2	S 3	SEVERITY OF EVASIVE ACTION L 1	M 2	H 3	E 4	SIMPLE OR COMPLEX S 1	C 2	PROXIMITY N 1	N M 2	V N M 3	NO. OF OTHER VEHICLES INVOLVED	SEVERITY	CLASSIFIC-ATION
7.10	1	A	3	B	✓				✓				✓		✓		+ 2 cars		

Figure 11 : Lettering for manoeuvres of vehicles at T-junctions on recording sheet.

While there is only one measure of accidents available ie. reported injury accidents, there are a number of measures of conflicts used in the following correlations. Where flow is being correlated with either accidents or conflicts, it is necessary to examine the correlations with the total inflow across all junctions. When analysed by location within the sites, two measures of flow have been used: sum of intersecting flows, and the square root of the product of intersecting flows, but unless otherwise stated, the latter is the measure of flow used. For conflicts the measures used are: all, serious and slight. Any or all of these may or may not include rear end conflicts, so where these have been excluded, this is made clear by the expression "minus rear ends". In the analysis by location, some are, by definition, of the rear end type only, because of the manoeuvres involved. At certain sites there were a large number of rear end conflicts, particularly where the flow of traffic was restricted by road width to only one lane in each direction. This meant that, in moderate to heavy flows, almost all vehicles turning off the through route, either to left or right, caused the following vehicle to brake and/or swerve. The grading of these conflicts by the four factor system quite often caused these incidents to be subsequently classified as Grade 3, usually because of the ultimate proximity of the vehicles involved. For example, if the offended vehicle was graded in the following way:

Moderate, Medium, Simple, Less than one car length

then the result would add up to a Grade 3 conflict on conversion to grades. Clearly these events are not serious. Such accidents as occur are likely to be at low speeds and therefore minor, involving damage only, and it is likely that only a very few would be reported and appear on the official accident statistics for the site. Inspection of the accident statistics confirmed this expectation. Analysis has therefore been concentrated at the locations in the site where the paths of manoeuvering vehicles crossed or merged. Accident statistics have also been limited to crossing or merging manoeuvres ie. reported rear end accidents have been excluded from the accident data presented. Some other accidents were excluded because, on closer inspection of the accident booklets themselves (as opposed to the abbreviated accident data by which the sites had initially been chosen) it became apparent that some had not actually occurred at the junction or were independent of the junction. For example, at one site a serious accident apparently between two vehicles turned out to be nothing to do with manoeuvres of vehicles at the junction. A digger had got stuck in the mud of some road works at the site and a dumper was attempting to pull it out. In the ensuing tug-of-war, a man fell off the digger and broke his leg. This highlights the caution with which raw accident statistics must be treated.

The most important statistics used were serious conflicts per vehicle flow, accidents per vehicle flow and total vehicle flow. Serious conflicts per vehicle was calculated by dividing the number of serious conflicts (minus rear ends) by the total inflow from the same period over which the conflicts were recorded. Accidents per vehicle was calculated by dividing the number of accidents (minus rear ends) by the total inflow for the same period over which the accidents occurred.

3. Results

The analysis will be presented in the following order:-

3.1 Conflicts and accidents for different sites
3.2 Conflicts and accidents for different manoeuvres
3.3 Conflicts and flows at different sites and for different manoeuvres
3.4 Rear end conflicts.
3.5 Summary of main results of this study

3.1 Conflicts and accidents for different sites

Raw data including a map of each site and showing flows and conflicts by manoeuvre and location respectively, as well as accidents, can be found in the

Appendix, Figures 22a-h. The data relating different sites are summarised in Table 16.

Site no.	Accidents/ vehicle $\times 10^{-6}$	Rank	Serious conflicts/ vehicle $\times 10^{-6}$	Rank	Conflict to accident ratio
1	1.7	2	153.2	1	95:1
2	3.2	5	707.5	3	220:1
3	1.7	2	386.1	2	230:1
4	3.0	4	721.3	4	240:1
5	5.0	7	1713.6	6	340:1
6	1.7	2	737.7	5	420:1
7	13.2	8	1923.4	8	145:1
8	3.8	6	1865.7	7	490:1

rs = 0.79, $p<0.025$

Table 16 : Correlation of accidents/vehicle with serious conflicts/vehicle, and conflict to accident ratios, by site

The correlation coefficient, rs (Spearmans), was calculated for the accidents and serious conflicts. (Note that traffic density is taken into account in both measures) and

rs = 0.79, significant at the 2.5% level.
This figure accounts for over 62% of the variance.

This is perhaps the most important result in this thesis, since it is difficult to imagine an accident surrogate which could be more successful than this. It is important to remember that even under ideal conditions with observers repeatedly observing a training film, reliability coefficients were of the order of rs = 0.88. While this is a very satisfactory figure, it puts an upper limit on any validity coefficient. It appears that in predicting accidents from observations of conflicts, at least 23% of the variance is accounted for by the unreliability of the observations, 62% by the conflict/accident correlation, leaving only 15% to be accounted for by other factors such as variations in the weather or variations in driver skill or attitudes which might lead to variations in conflict to accident ratios. There is so little of the variance unaccounted for that reasons must be sought as to why the great variation between sites in conflict to accident ratios is not responsible for more of the variance. Inspection of Table 16 reveals why this is the case. Conflict to accident ratios are not independent of the other measures, since high conflict to accident ratios occur at sites which are high in other measures.

It is apparent that all the measures in Table 16 are intercorrelated. In a later section the correlation between flow and accidents is considered as to whether it can be exploited to devise a simpler and cheaper method of predicting accidents. Given the extraordinarily high proportion of the variance accounted for by the conflicts technique, it is extremely unlikely that a more powerful method can be found.

For the T-junctions as a whole, a serious conflict to accident ratio of approximately 275:1 was found.

Older and Spicer (1976) reported a ratio of about 2000:1 for serious conflicts and accidents at rural dual carriageways. Their figure is so much higher probably because there is more room to take evasive action on dual carriageways than at urban locations such as those studied here, and therefore there would be less chance of an accident occurring from a conflict. Furthermore the higher speeds on dual carriageways may mean drivers are more inclined to brake and reduce their speed in anticipation.

3.2 Conflicts and accidents for different manoeuvres

Ideally correlations of conflicts and accidents over all combinations of manoeuvres and sites should be made. However, there were too many empty cells in the matrix of accidents by manoeuvre and site to make this possible. Hence the correlation of conflicts and accidents by site is the best possible estimate of the validity of the conflict technique. Some information about the relationship between accidents and manoeuvres can be obtained if the data is averaged across all sites. Table 17 shows the relevant data and Figure 12 illustrates the relevant combinations of manoeuvres.

Manoeuvre	Accidents/ vehicle $\times 10^{-6}$	Rank	Serious conflicts/ vehicle $\times 10^{-6}$	Rank	Conflict to accident ratio
BC	3.84	3	641.9	3	165:1
BE	-	1.5	592.1	2	-
BF	15.36	5	1920.3	4	125:1
DF	4.31	4	3926.4	5	900:1
CF	-	1.5	187.5	1	-

--rs = 0.75 NS--

Table 17 : Correlation of accidents/vehicle with serious conflicts/vehicle, and conflict to accident ratios, by manoeuvre

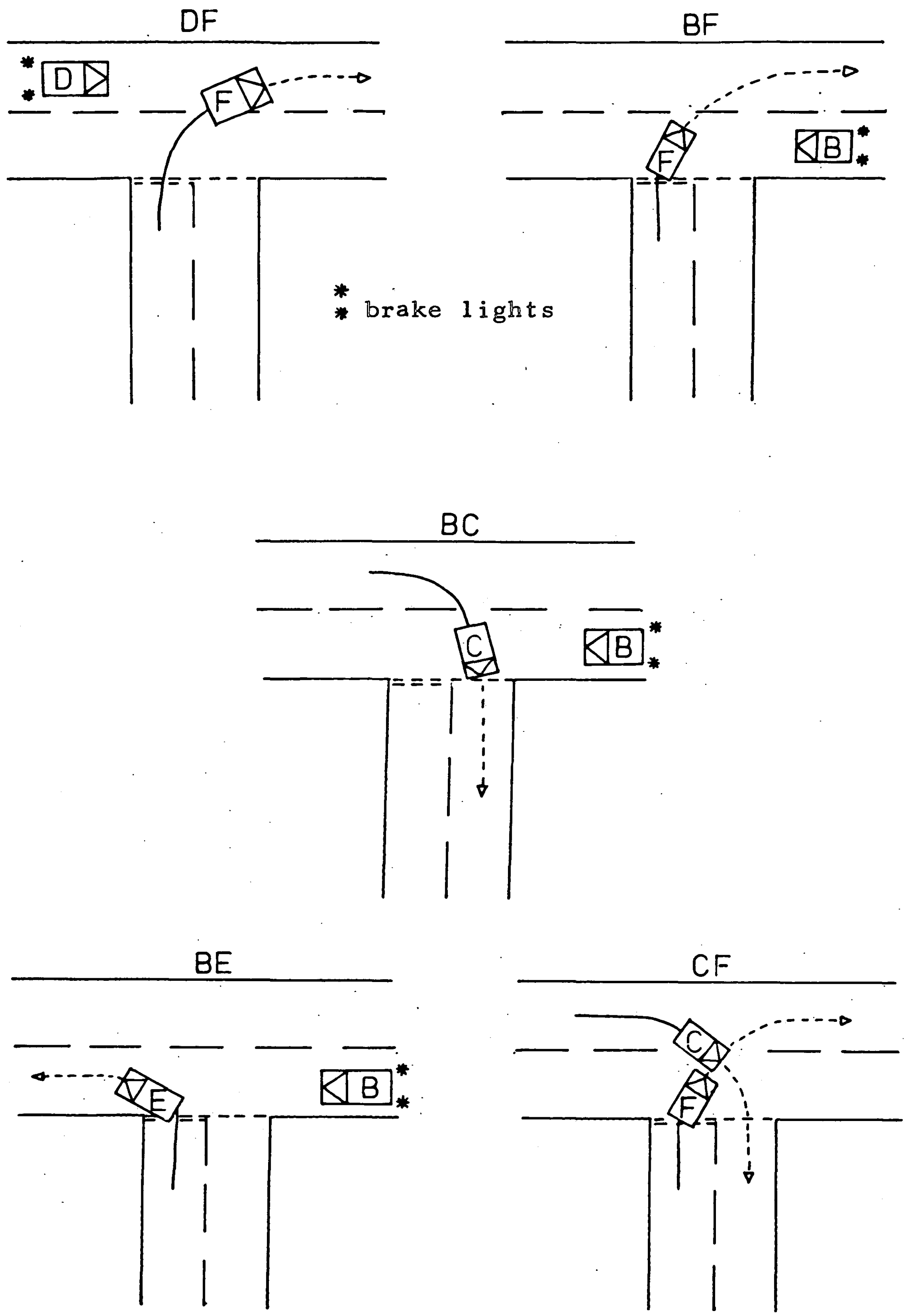


Figure 12 : The five combinations of manoeuvres at T-junctions

With only five pairs of figures to correlate, a correlation of 0.90 is required to reach significance at the 0.05 level. With this qualification in mind, it is still worth noting the following relationships in Table 17.

a) There is a positive (although non significant) correlation between accidents and conflicts, similar to that obtained across sites.

b) The conflict to accident ratios for the three manoeuvres which produced accidents vary between 900:1 and 125:1, almost a 7:1 variation. These ratios deserve further investigation and will be considered again when the relationship between conflicts and flow is examined. However, it is obvious that, as in Table 16, there is a positive correlation between all of the measures in the table, and in particular there is a positive correlation between the conflict to accident ratio and conflicts.

c) In relation to conflicts, the rank order of the manoeuvres is

$$DF > BF > BC > BE > CF$$

This is entirely consistent with the observations of Spicer, Wheeler and Older (1980).

d) In relation to accidents, the rank order is slightly different

ie. BF > DF > BC > BE = CF (no accidents)

The change in the order of BF and DF is, of course, due to the different conflict to accident ratios referred to in b) above.

e) The two most dangerous manoeuvres, BF and DF, judged by either accidents or conflicts, both involve crossing two streams of traffic. This will be discussed further in the following section.

3.3 Conflicts and flows at different sites and for different manoeuvres

Many researchers have found that conflicts and flow are highly correlated. These findings were reported in the review of the literature in the previous chapter. This is not at all surprising since the more vehicles present, the more conflicts they must generate. But this relationship does not indicate the intrinsic risk of any particular road layout or manoeuvre. It is for this reason that the previous two sections concentrated on the relationship between accidents per vehicle flow and conflicts per vehicle flow, thus eliminating the accidental factor of vehicle flow from the estimates of risk. An attempt will now be made to justify the use of these statistics.

There is no doubt that in the data presented here, the positive relationship between conflicts and flow can be observed. For example, if correlation coefficients are calculated separately for each manoeuvre, there is a correlation across sites between flow and conflicts. Table 18 shows these correlations were nearly all very large and significant for both serious conflicts and for all conflicts, when flow is measured by the square root of the product of the two conflicting flows. Less satisfactory correlations were obtained when the sum of the two flows is used. This is the justification for the measure of flow used in the previous sections.

However, in addition to assuming a relationship between conflicts and flow, it it is also implicitly assumed that the relationship between the two is linear since otherwise the simple ratio of conflict to flow would not be justified.

Figures 13-16 show the relationship between conflicts and flow for the four manoeuvres for which they are significantly related. (Calculations of the linear regressions using the method of least squares can be found in the Appendix, Tables 31a-d). These figures show, first of all, that the assumption of linearity is not really justified for manoeuvres DF and BF, because there is a fairly high threshold below which there are no conflicts. For manoeuvres BC and BE, the assumption of linearity is more justified since, although there is a threshold, it is much lower.

They also show that the conflict/flow ratio is rather different for the different manoeuvres. For manoeuvre DF conflicts increase very rapidly with flow. For manoeuvres BC abd BE the slope is very much less. For manoeuvre BF, the slope is somewhere between these two extremes.

	Correlation of serious conflicts with the square root of the product of flows generating them		Correlation of all conflicts with the square root of the product of flows generating them	
Manoeuvre	rs	Significance level	rs	Significance level
DF	0.84	0.5%	0.86	0.5%
BF	0.84	0.5%	0.89	0.5%
BC	0.83	1%	0.87	0.5%
EB	0.79	1%	0.77	2.5%
CF	0.30*	NS	0.30*	NS

*based on only 7 conflicts (4 serious) at the eight sites.

Table 18 : Correlations of serious and all conflicts with the square root of the products of flows generating them

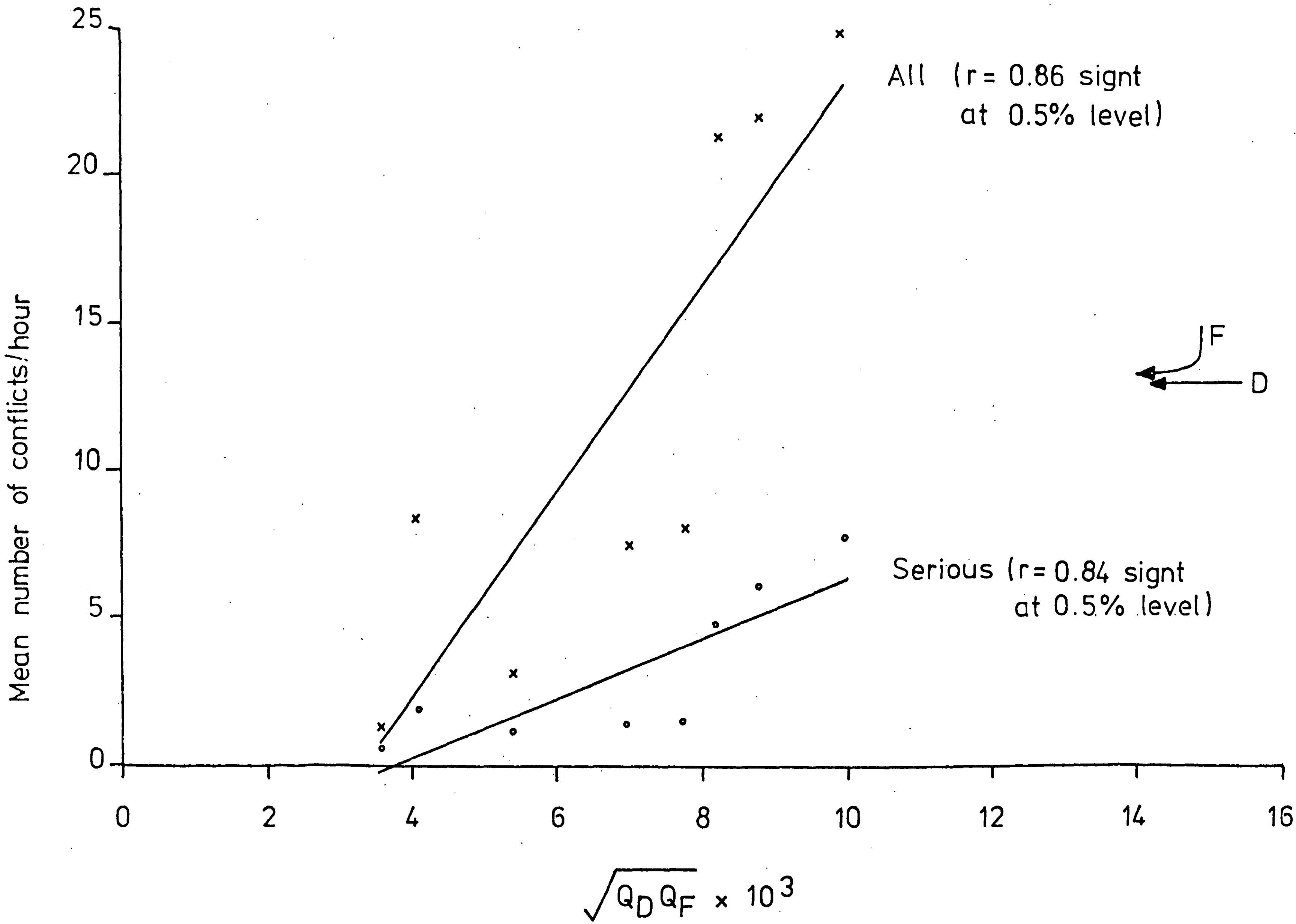


FIGURE 13 : Mean frequency of conflicts at DF against square root of the product of flows making the same manoeuvres (8 T-junctions)

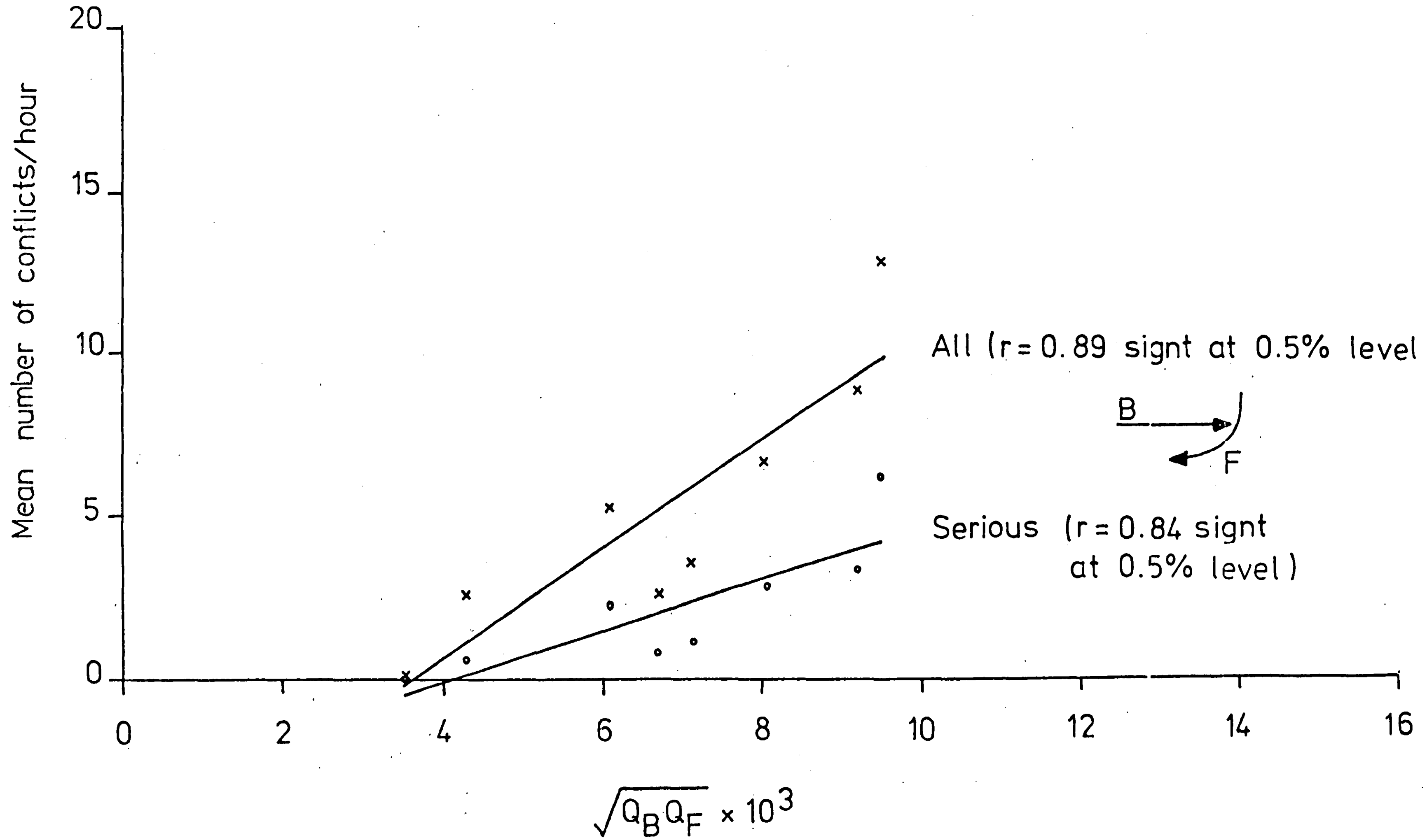


FIGURE 14: Mean frequency of conflicts at BF against square root of the product of flows making the same manoeuvres (8 T-junctions)

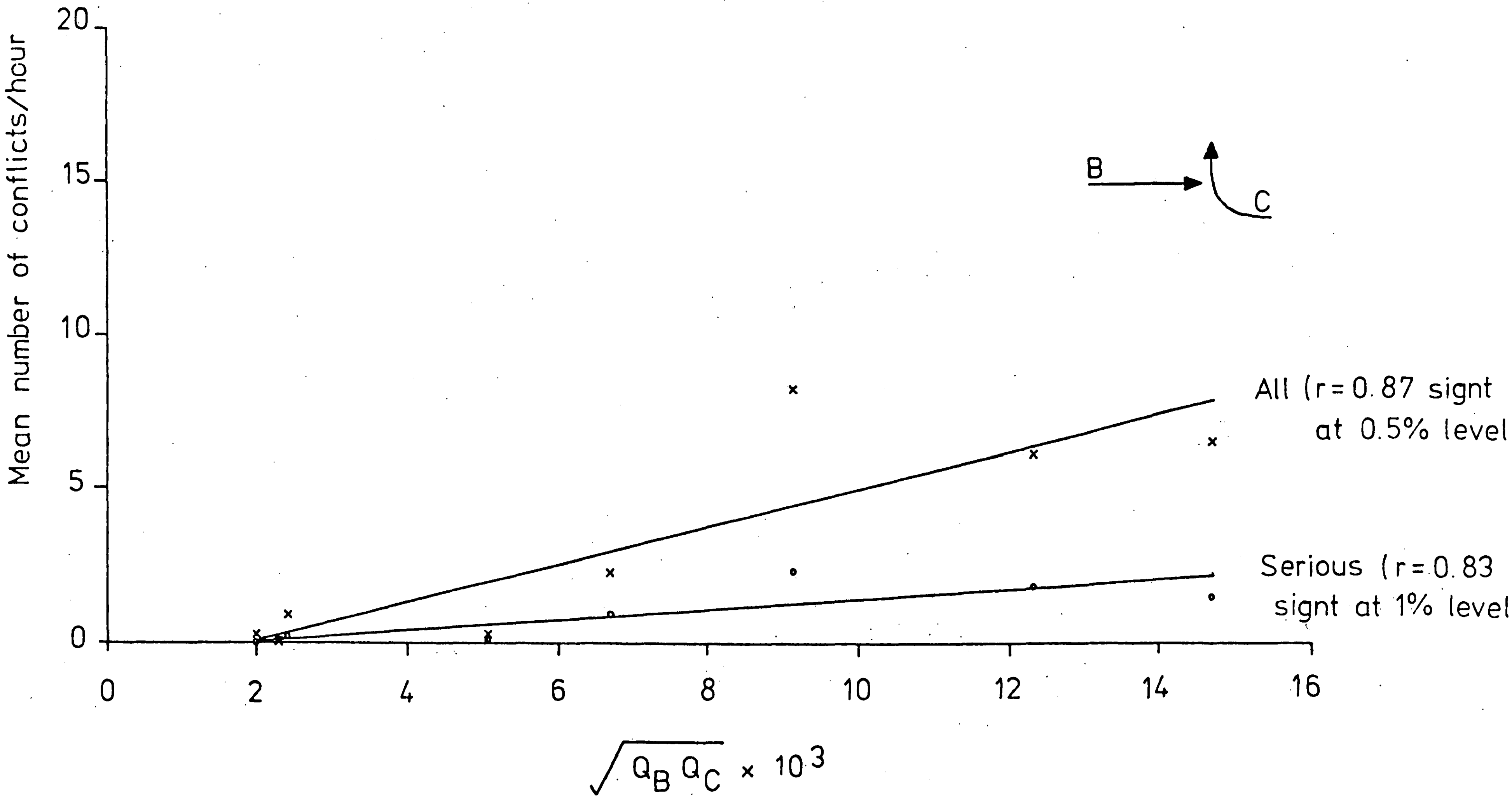


FIGURE 15 : Mean frequency of conflicts at BC against square root of the product of flows making the same manoeuvres (8 T-junctions)

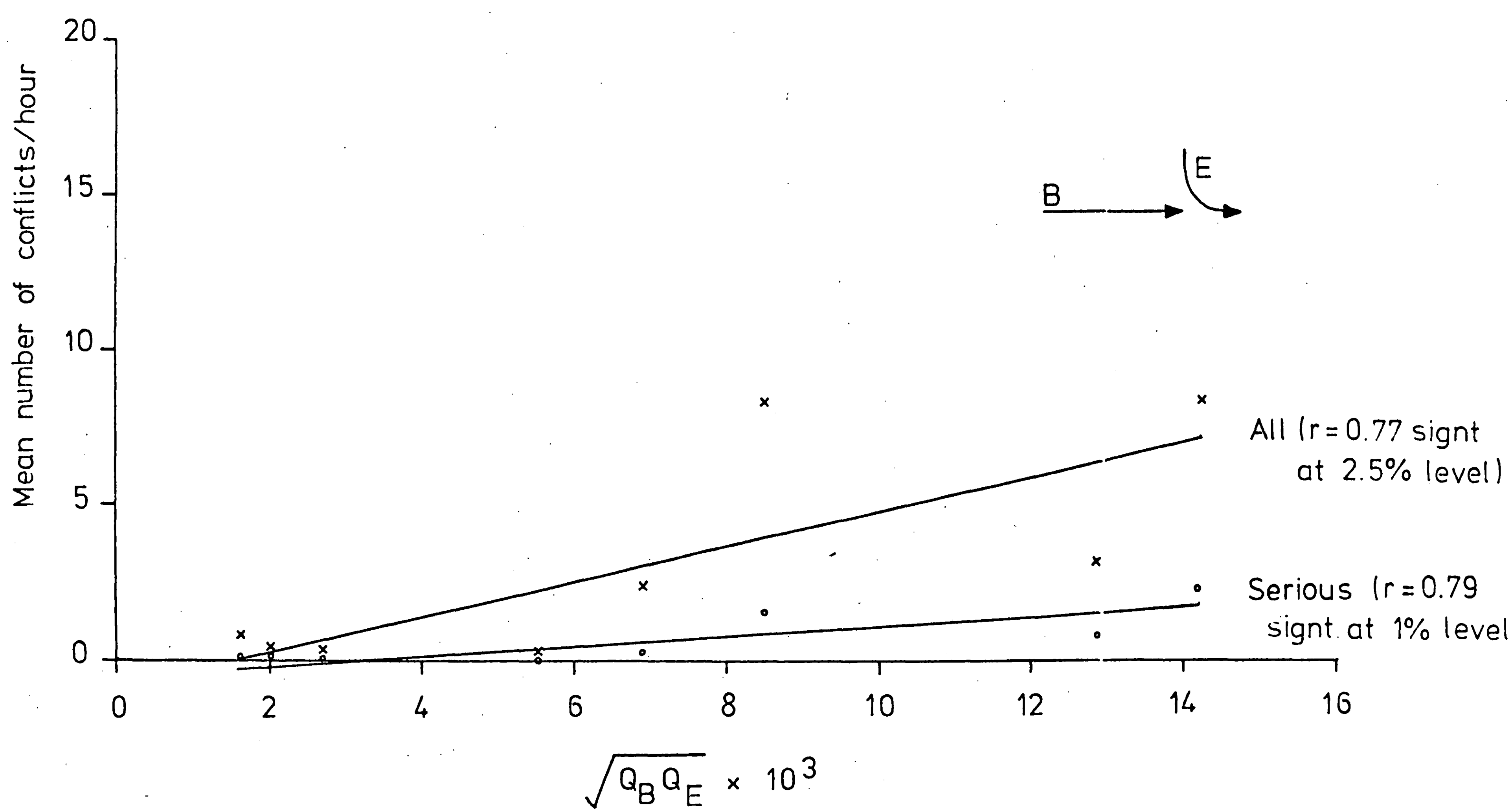


FIGURE 16 : Mean frequency of conflicts at BE against square root of the product of flows making the same manoeuvres (8 T-junctions)

It should also be noted that steep slopes and high thresholds seem to go together for conflicts and manoeuvres which involve a vehicle coming from a minor road and crossing to the far side of the main road. These are the most complex of the manoeuvres and the most difficult to judge because they require the driver who does not have right of way to make a judgement about two streams of traffic. In these circumstances, when the traffic flow is slight, the driver may decide to wait until there is a clear gap in the traffic, and hence there will be no conflicts. For higher traffic flows, this strategy would lead to intolerable delays, and the driver will be tempted to "push in" to smaller gaps. because of the need to judge traffic in both streams to be crossed, this is likely to lead to a rapid increase in conflicts for the higher traffic flows.

For manoeuvres BC and BE, only one stream of traffic needs to be considered. This seems to lead to slightly less caution at lower flows and to a less sharp increase in conflicts at higher flows. It should also be noted that both of these manoeuvres are likely to lead to a high proportion of rear end conflicts but these have been removed from the statistics reported here.

Despite these interesting findings, Figures 13-16 show only small deviations from linearity and hence justify the estimates of risk used in Tables 16 and 17. The justification, if it were needed, is provided by the very high correlation observed between the two estimates of risk (accidents per vehicle and conflicts per vehicle).

3.4 Rear end conflicts.

Although eliminated from the previous analyses because they so seldom lead to injury accidents, rear end conflicts also show positve relationships to traffic flow.

Correlations of rear end conflicts by locations and the product of the flows generating them produced the results shown below (Table 19). Here all conflicts (slight and serious combined) gave the highest correlations with the product of flows. With the exception of CD these were all smaller than the correlations for other conflicts.

Manoeuvres	Slight conflicts vs. $\sqrt{Q1xQ2}$	Serious conflicts vs. $\sqrt{Q1xQ2}$	All conflicts vs. $\sqrt{Q1xQ2}$
BB	0.60(NS)	0.56(NS)	0.69(5%)
DD	0.67(5%)	0.36(NS)	0.67(5%)
CD	0.93(0.5%)	0.93(0.5%)	0.93(0.5%)
BA	0.81(2.5%)	0.64(5%)	0.74(2.5%)

Table 19 : Correlation of rear end conflicts and the square root of the product of flows generating them at four locations

The issue of different conflict to accident ratios for different manoeuvres within a site has already been discussed (Chapter 8) and ratios produced for some manoeuvres within the T-junctions. Most rear end accidents are likely to be minor and go unreported, and therefore will not appear in the official statistics for the site. The under-reporting of accidents of this type is therefore likely to be considerable. Consequently the conflict to accident ratio is likely to be large. At the T-junctions there are four locations within the site where rear end accidents may occur. It is not possible to estimate these conflict to accident ratios, because when the rear end accidents are broken down by location, there are insufficient numbers to calculate the ratio with any confidence.

3.5 Summary of main results of this study

1. Rear end conflicts occur in large numbers at these urban sites mainly due to restricted road width. They were omitted from the analysis because most accidents occurring from such conflicts are minor, involving damage only, and therefore are not reported.

2. The correlation coefficient between serious conflicts/vehicle and accidents/vehicle at unsignalised T-junctions was found to be 0.79, significant at the 2.5% level.

3. The ranking of the combinations of manoeuvres at T-junctions in terms of conflicts per vehicle was found to be consistent with other studies and were as follows:-

a) Vehicles travelling along the through route with the junction on their right and vehicles turning right out of the minor road (Type DF).

b) Vehicles travelling along the through route with the junction on their left and vehicles turning right out of the minor road (Type BF).

c) Vehicles travelling along the through route with the junction on their left and the vehicles turning right into the minor road (Type BC).

d) Vehicles travelling along the through route with the junction on their left and vehicles turning left out of the minor road (Type BE).

e) Vehicles turning right into and out of the minor road (Type CF).

4. Numbers of serious conflicts correlated well with the products of flows generating those conflicts for four out of the five manoeuvres in the T-junctions.

5. Rear end conflicts and the product of flows generating them correlated significantly for four manoeuvres (BB, DD, DC and BA) in the T-junctions when all (slight plus

serious) conflicts were used (rs = 0.69, 0.67, 0.93 and 0.74 significant at the 5%, 5%, 0.5% and 2.5% levels respectively).

4. Additional information gained from conflict studies.

Conflict data can give additional information which accident data or volume counts alone cannot. Two particular examples are highlighted below. Firstly, the extent of involvement in conflicts by vehicles other than the two protagonists, and secondly the types of vehicles directly involved in the conflicts.

4.1 Numbers of vehicles involved in conflicts.

Spicer (1971) studied the part played by other vehicles present in conflict situations. The involvement of more than two vehicles was more likely in serious conflicts than in other conflicts. One reason for this may be that a non-serious conflict between two vehicles can be made into a serious conflict if the escape route is blocked by other vehicles. Spicer found that 75% of serious conflicts involved more than two vehicles and 40% more than three vehicles. Spicer (1972) reported that vehicles other than the two immediately involved were present in over 60% of the cases at a second dual carriageway intersection, and Spicer (1973) reported, in a study of four further intersections, figures of 54%, 58%, 58% and 70% of serious conflicts that involved more than two vehicles. Over all six intersections, more than 62% of serious conflicts involved more than two vehicles. Fatal and serious accident data for 1982 (Department of Transport, 1983) show that only 6% reportedly involve more than two vehicles. In the present study, 65% of the serious conflicts at all eight sites involved at least one other vehicle besides the two protagonists, and over 40% more than three vehicles. All of these vehicles had to take some form of evasive action, braking and/or swerving, to avoid one or both of the vehicles directly involved. The numbers of extra vehicles involved is shown in Figure 17.

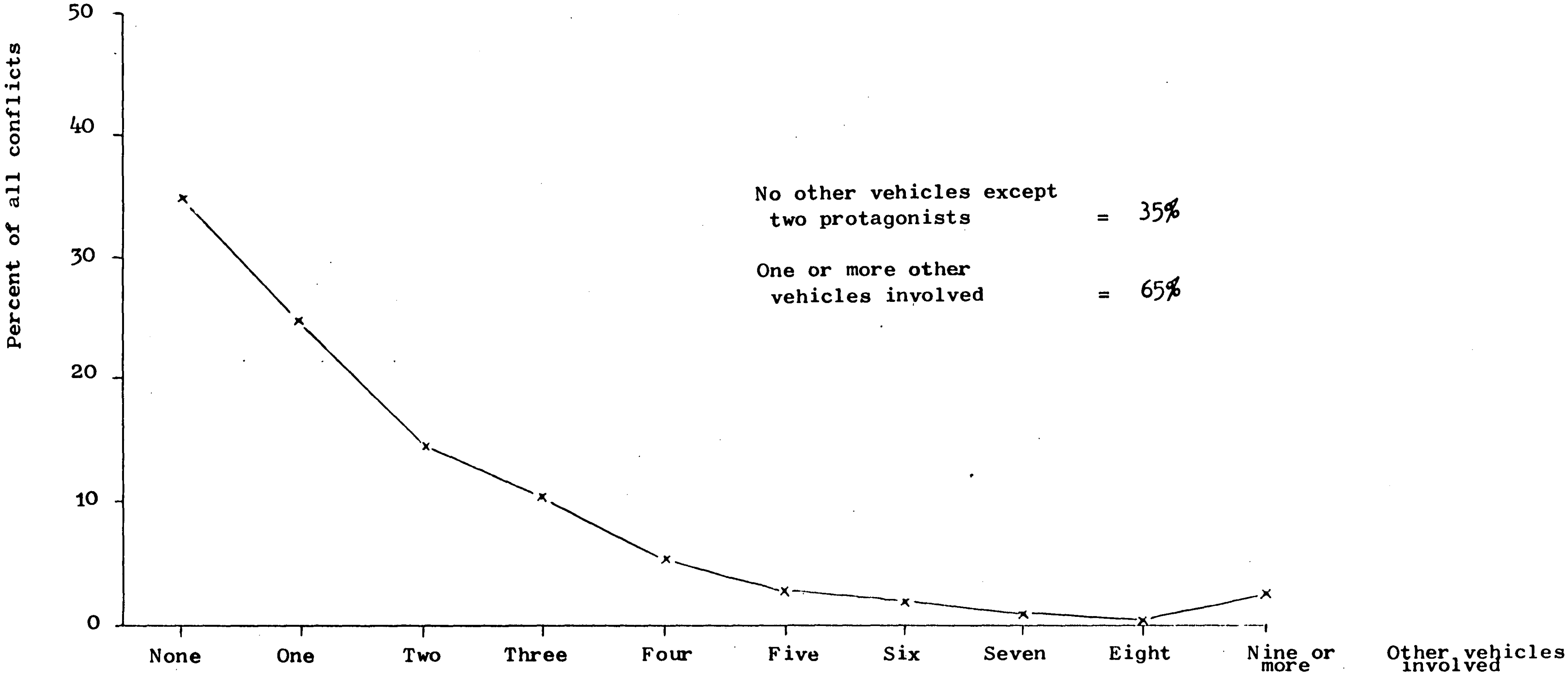


FIGURE 17 : The percentages of vehicles, in addition to the two main protagonists, involved in conflicts.

4.2 Types of vehicles involved in conflicts.

One of the common assumptions that exists in the lay driving population concerns the types of vehicles that "cause" conflicts. Heavy goods vehicles are often slow to accelerate and will therefore take longer to clear a junction. They are also of a greater length than most other vehicles on the roads so they therefore present a larger area to avoid (or not as the case may be). Because the drivers are less vulnerable, they may also be driving in a less considerate manner. Motorcycle riders, on the other hand, complain that other road users pull out in front of them particularly from side roads, and when such an accident occurs, the driver's plea is that he simply did not see the motorcycle approaching. Concern about this nationally led to the "Think once, think twice, think bike" campaign of television commercials, specifically aimed at motorists pulling out of side roads. Because of their greater vulnerability they might also be expected to drive more cautiously.

Examining the distribution of vehicle types in the present study of

a) the vehicles whose actions caused another vehicle to take avoiding action (the offender), and

b) the vehicles that had to take avoiding action

(the offended)

using the t test (calculations in Appendix, Tables 32a-d) gave the following results. In four out of the eight vehicle classifications, there were significant associations.

1. Heavy goods vehicles -- significantly more heavy goods vehicles cause other vehicles to take avoiding action than have to take avoiding action. ($p<0.01$).

2. Motorcycles -- significantly more motorcycles have to take avoiding action than cause other vehicles to take such action ($p<0.01$).

3. Cars -- significantly more cars have to take avoiding action than cause other vehicles to take avoiding action ($p<0.01$).

4. Light goods vehicles -- significantly more light goods vehicles cause others to take avoiding action than have to take such evasive actions themselves ($p<0.01$).

5. Conclusions.

It is suggested that rear end conflicts should be treated separately from other conflicts. They should be excluded from any attempts at validating the technique against accidents other than rear end accidents. Their role in masking what might otherwise have been significant relationships had been suspected (Campbell and King, 1970; Baker, 1972) but has now been confirmed. Rear end conflicts are very closely related to flow at the unsignalised T-junctions studied, both in terms of total inflow and the product of flows generating them. The issue of their exclusion is most important in studies at urban locations because of the large number occurring at these sites compared to rural dual carriageways.

The significant association between serious conflicts and accidents establishes that the Traffic Conflicts Technique is valid at these locations, and supports the view that it is important to classify conflicts by severity, because it is these events that are closest to accidents on the assumed continuum. The study carried out here extends the work by Spicer (1971, 1972, 1973) at rural dual carriageways into urban areas at T-junctions, and supports the hypothesis that serious conflicts are associated statistically with reported injury accidents. It is likely that the conflicts technique can be used to identify dangerous manoeuvres as well as dangerous sites, although this study failed to demonstrate a significant relationship.

Extra information, such as the type and number of vehicles involved in conflicts, is only available from conflict studies. This extra information can be most valuable in diagnosis of an accident location and the evaluation of countermeasures.

However, the present study has validated the conflicts technique only for urban T-junctions (the commonest of all accident sites). It could , therefore, only be used for evaluating the effects of very small changes in the layout of such junctions. It could be used to evaluate more radical changes eg. a change from a T-junction to a mini roundabout, providing the conflict to accident ratios of the different layouts were known. This study represents a step in this direction by producing the first conflict to accident ratios by manoeuvre for urban unsignalised T-junctions. By obtaining more information of this kind the utility of the conflicts technique could be greatly extended.

In the following chapter (Chapter 10) the two alternative measures of accident potential put forward in Chapter 1, namely traffic flows and subjective assessments of risk, are examined for their correlation with the accident history, to see if they can provide a satisfactory but cheaper alternative to the conflicts technique.

SECTION D : ALTERNATIVE MEASURES OF ACCIDENT POTENTIAL

CHAPTER 10

TRAFFIC FLOWS AND SUBJECTIVE ASSESSMENTS OF RISK

1. Introduction

Both traffic flow data and subjective assessments are easy and simple to collect. Traffic flows can be collected either by observers with counters, or by automatic traffic counters positioned on each approach. The latter will, however, only be able to provide data on numbers of vehicles on each approach or exit, whereas observers will be able to count vehicles carrying out specific manoeuvres and also classify the vehicles by type if required. From these data, estimates of weekly and annual flow can be made, by applying the appropriate weighting factors determined by Phillips (1979), to counts taken over short periods. This method is, therefore, both quick and economical. Traffic flows can, however, only provide quantitative data, whereas what is needed for full diagnosis of the possible causes of accidents is both a quantitative and qualitative measure. A method which potentially has this ability is described below.

Subjective assessments of risk can be collected merely by taking people to the site or, even more conveniently, by showing them photographs of the sites, and getting them to assess the whole site, and manoeuvres within the site, for risk. Using subjective assessments of risk and relating them to an objective measure of risk at locations in the road network is a new technique. It has been use by Watts and Quimby (1980) using subjects drawn from the general motoring public. They drove themselves round a set route and were asked to assess risk at a wide variety of locations eg. bends, brows, junctions, a level crossing (N = 45). While a significant correlation with accidents was found, it was of a low order (rs = 0.37), accounting for only 14% of the variance. There are a number of issues arising from this study:

a) These subjects were attempting to predict accidents presumably from simultaneous estimates of traffic flow and risk. This may be a subjectively easier thing to do than assessing risk (accident/flow) but additional variance will be introduced by accidental variations in traffic flow.

b) Subjects who drive themselves round the locations may be influenced by the manoeuvres they make at each location and the ease or difficulty involved in making that manoeuvre. A better method would be to let them view the location and assess it for risk before negotiating it, to avoid any prejudice resulting from the ease or difficulty of negotiation.

c) Watts and Quimby's (op cit) subjects were all drawn from the general motoring public and had no experience of accident investigation. They used them because they were in this respect, representative of the accident population. However, those who have the authority to diagnose and initiate remedial measures are traffic engineers. Their ability to assess sites should therefore also be investigated. A third group whose subjective judgements should be sought are driving instructors who should have experience of hazard perception.

d) the wide variety of sites assessed in Watts and Quimby's (op cit) study meant that only the riskiness of sites of different layout could be ranked. No comparison could be made between sites of similar layout. By limiting the locations to sites of similar layout eg. urban T-junctions, as in the previous study, it may be possible to rank the sites and pinpoint those that are under rated ie. are subjectively safe but objectively dangerous. Assessments of the various manoeuvres within the junctions should also be recorded in order to ascertain which are perceived as being the most risky compared to which are actually the most risky.

The study reported in this chapter was the first investigation into the usefulness of subjective assessments to measure risk at a number of sites of the same layout ie. urban T-junctions, and also to examine which manoeuvres within T-junctions are perceived as being the most dangerous. The subjects involved were of three sorts: ordinary drivers drawn from the motoring public, driving instructors and traffic engineers.

The empirical data relating to this study is reported in part 3 of this chapter. Before that, the relationship between accidents and traffic flows at the T-junctions is reported.

2. Traffic flows

2.1 Introduction

A review of the literature in Chapter 1 indicated that research into the relationship between traffic flow and accidents at junctions has been very limited and that the results have been inconsistent. Some of the studies relate to a wide variety of very different intersection types eg. MacDonald, 1953, in which no attempt was made to sort the intersections by type, and this partly detracts from the value of any result. The relationship between accident occurrence and traffic flow was first investigated at rural junctions, where the effects of other factors, such as pedestrians, were less complicated. However, the majority of accidents occur in urban areas, and it is therefore necessary to examine the relationship at these locations to see whether flows can predict where accidents will occur. The study reported below was carried out at eight urban T-junctions.

2.2 Method

The injury accident records for the previous four years were obtained for the eight unsignalised T-junctions used in this study. No alterations to the sites had occurred during this time. Accidents involving pedestrians and cyclists were excluded, as were rear end accidents.

Traffic flows were obtained by observers at the sites during weekdays, between 07.00am and 18.00pm. The figures for total annual inflow were calculated according to the method and weighting factors determined by Phillips (1979).

The measures of flow used in the correlations were:

a) total inflow (sum of all entering flows)

b) the product of intersecting flows

The Spearman Rank Correlation Coefficient (rs) was used to determine the degree of agreement.

2.3 Results

The raw data are presented in Tables 20 and 21 below.

Combination of manoeuvres	Site number 1	2	3	4	5	6	7	8	Total
A (BC)	3	0	3	7	3	3	0	0	19
B (BE)	0	0	0	0	0	0	0	0	0
C (BF)	0	0	0	0	4	0	12	6	22
D (DF)	0	5	0	0	0	0	0	3	8
E (CF)	0	0	0	0	0	0	0	0	0
Total	3	5	3	7	7	3	12	9	49
Accts per 100m vehs	1.4	1.4	1.4	16.2	5.3	5.0	29.1	14.5	

Table 20 : Numbers of accidents and accidents per 100 million vehicles by site and manoeuvres

Combn of man'res	Site number 1	2	3	4	5	6	7	8	Avge
A (BC)	5.10	2.34	6.69	12.32	9.06	2.40	2.00	14.71	6.83
B (BE)	5.55	2.74	6.87	12.76	8.48	2.02	1.62	14.21	6.78
C (BF)	3.43	6.72	4.34	7.14	6.07	9.18	8.07	9.51	6.81
D (DF)	3.54	7.67	4.09	6.94	5.44	10.06	8.25	8.76	6.84
E (CF)	1.37	3.06	0.69	3.45	4.96	1.81	0.73	4.48	2.57
Total	18.99	22.53	22.68	42.61	34.01	25.47	20.67	51.67	
Inflo	32.64	31.09	82.87	66.55	40.27	44.58	53.03	78.90	

Table 21 : Square root of the product of flows and total inflow by site and manoeuvre

Accidents and total inflow at the eight sites were found to be not significantly related (rs = 0.21).

Accidents and the average product of flows at the eight sites were not significantly correlated (rs =

0.32).

Correlations across manoeuvres were not attempted because only 3 manoeuvres produced accidents.

2.4 Conclusions

The correlation between accidents and the product of flows generating them at the eight T-junctions sites (rs = 0.32) accounts for only about 10% of the variance. This is rather surprising given the much better correlation between conflicts and flow reported in Table 18. It is possible that other alternative measures any account for considerably more of the variance than this. In the next study, subjective assessments are investigated as a possible alternative to accident statistics for measuring accident potential.

3. Subjective assessments of risk

3.1 Introduction

In this section, people's subjective opinions of the riskiness of a location and of the manoeuvres within the location will be considered.

The two studies reported below were designed to investigate whether subjective judgements of the dangerousness of a number of sites correlated with the objective risk, measured by the number of accidents, at a selection of urban T-junction sites.

In order to vary the type and amount of information available to the subjects at the time of the assessments, some subjects made their decisions based on scale maps and photographs (reported in 3.2) while others observed the same locations in the field (reported in 3.3). Clearly, the subjects in the second group have a view of the locations which is closer to that experienced in the driving situation and might be expected to make more "accurate" assessments. However, the reason for carrying out the first method of measuring subjective risk is that it is probably the quickest and easiest (and therefore the most economical).

On order to get assessments from people with a variety of types and degrees of experience of driving and its hazards, the subjects were drawn from three different sources: ordinary drivers from the general motoring public, not having any professional association with driving or traffic studies, driving instructors and local authority traffic engineers. In an attempt to minimise any familiarity with the sites to be assessed, the subjects were recruited from outside the study area.

3.2 Subjective assessments from scale maps and photographs

Thirty subjects took part in the experiment: ten ordinary drivers, ten driving instructors and ten traffic engineers. The reported injury accidents occurring were used as the basis for objective risk, which was calculated as the number of accidents per 100 million vehicles, in order to take account of traffic density at the sites.

Subjects were presented with a scale map of each of the eight sites showing the road layout and markings, road signs, bus stops, pedestrian crossings etc. Also provided were colour photographs taken from every approach. Each photograph was numbered and the places corresponding to the position from which the photo was taken was identified on the scale map by the number. The subjects were then asked to give the site a rating of risk on an eight point scale, with the probability increasing from a rating of 0 as no chance of an accident to a maximum rating of 7. The sites were presented to the subjects in random order, different for each subject.

Following this rating exercise, each subject was shown line drawings of the manoeuvres at the sites (Figure 18). The set comprised five drawings, each with a different combination of manoeuvres. Subjects were asked to rank these five in order of their likelihood in producing an accident.

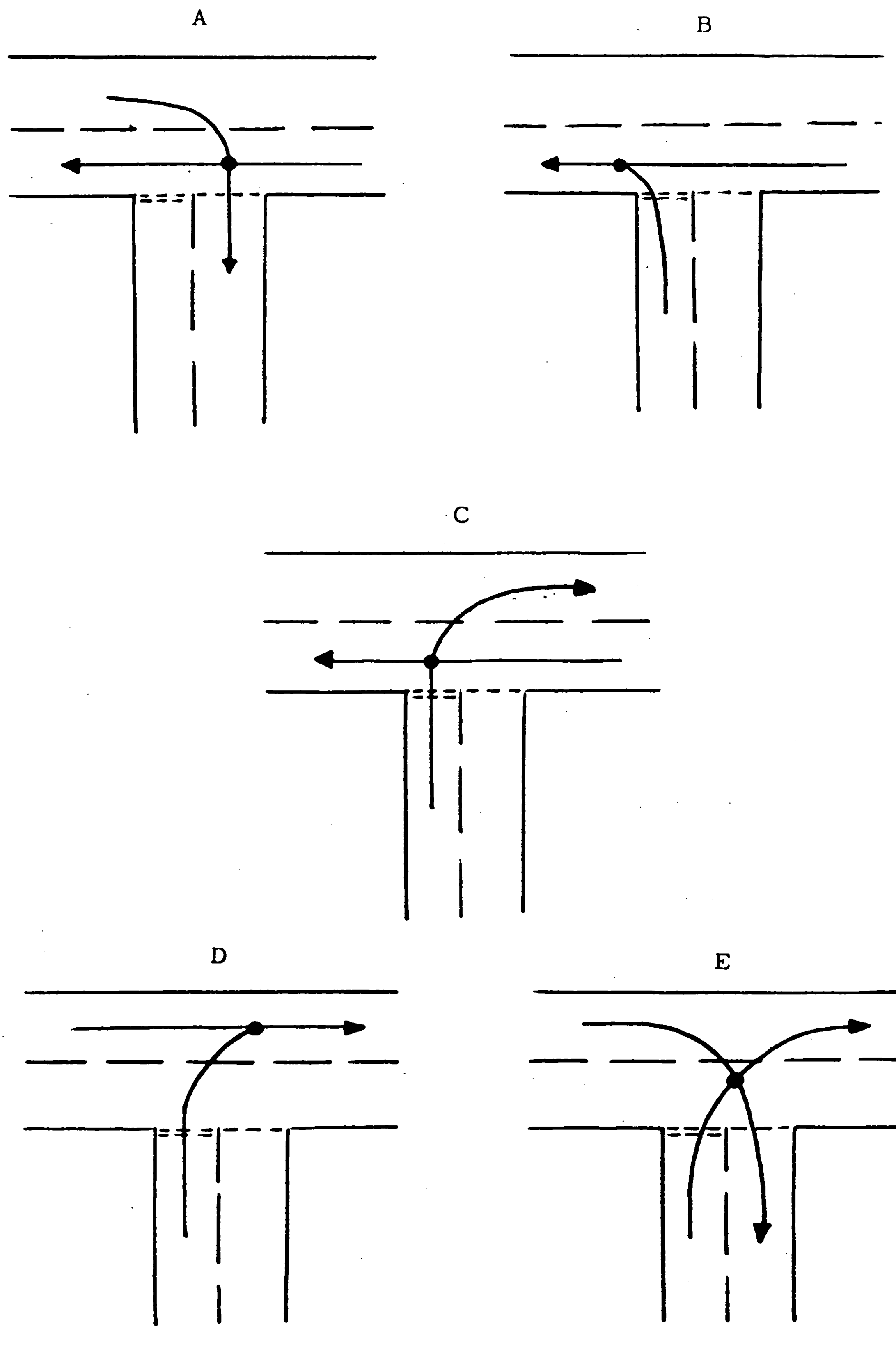


Figure 18 : Diagrams of the five combinations of manoeuvres at T-junctions judged for subjective assessments of risk

Each drawing was coded by a letter, and the rankings of each subject for each drawing was recorded. The results are presented below.

a) Relationship between subjective and objective risk.

The sites were ranked on the basis of the mean of the ratings assigned to them by each group of subjects such that the site with the lowest mean rating was ranked 1. The sites were ranked for objective risk with the site with the lowest number of accidents per 100 million vehicles ranked 1. The Spearman Rank Correlation Coefficient (rs) was used to examine the relationship between subjective and objective risk at the sites for eac group of subjects. The mean ratings from the subjective assessments of risk are shown in Tables 22-24 for ordinary drivers, driving instructors and traffic engineers respectively.

ORDINARY DRIVERS

Site no.	Mean rating	Rank based on subjective risk	Accidents per 100m vehicles	Rank based on objective risk
1	3.3	3	1.4	2
2	4.1	6	1.4	2
3	4.1	6	1.4	2
4	4.4	8	16.2	7
5	3.7	4	5.3	5
6	3.1	1	5.0	4
7	3.2	2	29.1	8
8	4.1	6	14.5	6

Table 22 : Subjective assessments of risk by ordinary drivers from scale maps and photographs, and objective risk

DRIVING INSTRUCTORS

Site no.	Mean rating	Rank based on subjective risk	Accidents per 100m vehicles	Rank based on objective risk
1	3.6	2	1.4	2
2	3.8	4	1.4	2
3	4.0	7	1.4	2
4	3.7	3	16.2	7
5	3.9	5.5	5.3	5
6	3.9	5.5	5.0	4
7	2.7	1	29.1	8
8	4.1	8	14.5	6

Table 23 : Subjective assessments of risk by driving instructors from scale maps and photographs, and objective risk

TRAFFIC ENGINEERS

Site no.	Mean rating	Rank based on subjective risk	Accidents per 100m vehicles	Rank based on objective risk
1	3.4	2	1.4	2
2	4.3	6	1.4	2
3	4.6	7	1.4	2
4	3.9	4.5	16.2	7
5	3.8	3	5.3	5
6	4.8	8	5.0	4
7	2.9	1	29.1	8
8	3.9	4.5	14.5	6

Table 24 : Subjective assessments of risk by traffic engineers from scale maps and photographs, and objective risk

The results of the correlations are given below:

rs ordinary drivers = 0.00 (not significant)
rs driving instructors = -0.23 (not significant)
rs traffic engineers = -0.44 (not significant)

These correlations seem to be randomly distributed and none are significant.

b) Manoeuvres likely to produce accidents

The ranks assigned to each combination of manoeuvres by the subjects were totalled and the final ranking of manoeuvres derived from these totals to provide subjective assessments of the riskiness of each manoeuvre within the T-junctions. To get objective risk the drawings were ranked according to the number of accidents at each. The ranks based on subjective and objective risk for each group of subjects are shown in Table 25.

Diagram	Subjective rankings			Numbers of accidents	Objective rankings
	Ordinary drivers	Driving instructors	Traffic engineers		
A	3	3	4	19	4
B	1	1	1	0	1.5
C	2	4	5	22	5
D	4	2	2	8	3
E	5	5	3	0	1.5

Table 25 : Subjective and objective rankings of manoeuvres at T-junctions

The two sets of ranks for subjective and objective risk were compared using the Spearman Rank Correlation Coefficient (rs). The results are shown below for each group of subjects.

rs ordinary drivers	= -0.20	(not significant)
rs driving instructors	= 0.20	(not significant)
rs traffic engineers	= 0.80	(not significant)

rs must be greater than or equal to 0.90 for significance at the 0.05 level where N = 5

While the figure for traffic engineers is non-significant (rs = 0.80), if it were significant it would account for 64% of the variance. However, the traffic engineers were all employed in Local Authority Accident Investigation Units and would be expected to knoww from their work experience the most dangerous manoeuvres (as measured by the accident rates) at T-junctions. These have been reported in the literature eg. Colgate and Tanner (1967). This result was therefore predictable and is irrelevant to the issue of whether different groups of subjects could identify the most dangerous sites from maps and photographs. However, it is not irrelevant when attempting to combine information about traffic flow with knowledge of the most dangerous manoeuvres. It may be that the most dangerous sites could be predicted by summing the product of flow multiplied by a risk factor for each of the possible manoeuvres in each site. This will be considered later.

3.3 Subjective assessments from on-site observations

Ten ordinary drivers and ten driving instructors took part in the study. The local authorities could not release their traffic engineers for the time required to travel and participate in the study as it would have involved taking them away from their work for too long a period.

The same eight road junctions were organised into a route. Objective risk was taken as the total number of reported accidents rather than accidents per 100 million vehicles as subjects were able to assess traffic density in this study, which they were not able to do from the photographs and incorporate them into their assessments.

The subjects were driven round the route in small groups, at the same time of the day for each group. They were given a brief verbal description of each site as they arrived, and allowed time to leave the vehicle on order to obtain a closer look at the junction and all its approaches and features. They were asked to a) rate the site for risk on an eight point scale as in the previous study and b) estimate how many vehicle accidents resulting in injury to the occupants occurred each year. It was emphasized to the subjects that they should make their assessments of each site as soon as, or before passing through the junction in the vehicle. This was to ensure that their assessments were not influenced by the manoeuvres made by the vehicle in which they were travelling or by any conflict the vehicle might be involved in. This procedure was repeated at all the sites and the ratings and estimates of accidents recorded for each subject.

a) Relationship between subjective and objective risk

Each site was assigned a rank based on the mean assessment by each group of subjects such that the site with the lowest mean rating was ranked 1. The sites were ranked for objective risk with the lowest number of accidents ranked 1. The Spearman Rank Correlation Coefficient (rs) was used to test the relationship between subjective and objective risk at the sites for each group of subjects. The two sets of ranks based on subjective and objective risk together with the total numbers of accidents are shown in Tables 26 and 27 for ordinary drivers and driving instructors respectively.

ORDINARY DRIVERS

Site no.	Mean rating	Rank based on subjective risk	Total numbers of accidents	Rank based on objective risk
1	2.3	1	3	2
2	4.2	6	5	4
3	3.4	2	3	2
4	4.9	8	7	5.5
5	4.0	5	7	5.5
6	4.3	7	3	2
7	3.9	3.5	12	8
8	3.9	3.5	9	7

Table 26 : Subjective assessments of risk by ordinary drivers from on-site observations, and objective risk

DRIVING INSTRUCTORS

Site no.	Mean rating	Rank based on subjective risk	Total numbers of accidents	Rank based on objective risk
1	2.6	1	3	2
2	3.4	3.5	5	4
3	4.3	7	3	2
4	4.8	8	7	5.5
5	3.4	3.5	7	5.5
6	3.3	2	3	2
7	3.6	5.5	12	8
8	3.6	5.5	9	7

Table 27 : Subjective assessments of risk by driving instructors from on-site observations, and objective risk

The results of the correlations are given below:

rs ordinary drivers = 0.16 (not significant)
rs driving instructors = 0.44 (not significant)

b) Estimates of vehicle accidents

For each individual subject the sites were ranked according to the estimate made at that site, so that the site with the lowest estimate of accidents was ranked 1.

Then for each group of subjects, the individual rankings of each site were totalled and the final ranking of sites derived from these totals. This formed a further subjective assessment of risk. The measure of objective risk was again the total number of accidents, and the sites were ranked accordingly. Subjective and objective risk were compared using the Spearman Rank Correlation Coefficient (rs) and the results were as follows:

rs ordinary drivers = 0.22 (not significant)
rs driving instructors = 0.29 (not significant)

3.4 Comparison of subjective assessments from scale maps and photographs with on-site observations

By comparing the subjective assessments of the riskiness of each of the eight sites made by the ordinary drivers and driving instructors, the following correlation coefficients were found:

rs ordinary drivers = 0.63 (significant at 0.05 level)
rs driving instructors = 0.61 (significant at 0.05 level)

This shows that there was significant agreement between similar groups of subjects when comparing their assessments from the scale maps and photographs and from on-site observations which suggests that subjects are applying the same sorts of criteria when making their assessments in the two studies.

4. Combining traffic flows and subjective assessments

Accidents and the product of flows at the eight produced a non-significant correlation of 0.32 accounting for only 10% of the variance. Subjective assessments based on maps and photographs or on-site observations also do not account for a significant proportion of the variance. Neither ordinary drivers, driving instructors or traffic engineers could produce significant results when assessing the sites from maps and photographs (rs = 0.00, -0.23, -0.44 respectively). When the subjective assessments were made from on-site observations, the correlation coefficients for ordinary drivers and driving instructors were again non-significant (rs = 0.16 and 0.44. Even for significance at the 0.05 level, rs must be equal to or greater than 0.64).

A weakness of all these techniques is that they ignore any variations in the dangerousness of different manoeuvres at different sites and when calculating accidents/flow for each of the sites the flows through all the possible manoeuvres are conflated.

A better test of people's ability to predict risk might be to get separate estimates of the riskiness of each manoeuvre. As a preliminary test of this hypothesis, a separate estimate of the likelihood of accidents for each manoeuvre at each site was obtained by multiplying the product of flows at each site and for each manoeuvre by the traffic engineers estimate of the riskiness of each manoeuvre from the maps and photographs. The results are shown in Table 28. These estimated likelihoods were summed for each site and the summed likelihoods were ranked. These ranks were then correlated with the ranked acciednt records of the different sites. These two sets of ranks correlated 0.46 (Spearmans) which again failed to reach significance.

	Site number							
	1	2	3	4	5	6	7	8
A	20.40	9.36	26.76	49.28	36.24	9.60	8.00	58.84
B	5.55	2.74	6.87	12.76	8.48	2.02	1.62	14.21
C	17.15	33.60	21.70	35.70	30.35	45.90	40.35	47.55
D	7.08	15.34	8.18	13.88	10.88	20.12	16.50	17.52
E	4.11	9.18	2.07	10.35	14.88	5.43	2.19	13.44
Tot	54.29	70.22	65.58	121.97	100.83	83.07	68.66	151.56
Rank	1	4	2	7	6	5	3	8
Rank (accidents)	2	4	2	5.5	5.5	2	8	7

rs = 0.46 (not significant)

Table 28 : An attempt to predict the number of accidents likely to occur at each manoeuvre within each site by multiplying the traffic flow (root product of flow) by the estimated risk of each manoeuvre.

5. Conclusions

None of the correlations between traffic flows, subjective assessments, or a combination of the two with accidents were significant, but the failure of any one of the correlations to be higher than 0.46 (while many of them were negative) suggests very strongly that these simpler methods are very unlikely to have the validity of the full conflicts technique.

CHAPTER 11

APPLICATIONS AND FUTURE STUDIES

1. Applications for the Traffic Conflicts Technique
   1.1 Data base
   1.2 Diagnosis
   1.3 Evaluation

2. The future development of the technique.
   2.1 Evaluation of remedial measures
   2.2 Conflict generation studies
   2.3 Extending the technique to study pedestrian-vehicle interactions

1. Applications for the Traffic Conflicts Technique.

While accident statistics will always be one of the two main reasons for investigating individual locations (the other being public pressure), their paucity in absolute terms and the problems inherent in their collection create difficulties when diagnoses of operational deficiencies and evaluation of remedial measures are sought. Accident data is retrospective and by its very nature omits much detail that would be of interest to accident investigators. Furthermore, the information collected is not necessarily recorded systematically due to response or recorder bias, and the circumstances surrounding the incident. Improving the scope and reliability of accident data would go some way to making the data more reliable, but even the most accurate records of accident numbers cannot suggest countermeasures. It is difficult even to use them to indicate possible target groups in the absence of exposure data, or even to evaluate countermeasures, because in the time between the before and after studies (often lengthy due to the time taken to collect sufficient accident data for analysis) it is possible that any change could be due to other factors.

In order to try to overcome some of these problems, alternative measures have been put forward as candidates for predicting accident potential. Before any can be accepted as providing an indirect measure of safety, it must be shown that it is directly related to accidents. Conflicts have an appealing face validity, and much work has been undertaken in the last 15 years in trying to establish the theory as fact. Without such corroborative evidence, conflicts can never be used in practice with any degree of confidence for diagnostic or evaluative purposes.

This thesis put forward the hypothesis that conflicts are related to accidents, and this has been demonstrated empirically in a study of urban T-junctions. Previous researchers have only successfully demonstrated its validity in rural dual carriageway locations. The review of the literature on validity of the technique has shown that many earlier conflict studies have been unable to find significant association between conflicts and accidents. It has been argued in this thesis that the possible reasons for this lie in the methods used and in the lack of classification by manoeuvre of vehicles involved and severity of conflicts resulting.

The widespread interest in the technique by the local authority accident investigation units indicated the potential importance of the technique in practical application. Their premature adoption of a technique still in its developmental stages led to some reservations about the ability of casual observers to reliably collect conflict data. The work in the first part of this thesis showed the levels attainable by casual enumerators with regard to both the detection and grading of conflicts and sets out a manual for the selection and training of observers. This should encourage and further the spread of the technique by local authorities and ensure a consistent and standardised approach which is soundly based on research findings.

The only serious contenders to conflicts as an alternative approach to the study of road accidents are traffic flow and subjective assessments, but their relationship with accidents seems unproductive as far as accurate diagnosis of accident potential is concerned. Flow counts can only provide quantitative data whereas conflicts can provide both a quantitative and qualitative reflection of events.

Now that both the validity and reliability of the technique have been shown to be within acceptable limits and that the notion of a continuum between conflicts and accidents has been established at urban T-junctions and rural dual carriageway intersections, studies are becoming more problem oriented. This is not to say that there are not still areas which need further clarification. As concluded at the end of Chapter 9, more conflict to accident ratios at sites of different layouts eg. crossroads and roundabouts, are required if the technique is to be used to evaluate radical changes. Other investigations into, and developments of, the technique to which research workers might profitably devote their future energies include continued evaluation, conflict generation, and the extension of the technique to study pedestrian-vehicle interactions. These are discussed in the final section.

The application of the technique lies in the hands of the local authority accident investigation units, who have the responsibility and power to use it at the sharp end of road safety, namely the location of road accidents. Its main use will be at sites such a urban T-junctions where small road improvements could give a high economic rate of return, and the Traffic Conflicts Technique can provide information without waiting for an accident history to develop. The purposes for which the technique will be used at such sites, and for which it was developed, are threefold:-

1.1 to provide a record of road user behaviour for analysis (data base),

1.2 to provide an indication of the accident problem at a specific site and to identify suitable small road improvements as countermeasures (diagnosis), and

1.3 to provide a measure of safety to be used in evaluation of those small road improvements as countermeasures by before and after studies (evaluation).

These purposes are each discussed more fully below.

1.1 Data base.

On the positive side, conflicts have a good many advantages, fulfilling most of the requirements of an alternative approach to the study of accidents. Conflicts occur in much greater frequency than accidents thereby providing more incidents for analysis. Much more comprehensive data can be obtained because behaviour leading up to conflicts can be studied. A full history of events can be obtained, especially if film is used. It is these events which so often highlight the combination of factors that lead up to conflicts and therefore to actual accidents. Conflicts become the base which provides the indication of the specific remedial action required to remedy the operational deficiency.

Although a serious conflict will usually contain most of the factors which are present when an accident occurs, it may not contain them all, otherwise, by definition, an accident would have occurred. Comparing the conflict data with the available accident data is always advisable and for this reason conflict data should be viewed as a supplement to, rather than as a substitute for, accident data. Partly because of the variability of observers in the identification of conflicts and the inaccuracies inherent in the accident statistics, the traffic conflicts technique is not recommended as a means of predicting numbers of accidents at a site. What it can be used for is to provide additional information on deficiencies that may or may not be contributing factors in accidents. Clearing up ambiguities at intersections and other locations will inevitably lead to a decrease in erratic manoeuvres, which should in turn increase the operational efficiency of the system and hence improve safety.

1.2 Diagnosis.

The Traffic Conflicts Technique is useful for the traffic engineer to use as an aid to diagnosing operational deficiencies at sites that have already been singled out for attention, usually on the basis of their accident history. It is not appropriate for identifying hazardous locations, simply because of the cost per location required for its application. However, the technique is particularly well suited for confirming (or refuting) suggestions that an intersection has inherent problems that are perhaps not yet illustrated by a sufficiently large accident history. Typically, complaints of "dangerous" locations come from local residents and are often precipitated by an isolated, but particularly serious or fatal accident, or a short-term "rash" of incidents. In personal communications, Lancashire and Cheshire County Councils (1979) said that up to twothirds of their investigations were directly due to public pressure and scored highly where a points rating system was used to rank improvement sites. The traffic conflicts technique provides a readily available means of supplying up to date information to authorities and road users. Thus if the public ask for some action to be taken at a site, their complaint can be evaluated quickly.

Because of the usefulness in pointing out problems precisely, the technique should lead to lower cost remedial measures. It is also easier to establish a direct relationship bewteen cost and effectiveness in accident reduction. The technique can be applied to both urban and rural junctions of most types (possibly with slight modifications). With improved knowledge of potentially dangerous features, there should be better initial design and layout of new roads.

1.3 Evaluation.

Traffic conflicts are also applicable to evaluations of the remedial measures which an initial study might have suggested. Measures that have been implemented can be evaluated as to their benefit in improving a junction layout. An "after" study can be carried out and completed just a few weeks after a change without waiting for an accident history (or lack of it) to evolve. Often it is possible to modify the local environment with temporary materials. In this way the benefits of several alternatives may be assessed, and the best chosen and implemented in permanent materials.

There are three "rules" that should be followed in respect of these before and after studies:-

1) The before and after periods must be identical in length and must be carried out at similar times of year under the same conditions with regard to weather, traffic density and so on.

2) The construction period should be omitted from both periods.

3) The after study should not begin until some time after the measure comes into operation, to allow road users time to fully adapt to the new situation.

In conclusion, the Traffic Conflicts Technique is gaining widespread acceptance as a valuable diagnostic and evaluative aid in accident investigations, and it is hoped that it will lead to increased safety and more efficient and economic deployment of financial resources. There are still some areas where further development is required, and a discussion of the some of the areas of future work conclude this thesis.

2. Future developments of the technique.

It is hoped that research will continue on the further development of the technique, especially on the calculation of more conflict to accident ratios for other types of layout eg. crossroads and roundabouts.

The chief weakness of the present validation of the conflict technique is that it applies only to T-junctions. Therefore it cannot yet be used to predict or evaluate the effects of radical changes in layout such as the installation of a mini roundabout. In principal there is no reason why it should not be used for this purpose, but it would not be safe to do so until further studies have been done on a wider variety of road lay-outs. In particular it seems likely that conflict to accident ratios will be appreciably different at different types of sites. Allowance would need to be made for such differences in the application of the technique, since an observed reduction in conflicts following a traffic engineering change could be due either to a decrease in accident risk or to a decrease in the conflict to accident ratio. The very different ratios found in this study for different sites and for different manoeuvres, and the even greater ratio found by Spicer for dual carriageway intersections, indicate that the variations in the conflict to accident ratios may be very large and must be taken seriously.

Three further areas of future work are suggested below. The directions and emphasis of each are very different. The first concerns the on-going evaluation of the effect of remedial measures that have been implemented and is thus an extension of that application of the technique. The second goes right back to the beginning, to the generation of a conflict, to see whether the distribution of certain characteristics of drivers involved in conflicts differs from the distribution of the same characteristics in the general population. Specifically, the characteristics to be investigated are age and gender of the drivers, but the speed of those involved in conflicts prior to the conflict occurring is also suggested as being worthy of further study. Finally, a departure from the study of vehicle-vehicle conflicts and accidents is suggested, by applying the technique to another area of road safety, namely pedestrian-vehicle accidents.

2.1 Evaluation of remedial measures.

There has recently been some concern that remedial measures reduce accidents for only a short time and then the effectiveness decays and the accident numbers then creep back towards the original level. Hertfordshire County Council (1979) found no evidence that accidents increase throughout the lifetime of a scheme. In fact, they suggested that it may even be possible that schemes tend to perform better in the second and third years, as local drivers become used to them. On the other hand, Nottinghamshire County Council (1980) have found that there may be a reduction in the effectiveness of a scheme over time. Using a comparison of the cumulative savings using first year figures with the cumulative savings using three year average figures, they have estimated it to be in the order of 13%. Because of this, achievement in terms of accident reduction may not reach the targets predicted for remedial measures. It might then appear that the scheme has not been as successful as predicted, when in fact the "tailing off" factor should be taken into account. Hauer (1978) discusses the likelihood of failing to observe an improvement when such exists.

Furthermore, the introduction of any new scheme will almost always lead to an immediate response from road users. If the subsequent improvement in road user behaviour at the site is short-lived, then it is possible that the original response is merely due to local drivers taking more care when they come across the unfamiliar scheme at a familiar location. Therefore, while the question of whether a countermeasure is effective is a simple one, the answer is not. A successful after study is therefore not necessarily cause for resting on one's laurels. Continued monitoring is required at improvement sites to ensure that changes in coflicts and/or accidents are causally related to the implemented countermeasures.

2.2 Conflict generation studies.

For a more complete picture of traffic conflicts at an intersection, there is a need to develop the background data to try to explain the process of conflict generation. Other factors related to the development of conflicts include the age and gender of drivers, and the speed at which they are driving. Studies of the characteristics of drivers involved in accidents show that the distributions often tend to follow the normal distribution of those characteristics in the general population with certain exceptions. Two of those exceptions are the age and gender of the drivers. The two are inseparable from experience, since the young have less than the old, and women generally drive fewer miles than men. Garwood (1956), Johnson and Garwood (1957), and Munden (1962) analysed insurance claims which showed that

a) the highest car driver involvement rate in accidents (per distance driven) is for those under 25 years of age and over 70 years of age (Figure 19), and

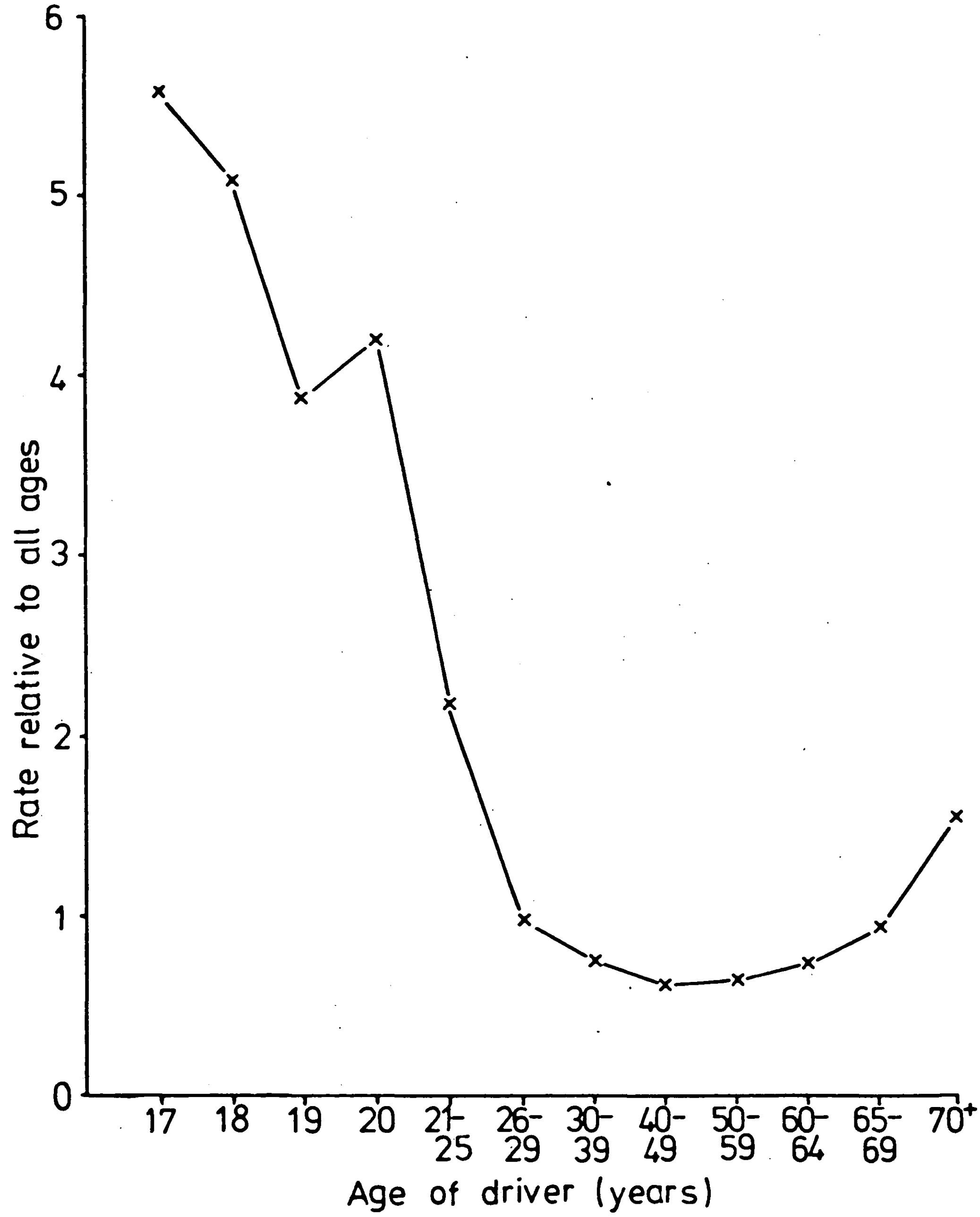


Figure 19: Casualty rates per distance driven, 1975-6.

Source: Police accident reportsfor injured drivers (from Sabey, 1980)

b) the high rate in youth is closely related to inexperience. The effect of experience, irrespective of age, was compared with the age effect (Table 29). The two ends of the scale are inevitably biased by the lower and higher age groups respectively.

Claims per policy year

Experience in years	Number
0	0.195
1	0.170
2	0.155
3	0.140
4- 8	0.140
9-13	0.115
14-18	0.105
19-28	0.120

Source: Sabey, 1980

Table 29 : Insurance claims data for male driver policy holders involved in accidents.

c) the increase in risk with age is associated with particular kinds of accidents, especiaslly those involving judgement of speed and/or distance, as reactions become slower and sight poorer. At the same time the older driver shows a decline in other types of accident such as those involving skidding and driving with excess alcohol.

While responsibility for the accident in which they were involved is approximately equal, it has been shown that men and women are involved in quite different types of accident. Women tend to have accidents due to lack of skill, while men tend to be driving too fast, taking risks and are more often impaired by alcohol.

The age and gender of drivers in conflicts has not received widespread attention. Darzentas, McDowell and Cooper (1980), using a simulation model of driver behaviour based on the concept of a minimum acceptable gap, used empirical data to show how risk taking behaviour varies with the age and sex of the driver. They found that older drivers (61-70) were involved in more conflicts than younger drivers (31-40) of the same sex, and male drivers are involved in more conflicts than females of the same age class at all flows considered.

Spicer (1972) also examined conflict generation. He studied vehicle speeds approaching a rural dual carriageway junction and the times that vehicles took to complete their crossing manoeuvre. He found that older drivers (55+) were over-represented in the accident data for those vehicles emerging from the minor road. He noted the performance of drivers of different ages emerging from the minor roads, and found that older drivers, although no slower in completing the crossing to the central reserve, did tend to be more cautious, waiting longer to emerge, but then causing a conflict with a major road vehicle by emerging into an unsafe gap. In contrast, 75% of the major road drivers involved in the accidents were under 35 years, and all were, without exception, male. Clearly, without exposure data on the frequency of each group of drivers on the two types of road, relative risk measures cannot be derived, and the possible implications of this finding cannot be assessed. It was suggested (Spicer, 1972) that the minor road had a different age distribution of drivers because older people possibly preferred to avoid major roads. However, a survey estimating the ages of a sample of drivers on both roads showed no difference in the distribution by age. Unfortunately the survey did not classify the drivers by gender. This measure, notably providing more reliable data than age estimation, could and should have been carried out simultaneously. It seems highly unlikely that drivers on the main road were 100% male, although due to the higher number of males holding driving licences, it would be expected that a majority would be male. Certainly the age and gender of drivers involved in conflicts merits further study.

In the complex situation that exists at junctions, other factors may also influence the rate at which conflicts and accidents are generated. The influence of traffic flow has been discussed in its relationship with both accidents and conflicts. One of the reasons why flow appears to be a complex factor in their generation is that a decrease in flow may not give a decrease in conflicts due to the fact that it may allow the speeds of vehicles to increase. Spicer (1971) calculated the approach speeds of vehicles involved in conflicts at a rural dual carriageway from film records. There was no evidence to suggest that vehicles travelling within any given speed range (higher or lower than the mean) were more likely to be involved than others. The conflict simulation model of Cooper and Ferguson (1976) looked at the relationship between conflicts and speed. They found that the overall conflict rate at the site was predicted to be independent of the distribution of vehicle speeds. They expressed surprise at the absence of any significant relationship and put it down to

> "the independence of gap acceptance and speed assumed in the model".

Observational studies (Bottom and Ashworth, 1973; Cooper, Smith and Broadie, 1976) have indicated that drivers accept slightly smaller time gaps in front of faster approaching vehicles. It is logical to assume that all drivers use speed to some extent in calculating whether to pull out into a gap. There are therefore two possible explanations:- drivers are either basing their decisions on fixed distance and modifying this with regards to the speed of the oncoming vehicle or they are basing their decisions essentially on time gaps but are repeatedly under-estimating the speeds of faster vehicles and/or underestimating the speeds of slower vehicles. The effect of speed appears complex and further study should be undertaken in relation to other factors important in conflict generation to establish its importance, if any.

2.3 Extending the technique to study pedestrian-vehicle interactions.

The extension of the Traffic Conflicts Technique to pedestrian-vehicle and cycle-vehicle interactions has focussed attention on an area hitherto largely ignored. It would seem logical to maintain that the notion of a continuum between behaviour and accidents exists in these types of encounter. The study of normal pedestrian behaviour in particular has not been as productive in explaining the causes of pedestrian accidents as was originally hoped. Further progress in this area may well come from moving further along the continuum towards the accident event itself. Previous research on pedestrian safety has tended to concentrate on either pedestrian behaviour or driver behaviour, as if the two occur independently of one another. The conflict technique has encouraged researchers to examine the interaction of these two categories of road user and question some of the stereotyped beliefs as to their attitudes and reactions towards one another. The behaviour of each cannot be considered in isolation and in this respect the application of the Traffic Conflicts Technique has played a valuable part in focussing attention on the relative roles each plays in the traffic environment with respect to one another. This approach will have its own issues, not the least of which will be that of its validity. Curiously, the way the technique has developed with respect to pedestrian-vehicle interactions is completely the reverse of the way the technique has developed for vehicle-vehicle conflicts, in that it has been put into practice before its validity as an accident surrogate has been investigated (Guttinger and Kraay, 1976).

While the definition of a conflict as agreed at the First International Workshop on Traffic Conflicts, Oslo (1977) would seem at first glance to be equally applicable to pedestrian-vehicle interactions or cycle-vehicle interactions, there is some doubt as to whether the technique can be applied without further development. The main reason for this reservation is that avoiding manoeuvres made by pedestrians and cyclists to vehicles and vice versa are not directly comparable to those made by vehicles to other vehicles. Nor are pedestrian reactions in particular as easily observed and measured. An equivalent of the illumination of brake lights as a criterion for the occurrence of a conflict simply does not exist for the pedestrian, and is not often seen in a vehicle involved in an interaction with a pedestrian (Howarth and Lightburn, 1980). If the illumination of brake lights on a vehicle were taken as the only evidence of an interaction with a pedestrian, then the data on all interactions in which only the pedestrian takes the avoiding action would be lost. Development in this area to establish a classification and recording method is clearly complex and there is still a great deal of effort required to establish the technique as a valid tool in pedestrian and cycle accident investigations.

Accident research is now demonstrating its practical value in a number of areas. The validation of the Traffic Conflicts Technique is a further development in this direction. Given a valid relationship to accidents and a well developed manual and scheme for training observers, the technique appears to be a tool of great practical value which can be applied to many traffic engineering and other road safety problems. There is still room for improvement, particularly in developing further estimates of conflict to accident ratios, but if its limitations are clearly indicated, then its use can be recommended to Local Authorities and other organisations involved in road safety.

APPENDIX TO SECTION A, CHAPTER 4

TABLES 30a-d

Table 30a : Consensus of gradings among subjects - Film A

Film A	NC	0	1	2	3	4	Consensus	Criterion	% correct
1	5	1	32	47	35	9	2	3*	27.8
2	0	1	23	65	31	6	2	2	51.6
3	2	1	57	56	9	1	1	1	45.2
4	62	37	27	0	0	0	NC	NC	49.2
5	3	4	81	28	8	2	1	1	64.3
6	15	82	21	8	0	0	0	0	65.1
7	4	14	87	20	1	0	1	1	69.0
8	6	3	37	43	33	4	2	3*	26.2
9	14	10	75	26	1	0	1	1	59.5
10	45	6	63	11	1	0	1	1	50.0
11	22	17	75	12	0	0	1	1	59.5
12	96	17	10	1	2	0	NC	0*	13.5

Table 30b : Consensus of gradings among subjects - Film B

Film B	NC	0	1	2	3	4	Consensus	Criterion	% correct
13	24	10	73	17	2	0	1	1	57.9
14	0	21	93	11	1	0	1	2*	8.7
15	79	23	20	4	0	0	NC	NC	62.7
16	8	12	75	24	4	3	1	2*	19.0
17	18	16	79	11	2	0	1	1	62.7
18	16	16	67	23	4	0	1	NC*	12.7
19	0	0	10	57	51	8	2	3*	40.5
20	12	7	60	39	6	2	1	2*	31.0
21	10	12	74	21	8	1	1	2*	16.7
22	23	4	60	37	2	0	1	1	47.6
23	52	17	30	20	5	2	NC	1*	23.8
24	106	13	7	0	0	0	NC	NC	84.2

* one grade out
** two grades out

Table 30c : Consensus of gradings among subjects - Film C

Film C	NC	0	1	2	3	4	Consensus	Criterion	% correct
25	34	14	60	16	2	0	1	3**	1.6
26	117	6	3	0	0	0	NC	NC	92.9
27	24	25	67	10	0	0	1	1	53.2
28	14	16	85	11	0	0	1	1	67.5
29	15	3	29	67	12	0	2	3*	9.5
30	42	25	55	4	0	0	1	1	43.7
31	123	3	0	0	0	0	NC	NC	97.6
32	19	10	40	47	7	3	2	2	37.3
33	10	33	80	3	0	0	1	1	63.5
34	6	12	84	22	2	0	1	1	66.7
35	33	25	57	9	2	0	1	1	45.2
36	4	2	8	31	56	25	3	3	44.4

Table 30d : Consensus of gradings among subjects - Film D

Film D	NC	0	1	2	3	4	Consensus	Criterion	% correct
37	14	13	65	31	3	0	1	2	24.6
38	21	13	83	9	0	0	1	1	65.9
39	24	10	79	12	1	0	1	1	62.7
40	3	6	76	40	1	0	1	2*	31.7
41	105	11	5	4	1	0	NC	NC	83.3
42	9	5	67	40	5	0	1	1	53.2
43	21	8	66	22	7	2	1	1	52.4
44	113	10	3	0	0	0	NC	NC	89.7
45	34	15	51	20	6	0	1	3**	4.8
46	118	6	2	0	0	0	NC	NC	93.7
47	20	13	43	47	3	0	2	3*	2.4
48	0	0	3	5	52	66	4	4	52.4

* one grade out
** two grades out

Table 30e : Consensus of gradings among subjects - Film E

Film E	NC	0	1	2	3	4	Consensus	Criterion	% correct
49	24	43	57	2	0	0	1	1	45.2
50	23	46	45	12	0	0	0	1	35.7
51	5	13	90	17	1	0	1	1	71.4
52	89	13	20	4	0	0	NC	NC	70.6
53	6	7	98	14	1	0	1	2*	11.1
54	1	19	80	25	1	0	1	1	63.5
55	7	54	51	14	0	0	0	2**	11.1
56	4	1	35	72	12	2	2	2	57.1
57	49	10	25	21	21	0	NC	NC	38.9
58	33	82	10	1	0	0	0	0	65.1
59	6	14	96	10	0	0	1	1	76.2
60	3	3	43	66	10	1	2	2	52.4

Table 30f : Consensus of gradings among subjects - Film F

Film F	NC	0	1	2	3	4	Consensus	Criterion	% correct
61	0	1	68	51	6	0	1	2*	40.5
62	14	28	56	22	4	2	1	2*	17.5
63	125	1	0	0	0	0	NC	NC	99.2
64	5	21	97	2	1	0	1	1	77.0
65	3	3	70	44	6	0	1	1	55.6
66	3	12	91	18	2	0	1	1	72.2
67	4	10	89	22	1	0	1	1	70.6
68	6	10	58	33	13	6	1	2*	26.2
69	9	20	73	22	1	1	1	2*	17.5
70	122	3	0	1	0	0	NC	NC	96.8
71	9	20	87	10	0	0	1	1	69.0
72	30	17	46	27	6	0	1	2*	21.4

* one grade out
** two grades out

APPENDIX TO SECTION A, CHAPTER 5

FIGURE 20 : Coincident detection of conflicts between each observer and the criterion
a) site A, week 1
b) site A, week 2
c) site A, week 3

21 : Coincident detection of conflicts between each observer and the criterion
a) site B, week 1
b) site B, week 2
c) site B, week 3

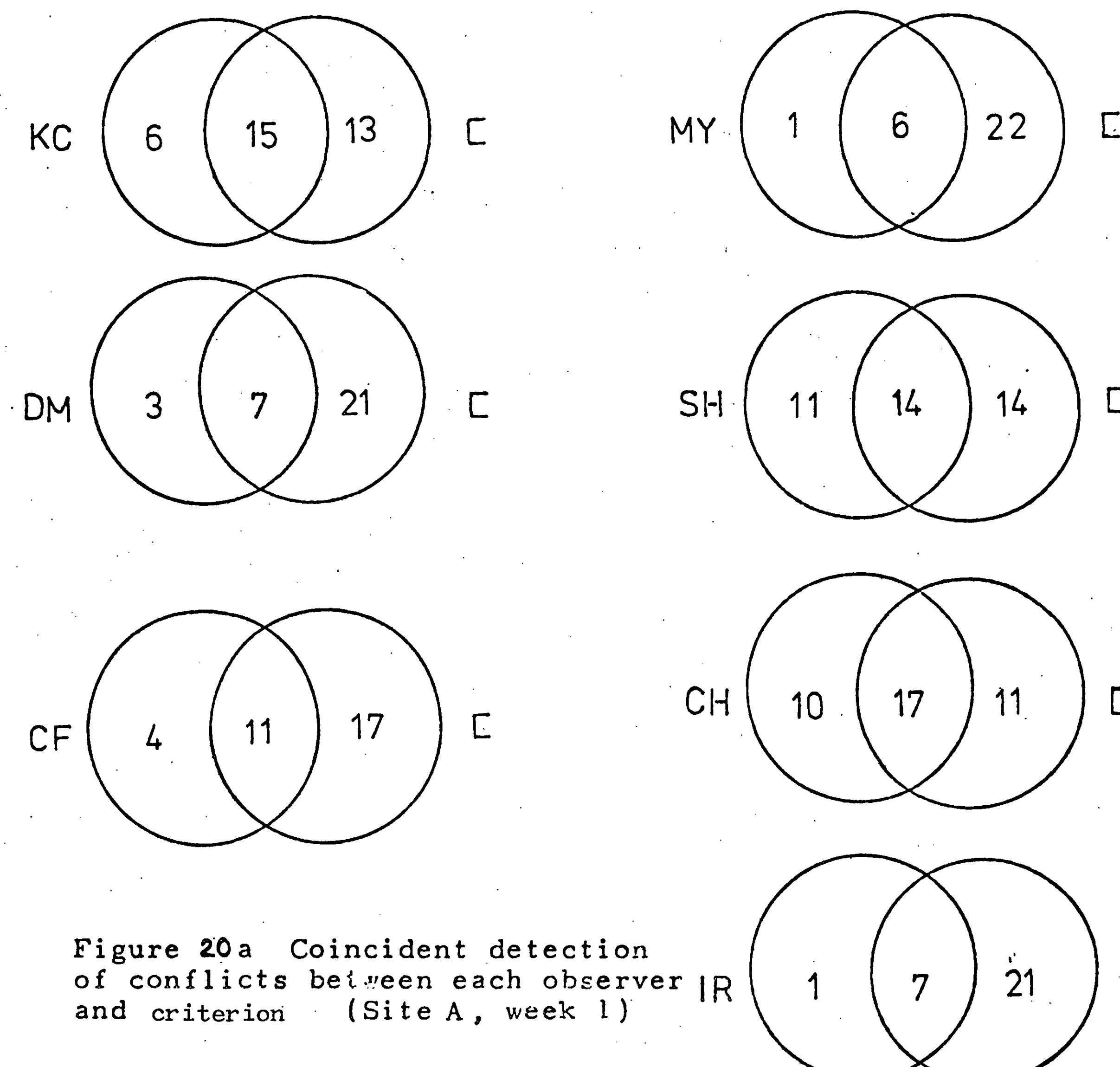


Figure 20a Coincident detection of conflicts between each observer and criterion (Site A, week 1)

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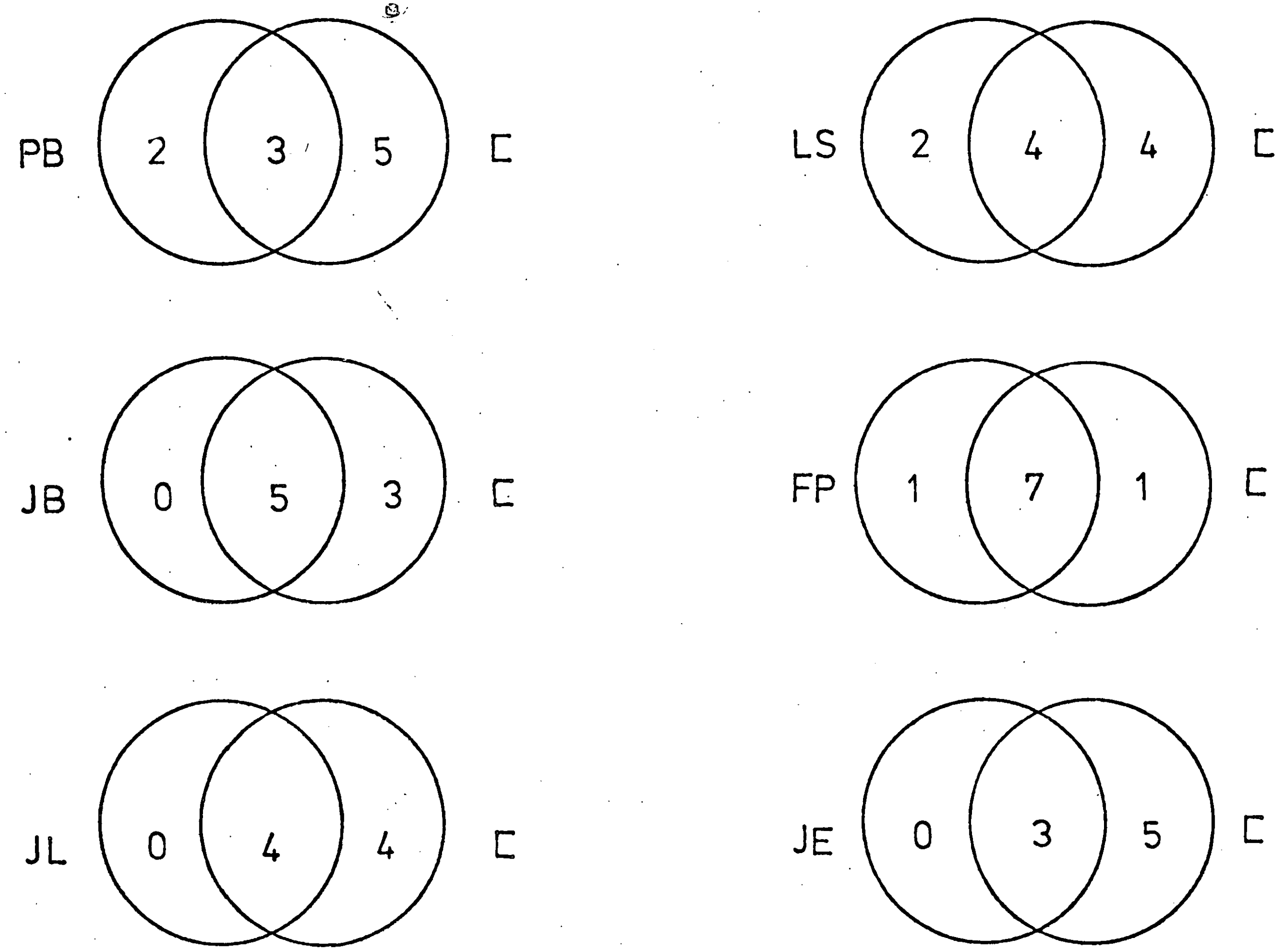


Figure 20 b Coincident detection of conflicts between each observer and criterion (Site A, week 2)

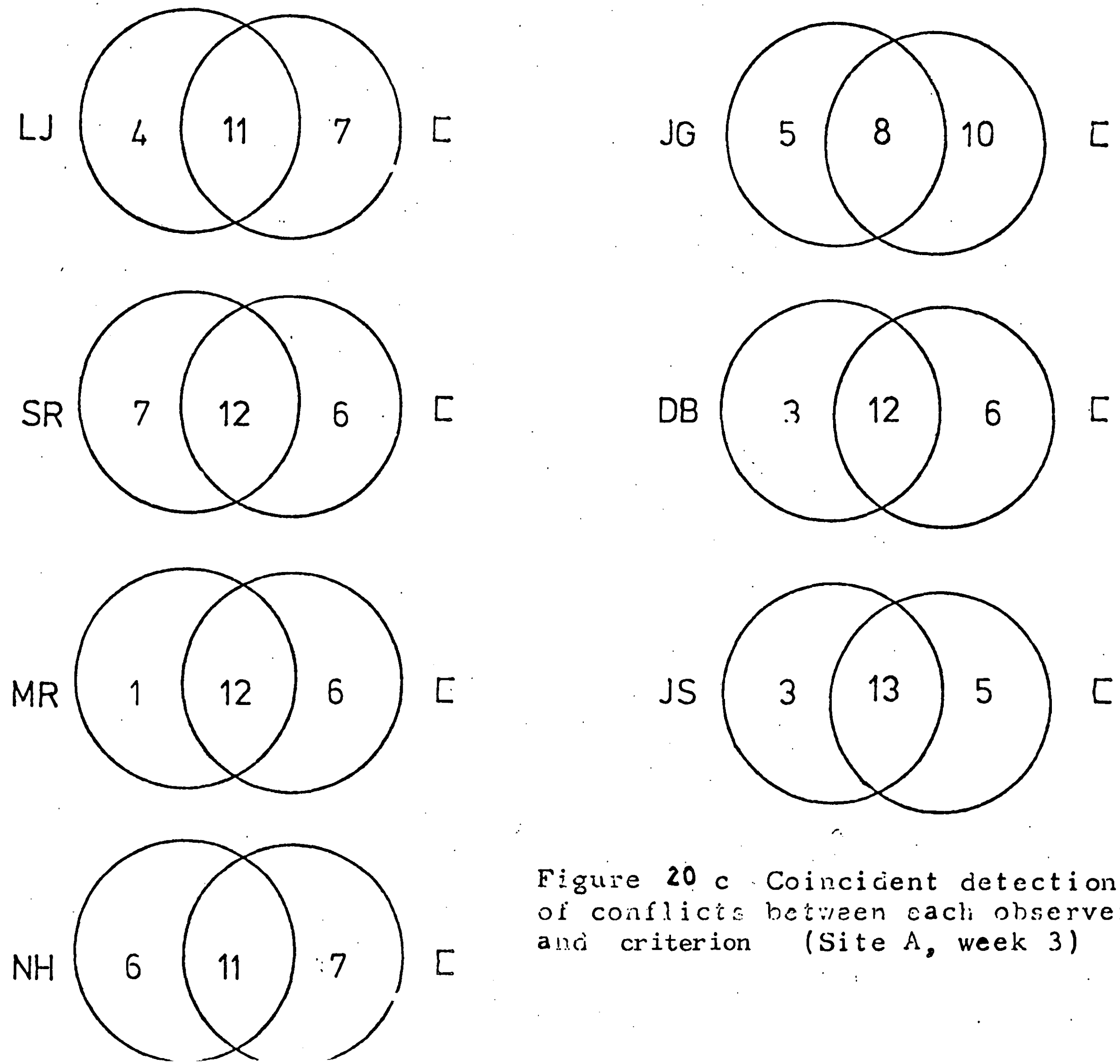


Figure 20 c Coincident detection of conflicts between each observer and criterion (Site A, week 3)

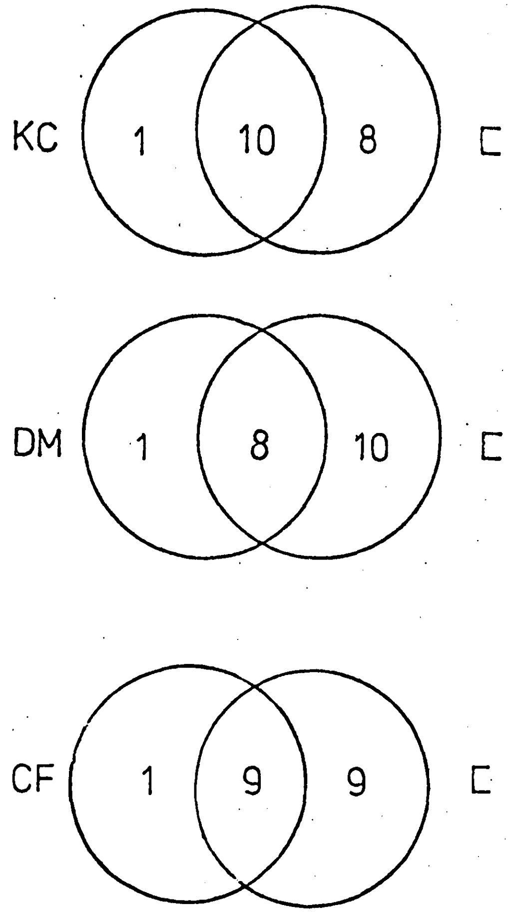
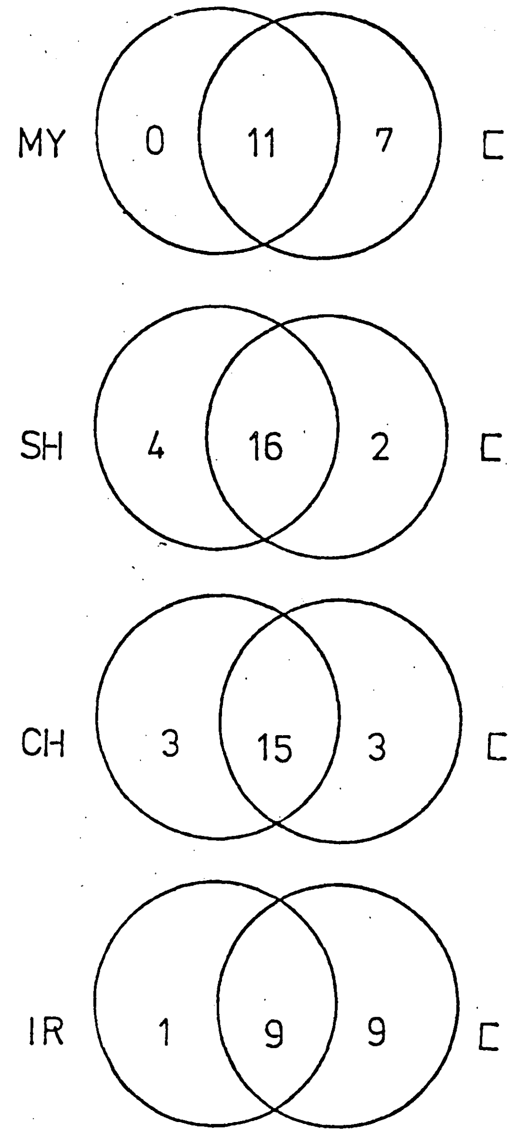


Figure 21 a Coincident detection of conflicts between each observer and criterion   (Site B, week 1)



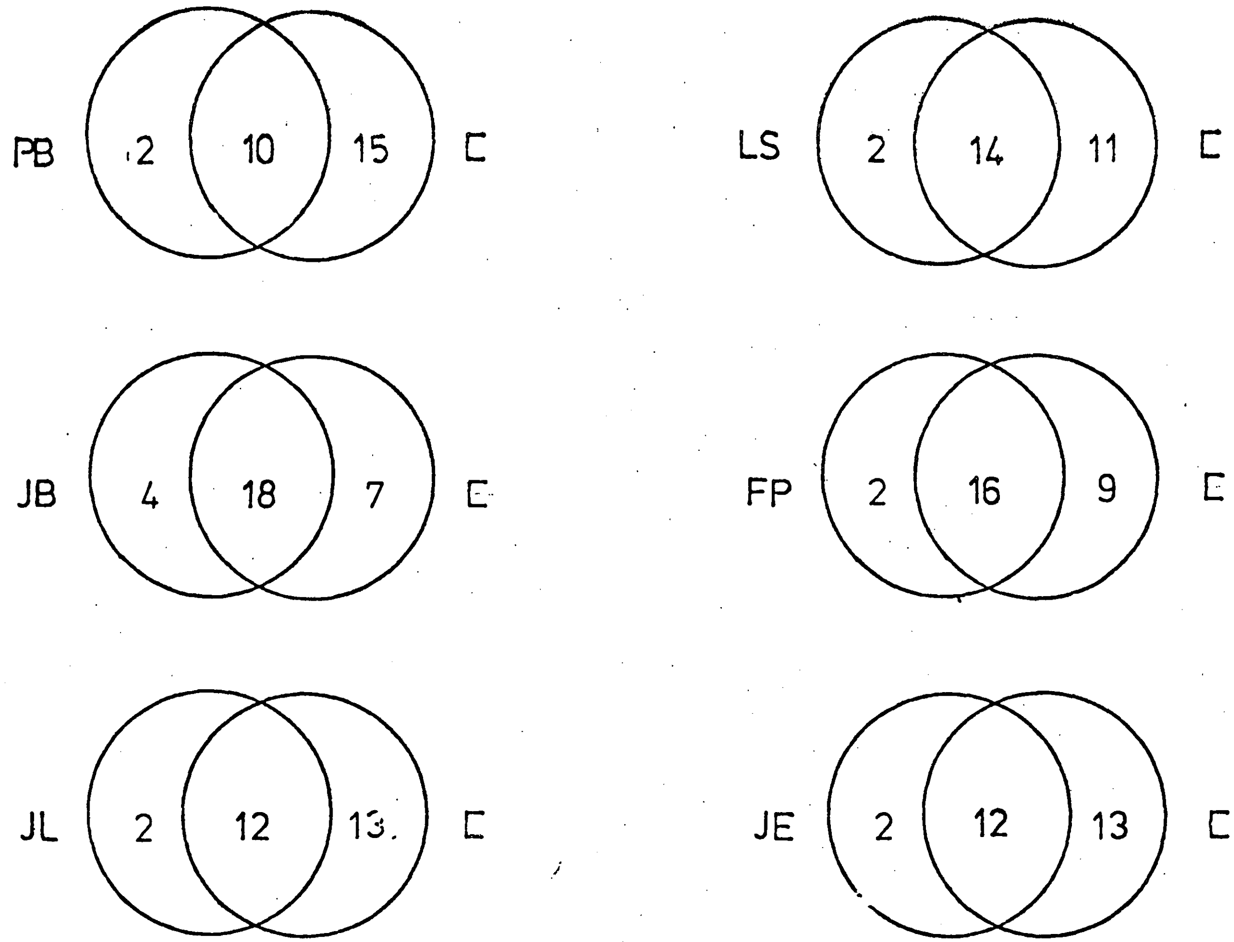


Figure 21b Coincident detection between each observer and criterion (Site B, week 2)

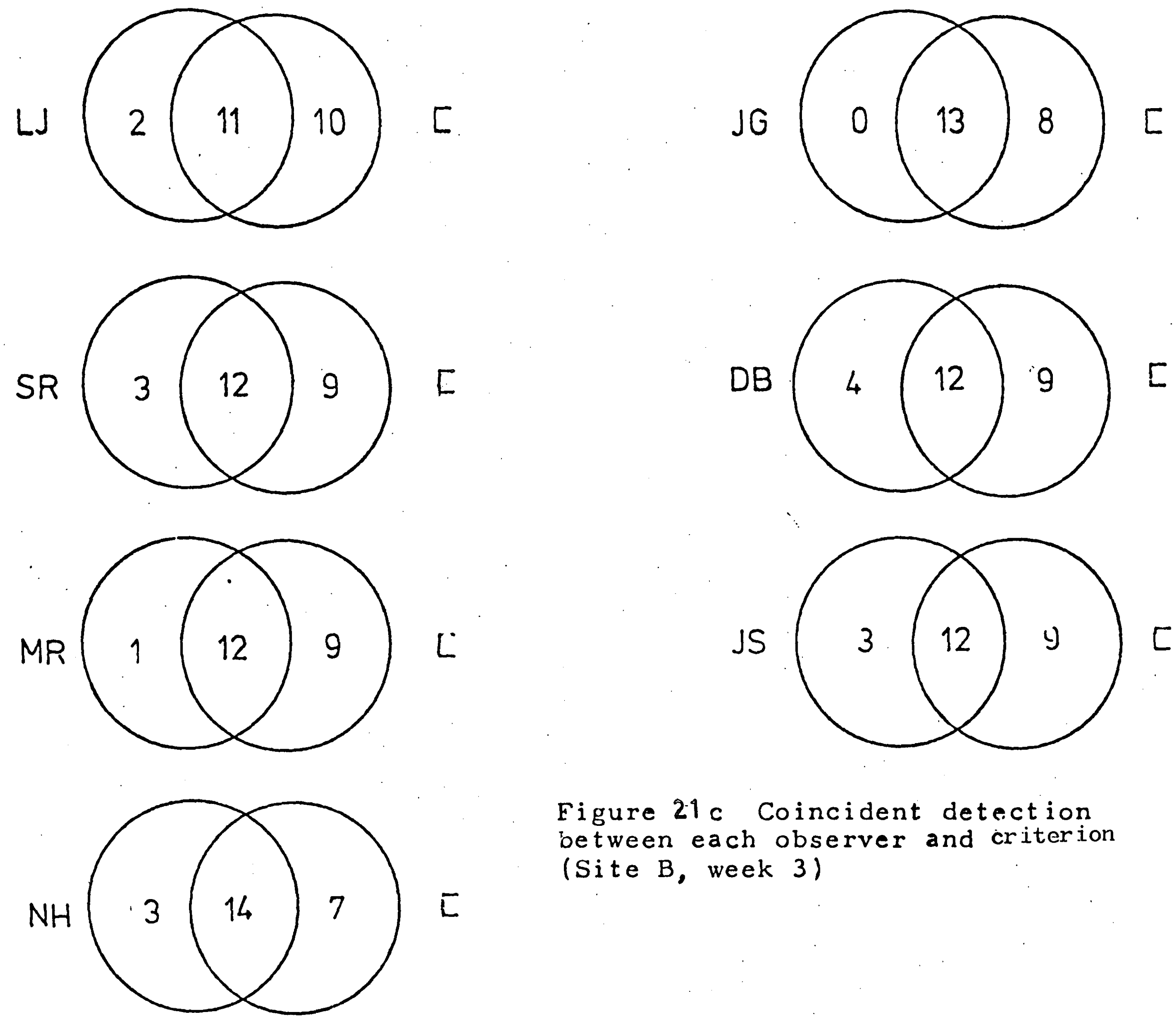


Figure 21c Coincident detection between each observer and criterion (Site B, week 3)

APPENDIX TO SECTION B, CHAPTER 7

Introductory training manual

INTRODUCTORY TRAINING MANUAL

INSTRUCTIONS

This is not a test of speed, so take as much time as you like.

Someone will be available to answer any queries that you have. Please do not hesitate to ask them about anything you do not understand or find confusing or ambiguous.

The manual is meant to be read from the beginning through to the end. Please do not omit any sections. It should all be self explanatory, but ask if there is anything that is not clear.

Remember, this is <u>not</u> a test of speed.

We are more concerned that you understand and assimilate the contents of this manual so that you can apply the information to real life situations.

INTRODUCTORY TRAINING MANUAL

i) The aims of traffic conflicts technique

The traffic conflicts technique (or TCT for short) provides us with a means for identifying those driving manoeuvres which might lead to accidents. It can pin-point deficiencies which can then be improved at low cost. The effect of these improvements should be that fewer traffic conflicts, and hence fewer accidents occur.

Observers can be trained to identify those aspects of a situation that indicate that a conflict has occurred. However for the results to be meaningful and useful we must be certain that observers would all identify a conflict when it occurs and record it in a uniform manner. The purpose of this manual is to teach those criteria by examples and exercises.

ii) Definition of a conflict

A conflict is defined as an observable situation in which two or more road users approach each other in time and space to such an extent that a collision is imminent if their movements remain unchanged.

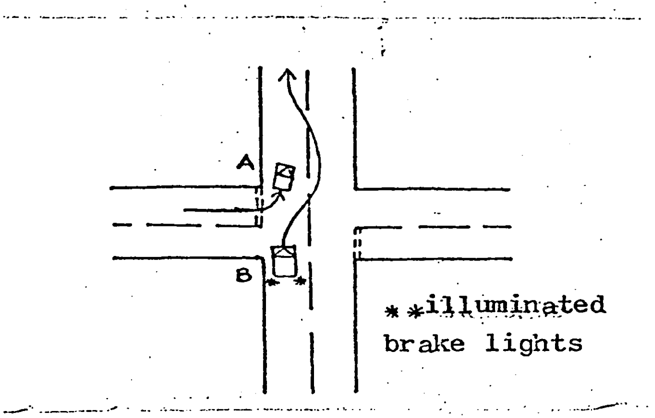
In other words it is a potential accident situation. At least one of the vehicles involved takes some form of evasive action, so that the possibility of an accident is averted. Note that "vehicles" include two wheelers, i.e., motorcycles, mopeds and pedal cycles.

The criteria that dictate whether or not a conflict has occurred are:-

1. One or more of the vehicles brake, usually indicated by the illumination of brake lights.
2. A change of lane or direction to avoid a collision.

For a conflict to have occurred, at least one of these must be identified.

EXAMPLE:



If a vehicle A pulls out from a side road causing vehicle B to brake and/or change lanes to avoid running into the back of A, then a conflict can be said to have occurred.

iii) Situations in which conflicts can occur

Conflicts can occur at any place where two or more vehicles are present. But the place where conflicts occur most frequently is junctions, and so most of the examples will be at junctions.

Junctions in this context include

Crossroads
Roundabouts
Staggered junctions
and T - junctions

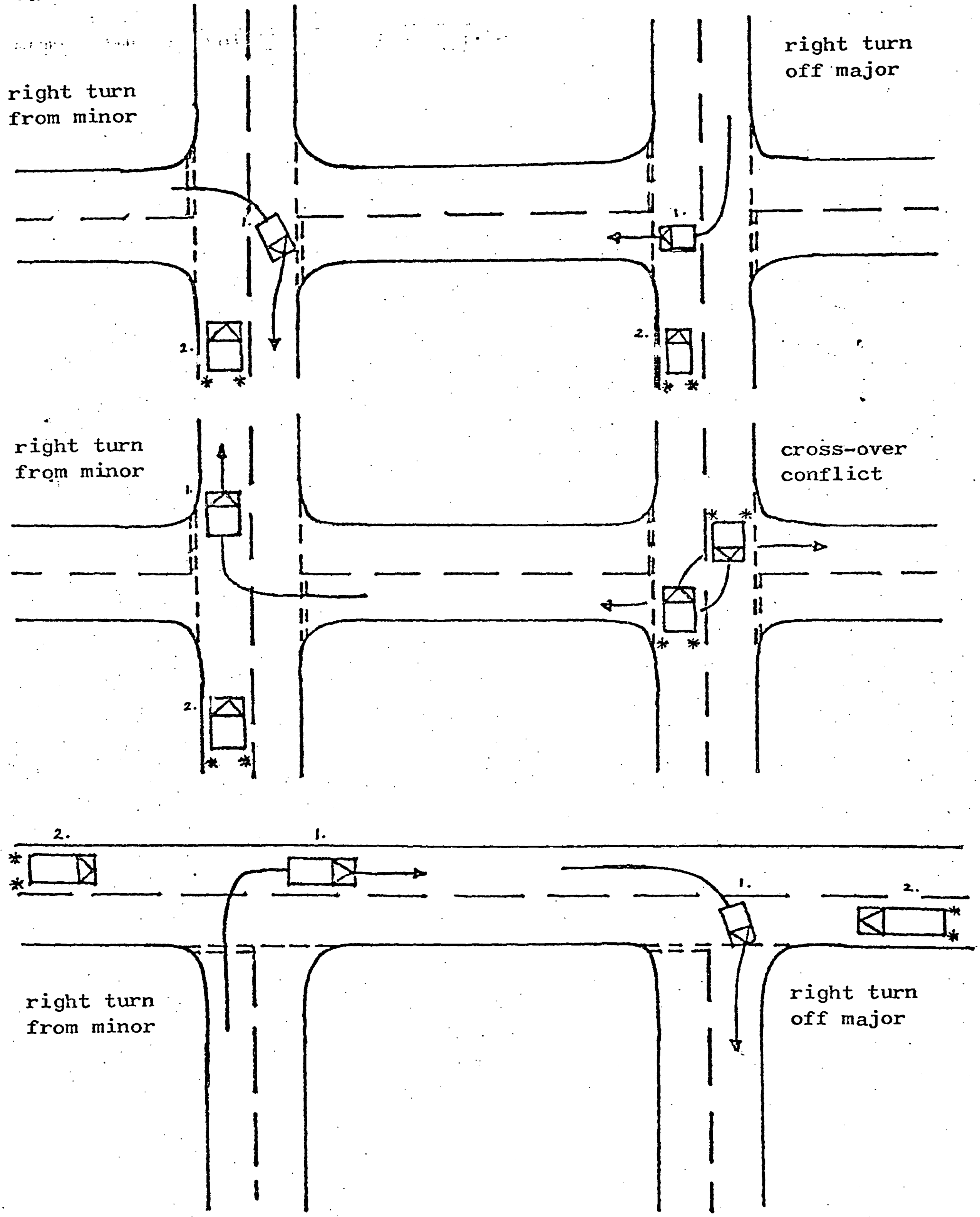
iv) Types of conflicts

The basic types of conflicts are linked to the types of accidents that occur. There are four basic types of accidents at intersections.

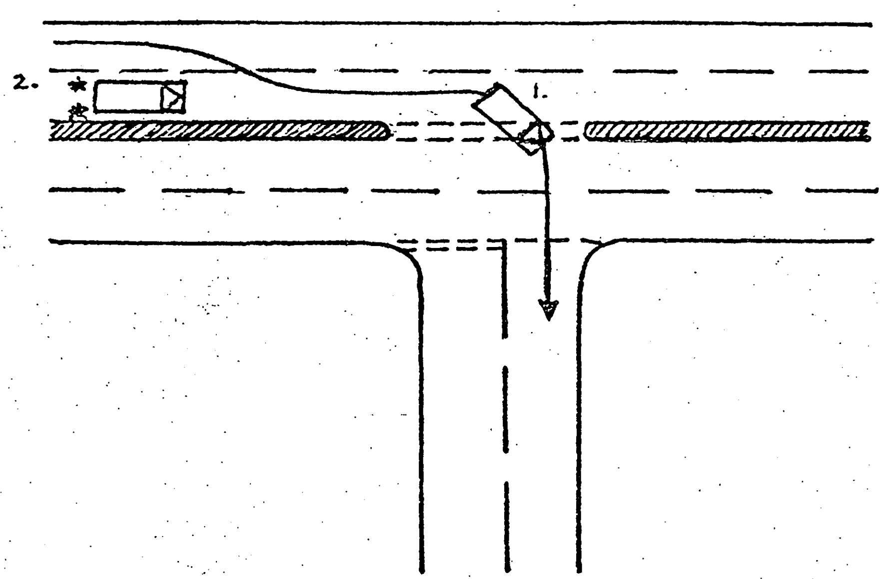
RIGHT TURN
LANE CHANGE
CROSS TRAFFIC
LEFT TURN
REAR END

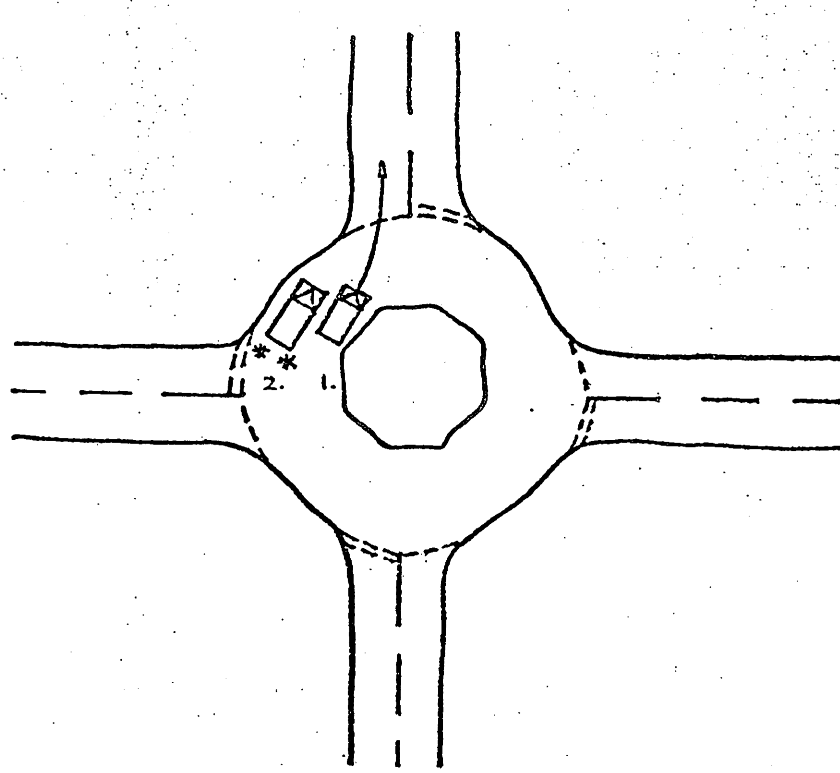
Conflicts are grouped as to the type of accident that would result as well as the manoeuvre executed.

A right turn conflict is defined as a situation in which a right turning vehicle crosses directly in front of an opposing through vehicle. If vehicle 2 is viewed from the rear as it approaches the intersection, a brake-light application and/or a weaving manoeuvre can be observed.



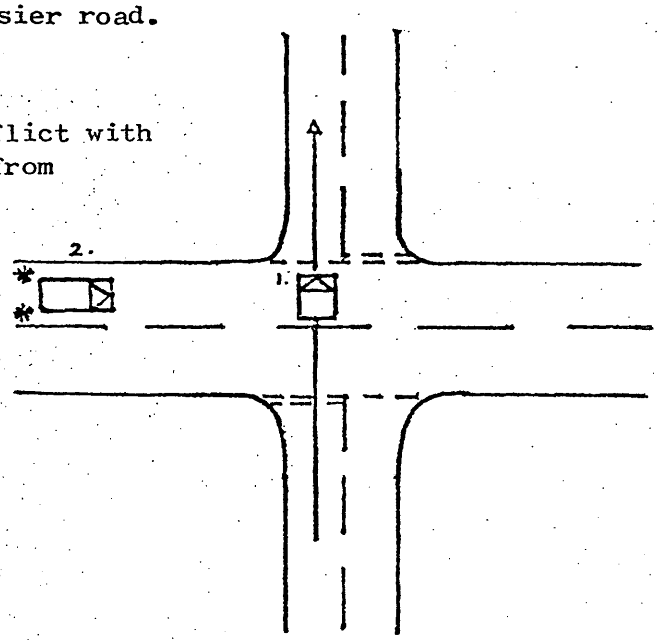
A lane change conflict associated with a weave or side swipe accident, is defined as a situation in which a vehicle changes lanes into the path of another vehicle. The offended vehicle is caused to brake or swerve to avoid a collision. If vehicle 2 is viewed from the rear, a brake light application can be observed. Weave conflicts can occur as a result of lane changes and turns into and/or from wrong lanes. These conflicts do not necessarily occur at junctions, but can occur on straight sections of road.



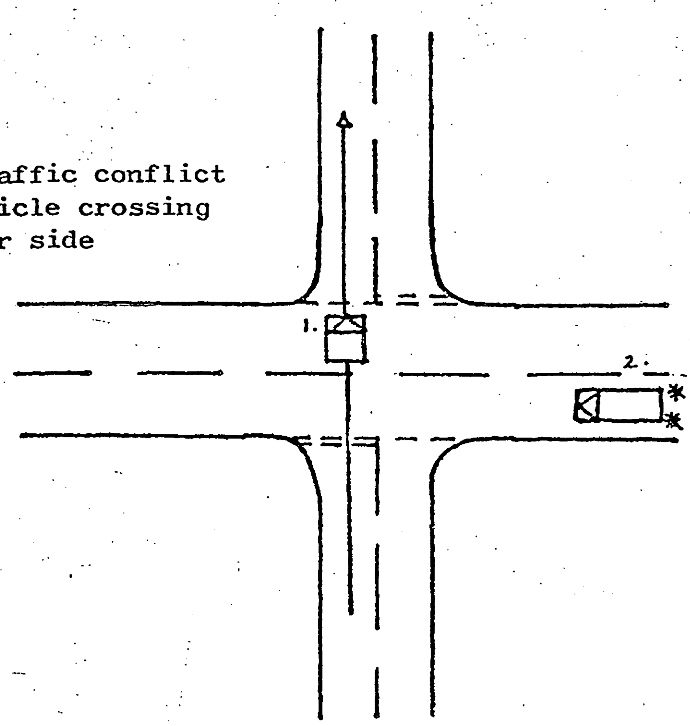


<u>A cross-traffic conflict</u> is defined as a situation in which a vehicle crosses the path of a through vehicle causing the through vehicle to brake or weave. The criterior of the conflict is application of brake lights or a weaving manoeuvre by the through vehicle. These types of conflict are generally observed at junctions with no traffic lights or other form of control, where the vehicle on the minor road are supposed to give way to traffic on the major or busier road.

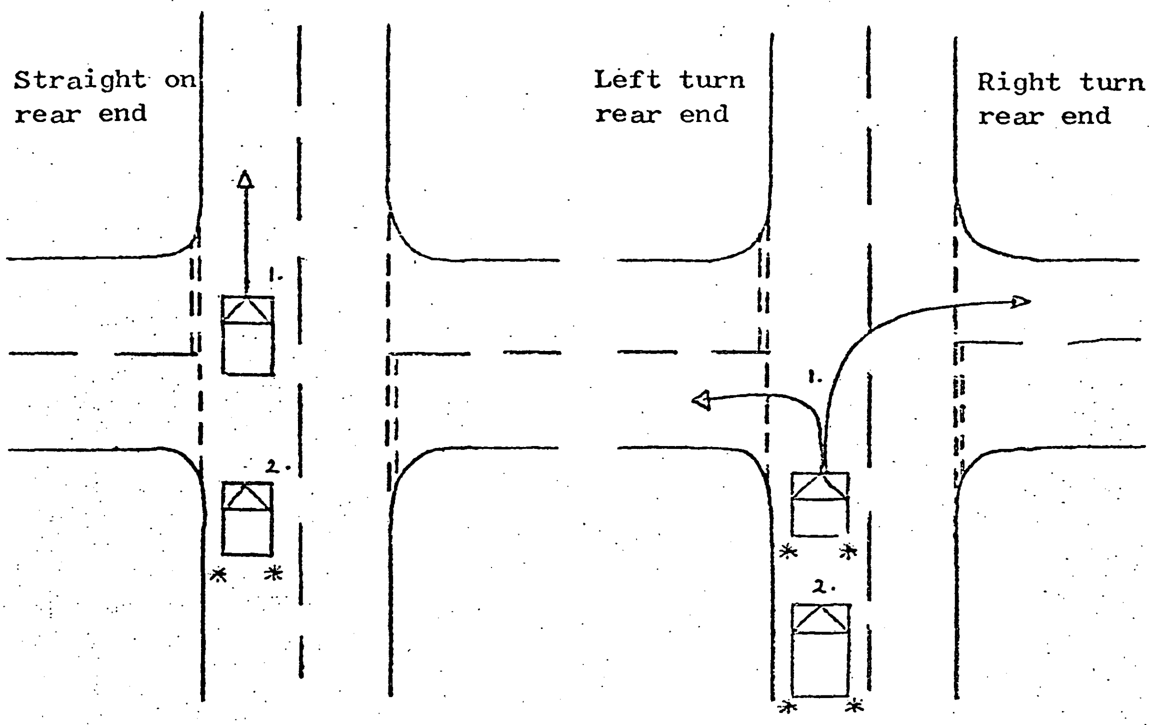
Cross-traffic conflict with
vehicle crossing from
off-side



Cross-traffic conflict
with vehicle crossing
from near side



A rear-end conflict is defined as a situation where a vehicle stops or slows and causes the following vehicle to take evasive action to avoid a rear end collision, usually by braking and/or overtaking.

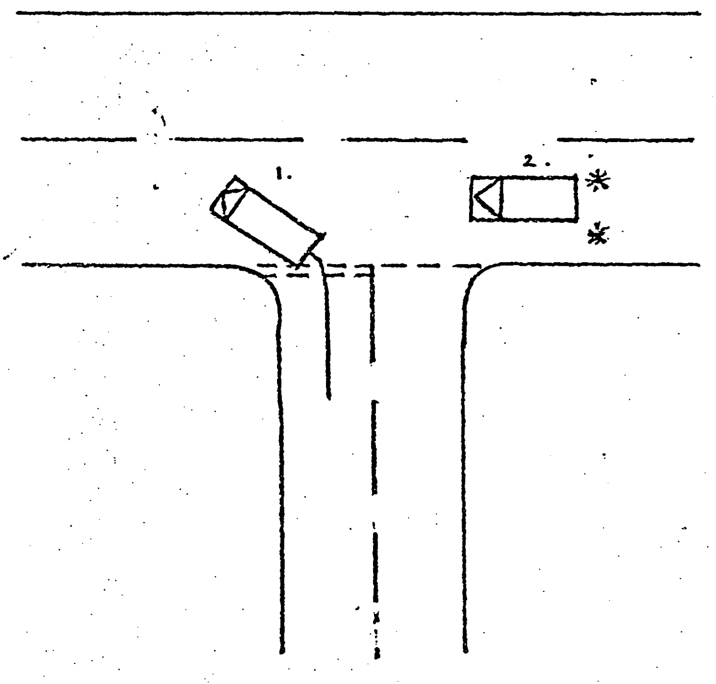


Some vehicles may have to brake because they are travelling faster than the vehicle in front with no opportunity to overtake. They may subsequently overtake.

Other vehicles may have to brake because the vehicle in front is slowing to turn off. If it is turning left the braking vehicle may decide to subsequently overtake if clear to do so

A left turn conflict is defined as a situation in which the through traffic is held up by a vehicle entering the main traffic stream from the left. Brake lights and/or a swerving or overtaking manoeuvre will be observed by the right-of-way vehicle.

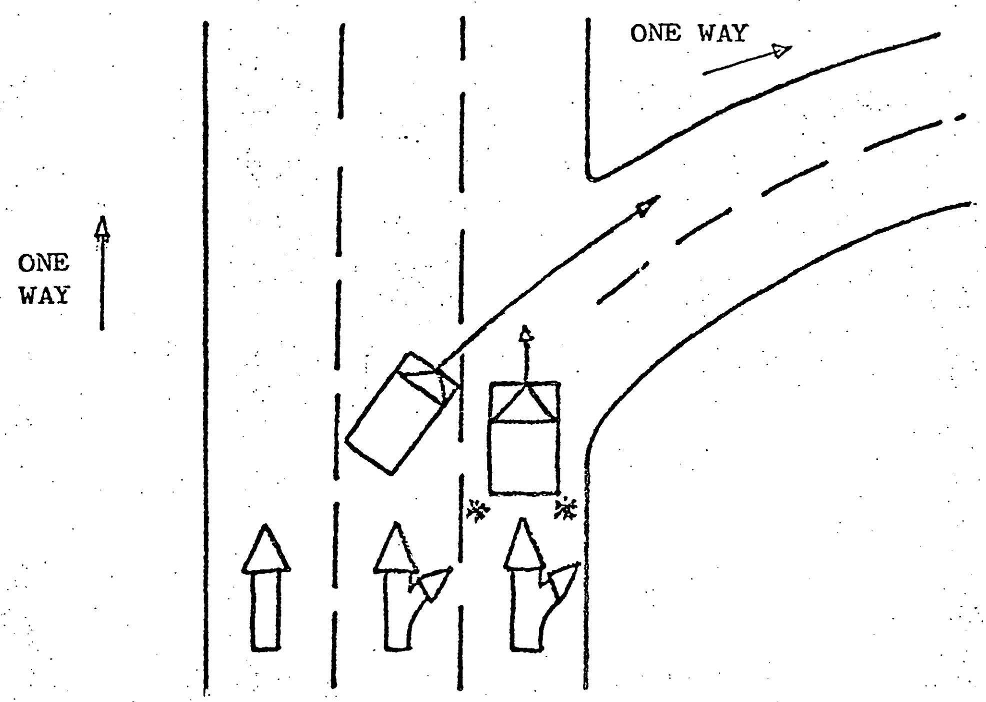
An example of a left turn
conflict at a T-junction



Left turn from minor

Miscellaneous

Other sorts of conflicts might occur in unusual junctions which have been specially designed to cope with a particular situation



Road markings

INTRODUCTORY TRAINING MANUAL

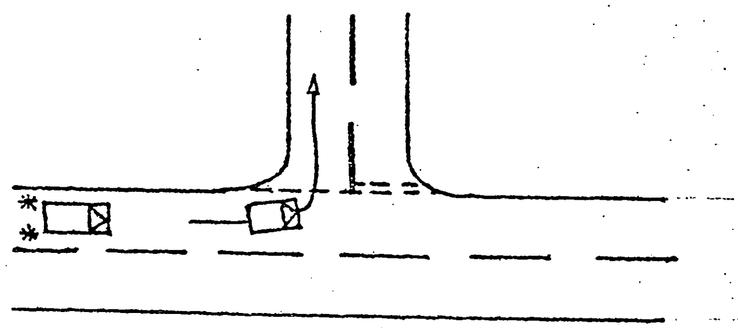
EXERCISE SHEETS

Please write your answers in the space provided in the Answer Booklet, Page 1

You may refer back to the example if you wish.

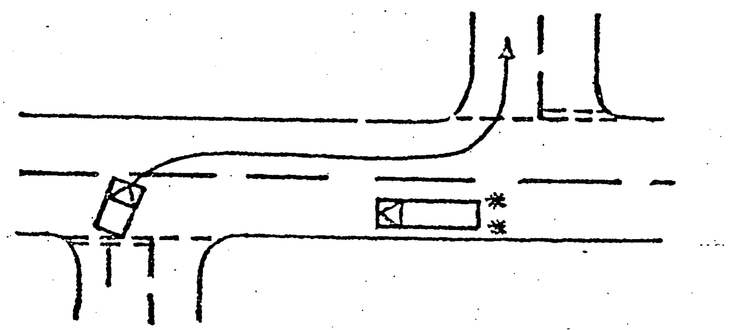
1. What type of conflict is this an example of?

....



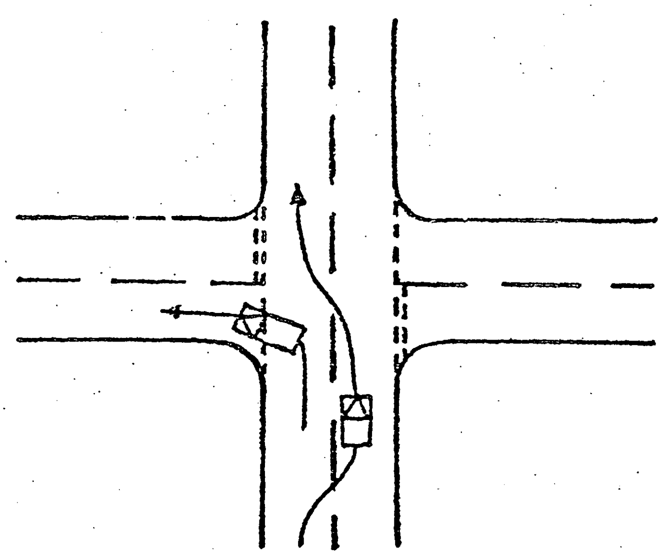
2. What type of conflict is this an example of?

....



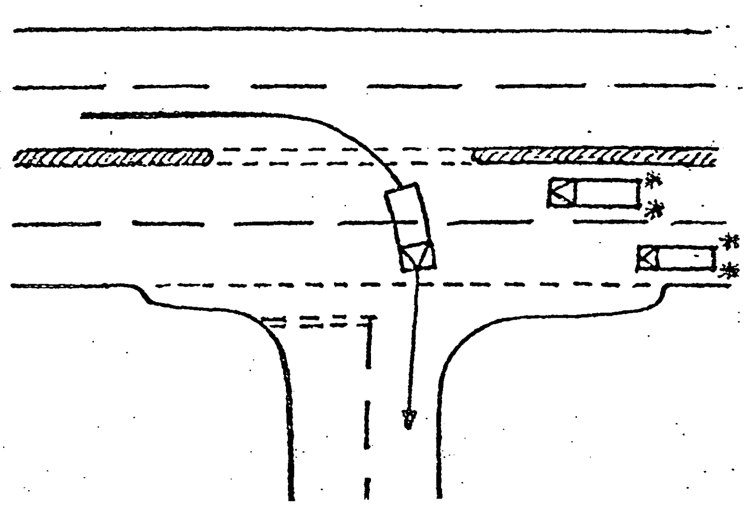
3. What type of conflict is this an example of?

....



4. What type of conflict is this an example of?

....

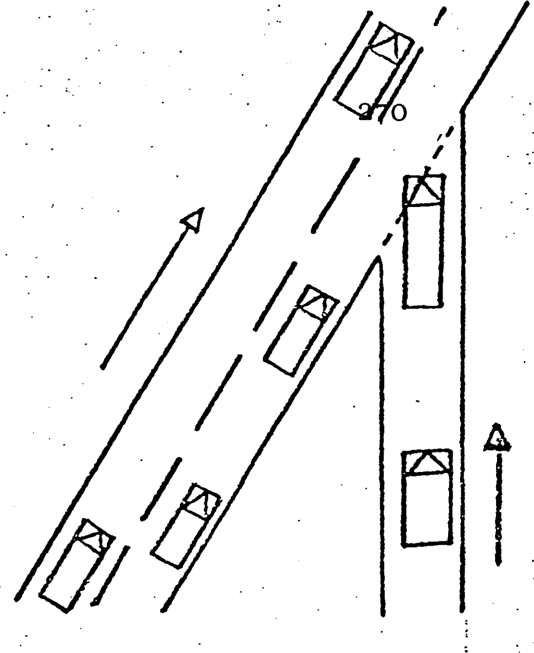


5. What types of conflict might be expected in this location where streams of traffic are merging?

....

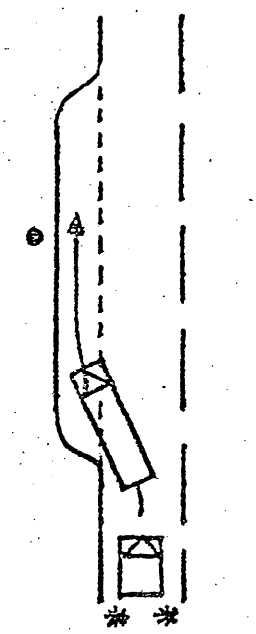
....

....



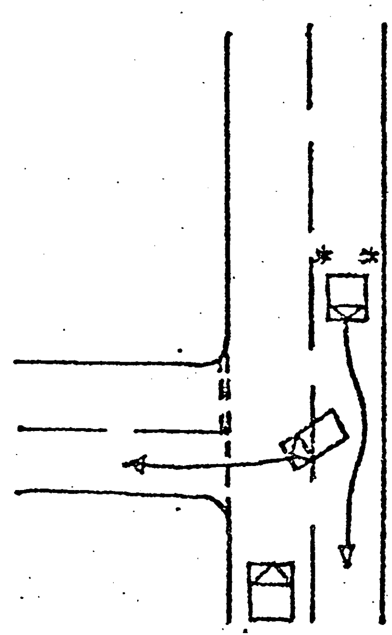
6. What type of conflict is this an example of?

....



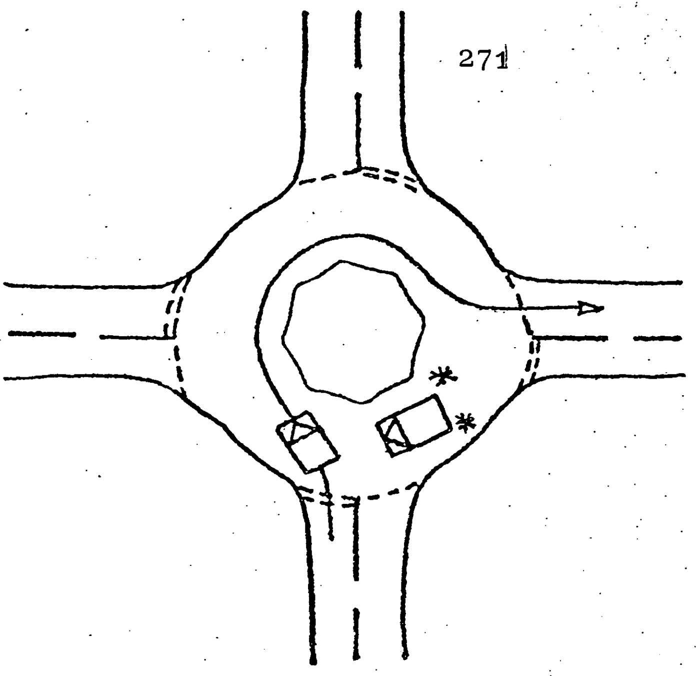
7. What type of conflict is this an example of?

....

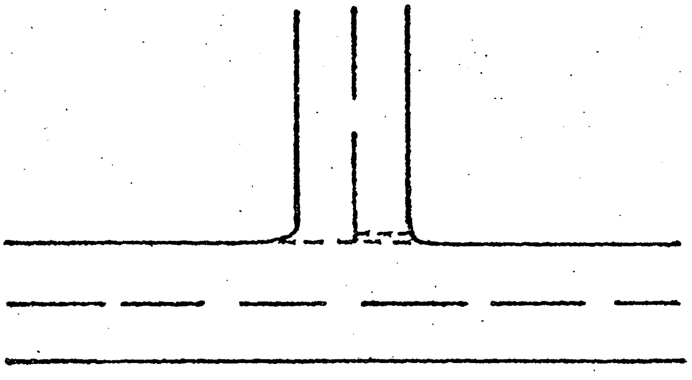


8. What typesof conflict is this an example of?

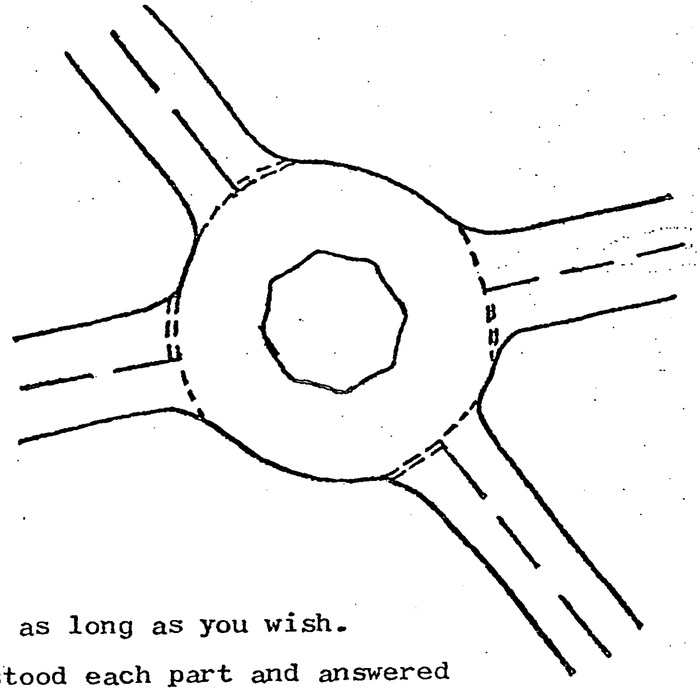
....



9. Draw a diagram to illustrate a right turn conflict.



10. Draw a diagram to illustrate a rear end conflict



You may go over any parts again. Take as long as you wish. Are you satisfied that you have understood each part and answered the exercises correctly?

Please hand these sheets to the instructor when you have finished.

TRAINING FILM

Now that you have some idea of what a conflict is and where they can occur, we will turn to some real examples on film, and learn how to grade them according to severity.

v. Grading Conflicts

Not only are conflicts of different types, they also vary as to their severity. Conflicts can be graded according to how severe or sudden were the avoiding maneouvre. The severity can be measured by considering the following four factors.

A. How long in time before the potential accident did the evasive action commence?

B. How sudden was the evasive action?

C. Was the evasive action simple or complex?

D. How close did the conflicting vehicle get?

The following grades of each factor are necessary to effectively differentiate conflicts from each other.

	FACTOR		GRADES
A.	Time to collision	-	Long, moderate, short
B.	Severity or rapidity of evasive action	-	Light (controlled) Medium (controlled) Heavy (less control) Emergency (uncontrolled)
C.	Complexity of evasive action	-	Simple (single action) Complex (more than one action)
D.	Closest proximity	-	Near, near miss, very near miss.

Distance between the closing vehicles and their speeds are the main factors to be judged.

We will take each factor, A, B, C and D in turn on the following pages, giving examples of the grades associated with each factor. At the end we will put them all together and thereby classify an incident according to severity using all 4 factors.

Firstly you will be shown film of the site used in all the following examples so that you may familiarise yourself with the layout. The instructor will explain the layout as you watch it. Tell the instructor when you are ready to view the film.

Do not turn over until told.

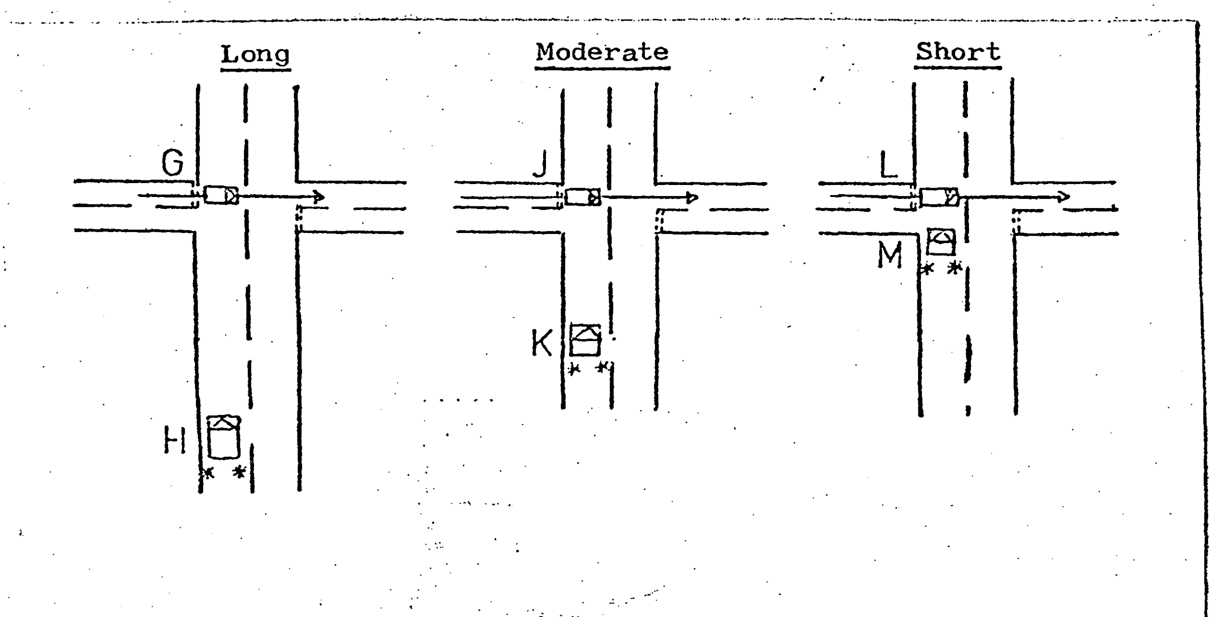
v.i Factor A

The first factor is FACTOR A - HOW LONG IN TIME BEFORE THE POTENTIAL ACCIDENT DID THE EVASIVE ACTION COMMENCE?

There are three possible severity grades:-

LONG MODERATE SHORT

An example of each is shown below. Please study carefully.



You will now be shown an example of film of each of the three severity grades in the order illustrated above. Remember, for each incident, only one can apply.

Please tell the instructor when you are ready to see the film with the examples of Factor A.

Do not turn over until told.

v. ii Factor B

The second factor is FACTOR B - HOW SEVERE OR RAPID WAS THE EVASIVE ACTION?
There are four possible severity grades:-

LIGHT	MEDIUM	HEAVY	EMERGENCY
(controlled)	(controlled)	(less control)	(uncontrolled)

Again, this will partly depend on speed and distance between the vehicles involved. 'Light' and 'medium' are controlled manoeuvres. They may be differentiated by the length of time spent braking. 'Heavy' may involve some squealing of tyres. 'Emergency' will include those instances where braking is continuous, very heavy and where the wheels may lock so that the car skids out of control. It may also include swerving.

By virtue of the nature of the factor, it is difficult to infer the differences between the severity grades from static diagrams. Please tell the instructor when you are ready and he will show you an example of each severity grade in turn on the film.

Do not turn over until told.

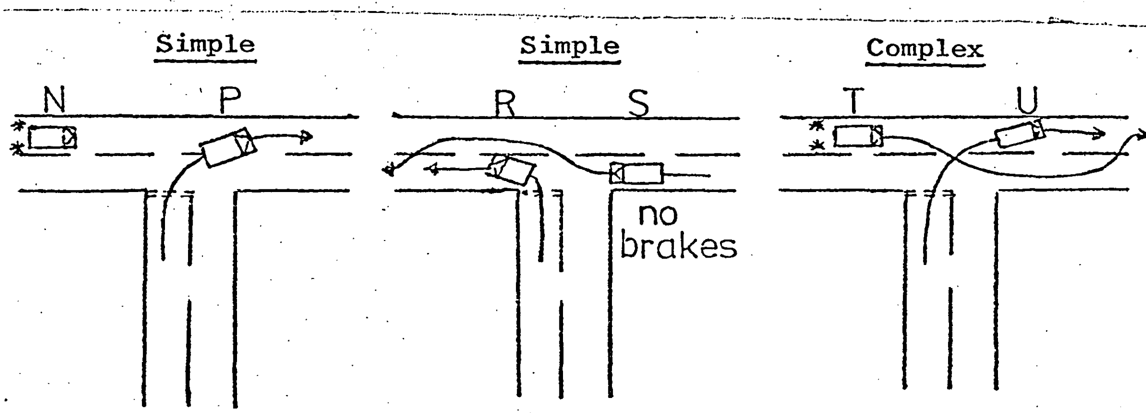
v.iii Factor C.

The third factor is FACTOR C - WAS THE EVASIVE ACTION SIMPLE OR COMPLEX?

There are two alternatives:-

SIMPLE	COMPLEX
(single action either braking only OR swerving only)	(more than one action braking AND swerving)

Two examples are shown below to illustrate simple evasive action and one complex.



Braking only — Swerving only — Braking and swerving

Please tell the instructor when you are ready to see these examples on the film in the order illustrated above.

v.iv Factor D.

The last factor is FACTOR D - HOW CLOSE DID THE CONFLICTING VEHICLES GET?

There are three possibilities:-

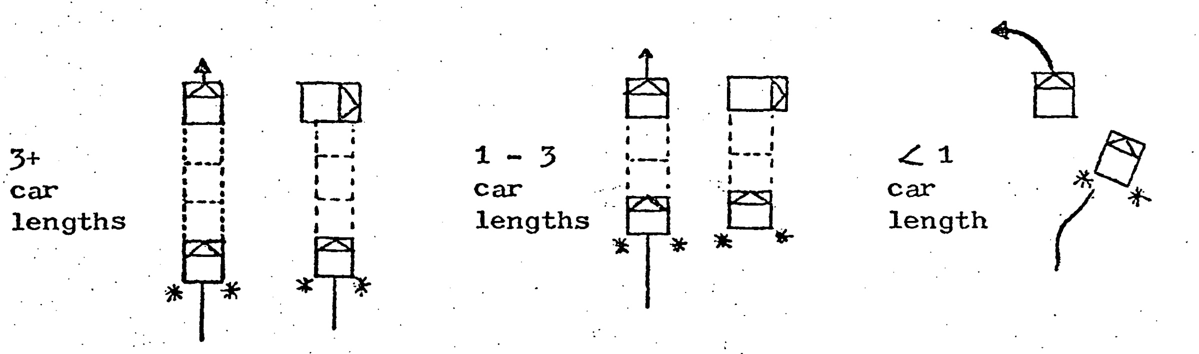
NEAR NEAR MISS VERY NEAR MISS

These are differentiated from one another mainly on the basis of the distance between the conflicting vehicles, at the point of minimal proximity when an accident could still occur.

Please read and study the illustrations below

This is taken from the point when the vehicles are closest.

Near | Near Miss | Very Near Miss



45 feet or more (3 car lengths plus)

Between 15 and 45 feet. (1 - 3 car lengths)

Below 15 feet (1 car length)

When you are ready to view each illustration on the film, please inform the instructor. They will be shown in the order illustrated above.

vi. Recording Sheets

When recording conflicts at locations, recording sheets as illustrated below are used. Each sheet has a diagram of the location and down each side a list of the four questions to be answered for each conflict. This is set out as shown below. Normally there are two of these per sheet so that two events can be recorded before having to turn over.

Diagram of location	FACTOR A How long in time before the possible collision did the evasive action commence?	Long	
		Moderate	
		Short	
	FACTOR B How severe or rapid was the evasive action?	Light	
		Medium	
		Heavy	
		Emergency	
	FACTOR C Was the evasive action simple (single action) or complex (more than one action)?	Simple	
		Complex	
Events leading up to incident	FACTOR D How close did the conflicting vehicles get?	3 or more car lengths	
		Between 1 and 3 car lengths	
		Less than one car length	

At the bottom is a section for writing down the build up of events leading to the conflict and a place for noting down the exact time of the conflict. An extra box labelled "collision" is sometimes included in Factor D in the (unlikely) event of an accident occurring.

You will now be shown three separate clips of film, one after the other. We now want you to try to assess each conflict on all FOUR factors. The answers are to be written on page 2 of the Answer Booklet.

Please turn over.

After seeing the first clip (and you may see it up to 4 times) write what you consider to be appropriate grades for each factor under column E. Likewise for the next two, which are F and G. Tell the instructor when you are ready to proceed.

<u>Answer booklet to accompany training film</u>

<u>Name</u>

<u>Age</u>

<u>Sex</u>

Introductory Training Manual

Exercises:

1.

2.

3.

4.

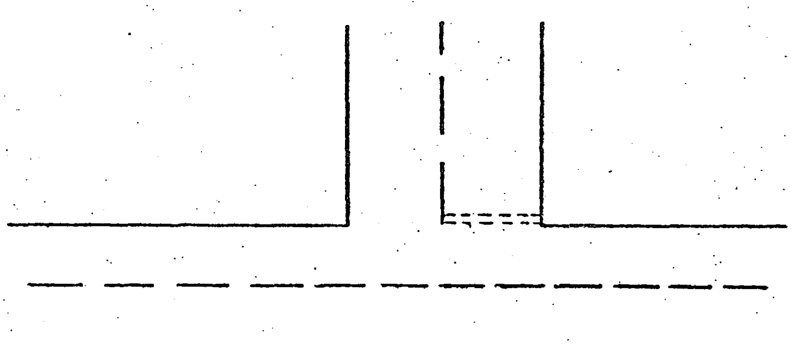
5.

6.

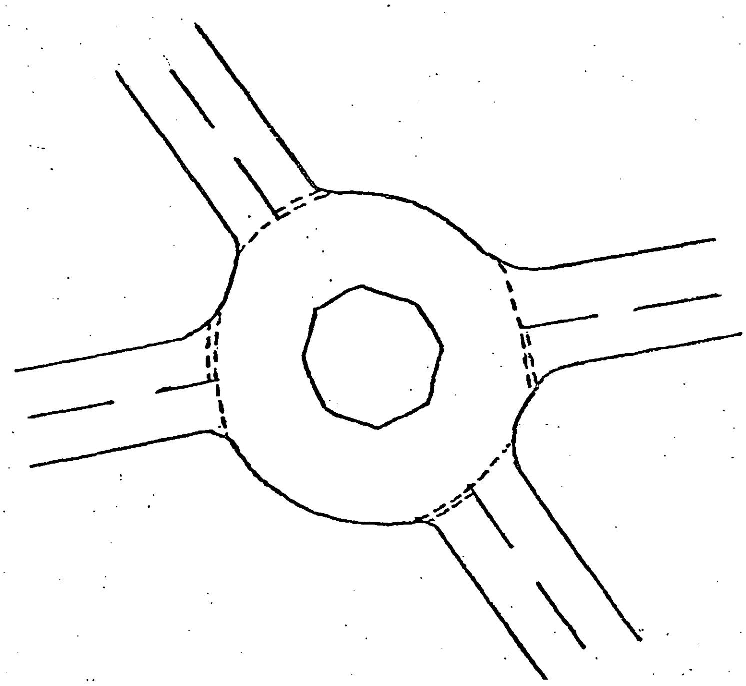
7.

8.

9.



10.



3.2.2 Scoring

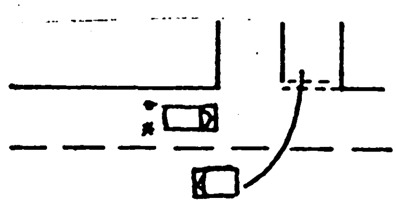
The correct answers are illustrated in Table 1 below

TABLE 1

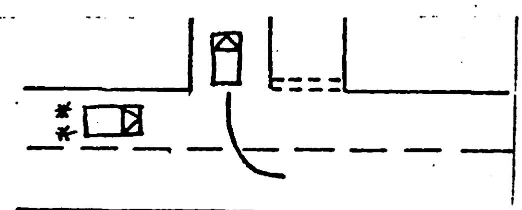
INTRODUCTORY TRAINING MANUAL SCORING SHEET

FOR EXERCISES

1. Rear-end conflict
2. Right turn from minor
3. Rear-end conflict
4. Right turn off major
5. Rear-end conflicts, lane change conflicts, right turn from minor road conflicts.
6. Rear-end
7. Rear-end and right-turn off major
8. Cross traffic conflict and left turn conflicts
9. EITHER OR

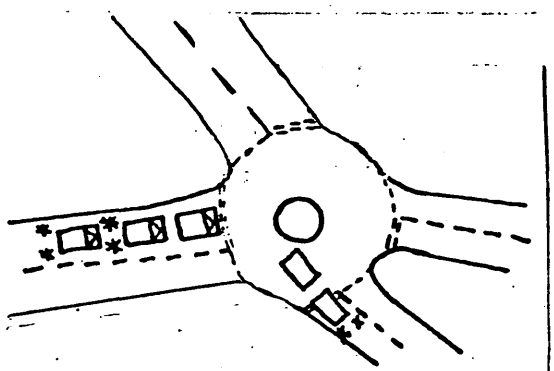


Right turn from minor



Right turn off major

10. E.G.,



A 100% level of performance is required before continuing training.

Compare this sheet with the sheet on which the trainee has completed the exercises (Answer Booklet, Page 1). Place a ✓ in the box at the end of each answer on the trainees sheets if the answer the trainee has given corresponds to the answer given on the master scoring sheet. Total number of correct answers according to the number of ticks.

Scoring Sheet for Training Film

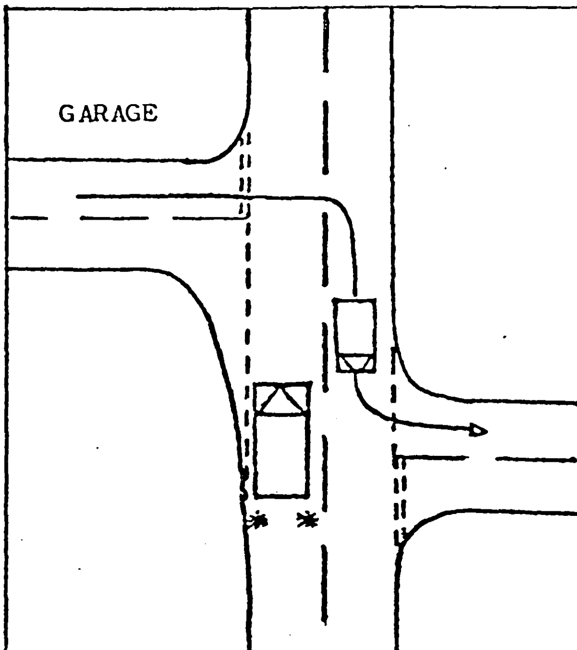
FACTOR	DESCRIPTION	Choose one from:	Trial	Answer
A.	How long in time before the potential accident did the evasive action commence?	LONG MODERATE SHORT	A1	
			A2	
B.	How sudden or rapid was the evasive action?	LIGHT MEDIUM HEAVY EMERGENCY	B1	
			B2	
C.	What was the evasive action simple or complex?	SIMPLE COMPLEX	C1	
			C2	
D.	How close did the conflicting vehicles get?	NEAR (less than 3 car lengths) NEAR MISS (between 1 and 3 car lengths) VERY NEAR MISS (less than one car length)	D1	
			D2	

SCORE:

Do not write in these boxe

FACTORS TRIALS	E	F		
A. How long in time before the potential accident did the evasive action commence? Choose one from: Long, Moderate, Short				
B. How rapid was the evasive action? Choose one from: Light, Medium, Heavy, Emergency				
C. Was the evasive action simple or complex? Choose one from: Simple, Complex				
D. How close did the conflicting vehicles get? Choose one from: Near, Near miss, Very near miss				

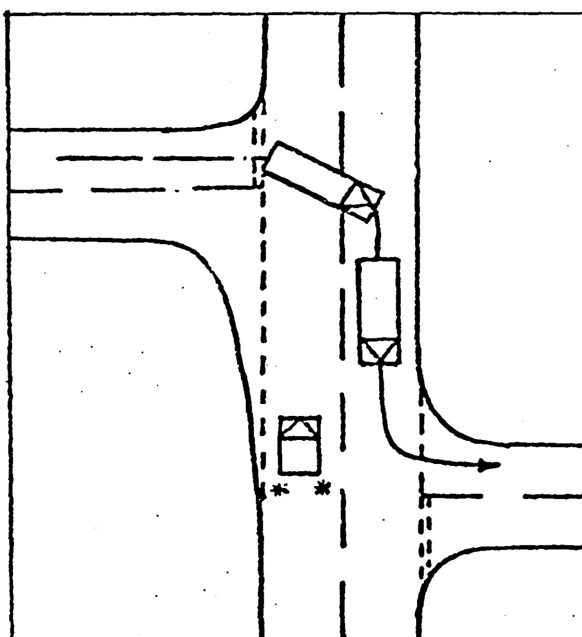
		Here	Blank
FACTOR A How long in time before the possible collision did the evasive action commence?	Long		
	Moderate		
	Short		
FACTOR B How severe or rapid was the evasive action?	Light		
	Medium		
	Heavy		
	Emergency		
FACTOR C Was the evasive action simple (single action) or complex (more than one action)?	Simple		
	Complex		
FACTOR D How close did the conflicting vehicles get?	3 or more car lengths		
	Between 1 and 3 car lengths		
	Less than one car length		



Events leading up to incident

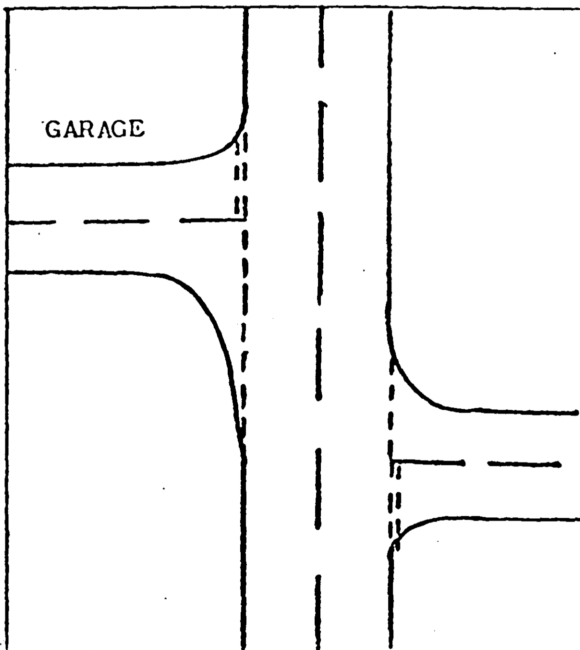
G

		Here	Leave Blank
FACTOR A How long in time before the possible collision did the evasive action commence?	Long		
	Moderate		
	Short		
FACTOR B How severe or rapid was the evasive action?	Light		
	Medium		
	Heavy		
	Emergency		
FACTOR C Was the evasive action simple (single action) or complex (more than one action)?	Simple		
	Complex		
FACTOR D How close did the conflicting vehicles get?	3 or more car lengths		
	Between 1 and 3 car lengths.		
	Less than one car length		



Events leading up to incident

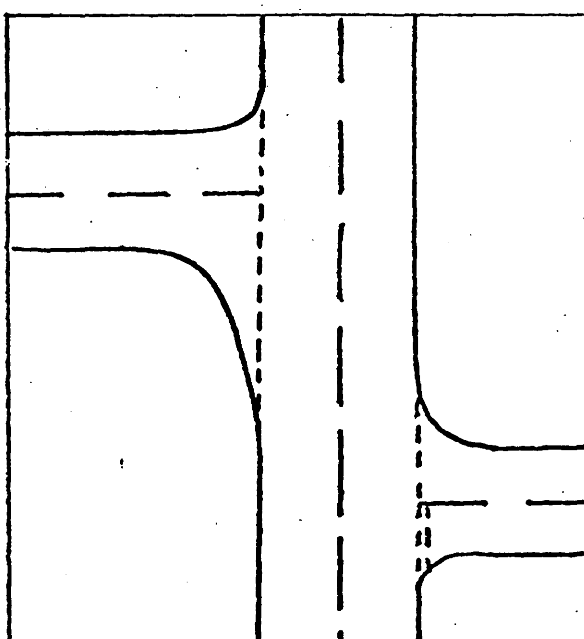
H



Question	Answer	✓ Here	Leave Blank
FACTOR A How long in time before the possible collision did the evasive action commence?	Long		
	Moderate		
	Short		
FACTOR B How severe or rapid was the evasive action?	Light		
	Medium		
	Heavy		
	Emergency		
FACTOR C Was the evasive action simple (single action) or complex (more than one action)?	Simple		
	Complex		
FACTOR D How close did the conflicting vehicles get?	3 or more car lengths		
	Between 1 and 3 car lengths.		
	Less than one car length		

Events leading up to incident

J



Question	Answer	✓ Here	Leave Blank
FACTOR A How long in time before the possible collision did the evasive action commence?	Long		
	Moderate		
	Short		
FACTOR B How severe or rapid was the evasive action?	Light		
	Medium		
	Heavy		
	Emergency		
FACTOR C Was the evasive action simple (single action) or complex (more than one action)?	Simple		
	Complex		
FACTOR D How close did the conflicting vehicles get?	3 or more car lengths		
	Between 1 and 3 car lengths		
	Less than one car length		

Events leading up to incident

K

APPENDIX TO SECTION C, CHAPTER 9

FIGURE 22 : Layout of site showing flows, serious and slight conflicts and accidents at crossing and merging locations

a) Site 1

b) Site 2

c) Site 3

d) Site 4

e) Site 5

f) Site 6

g) Site 7

h) Site 8

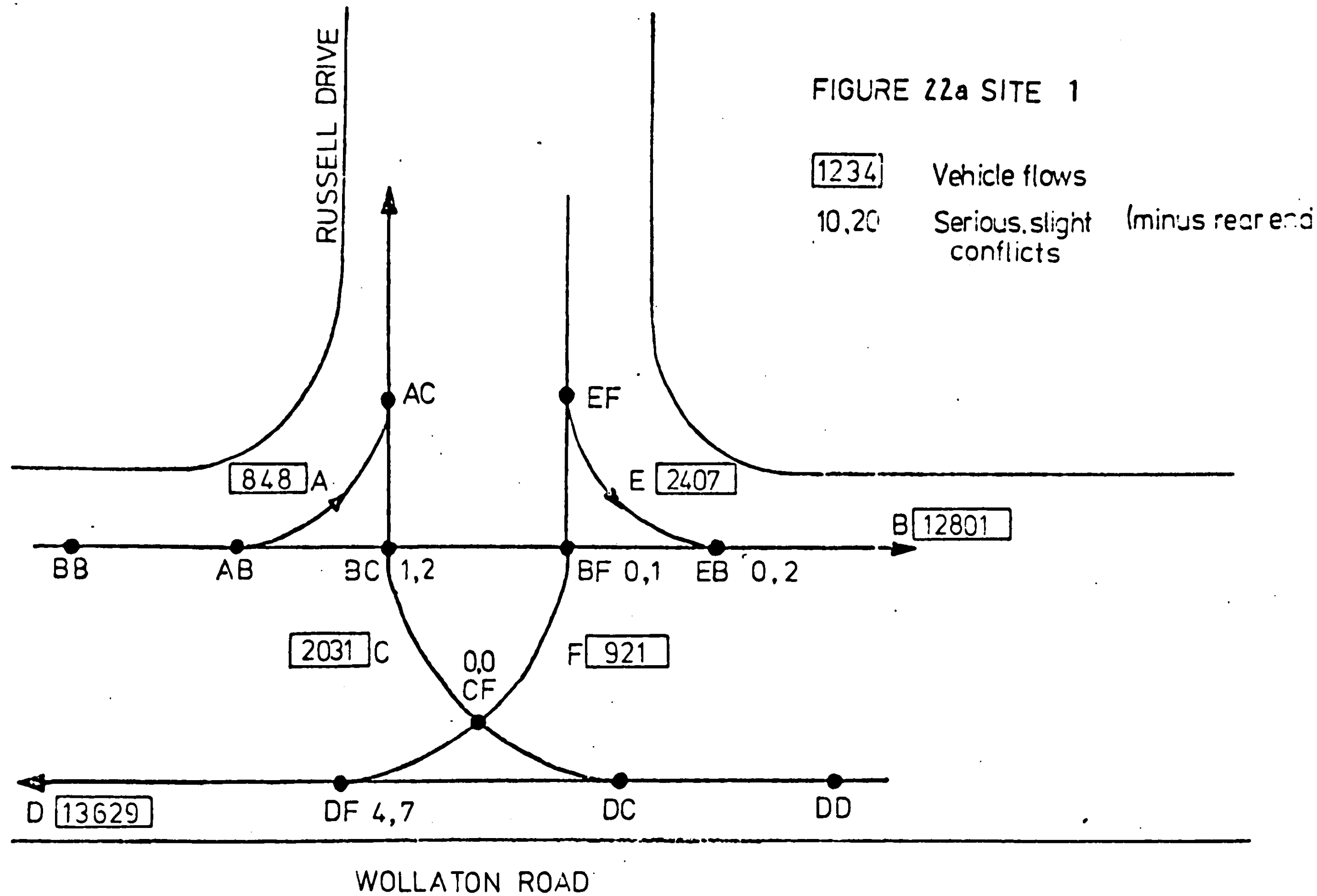


FIGURE 22a SITE 1

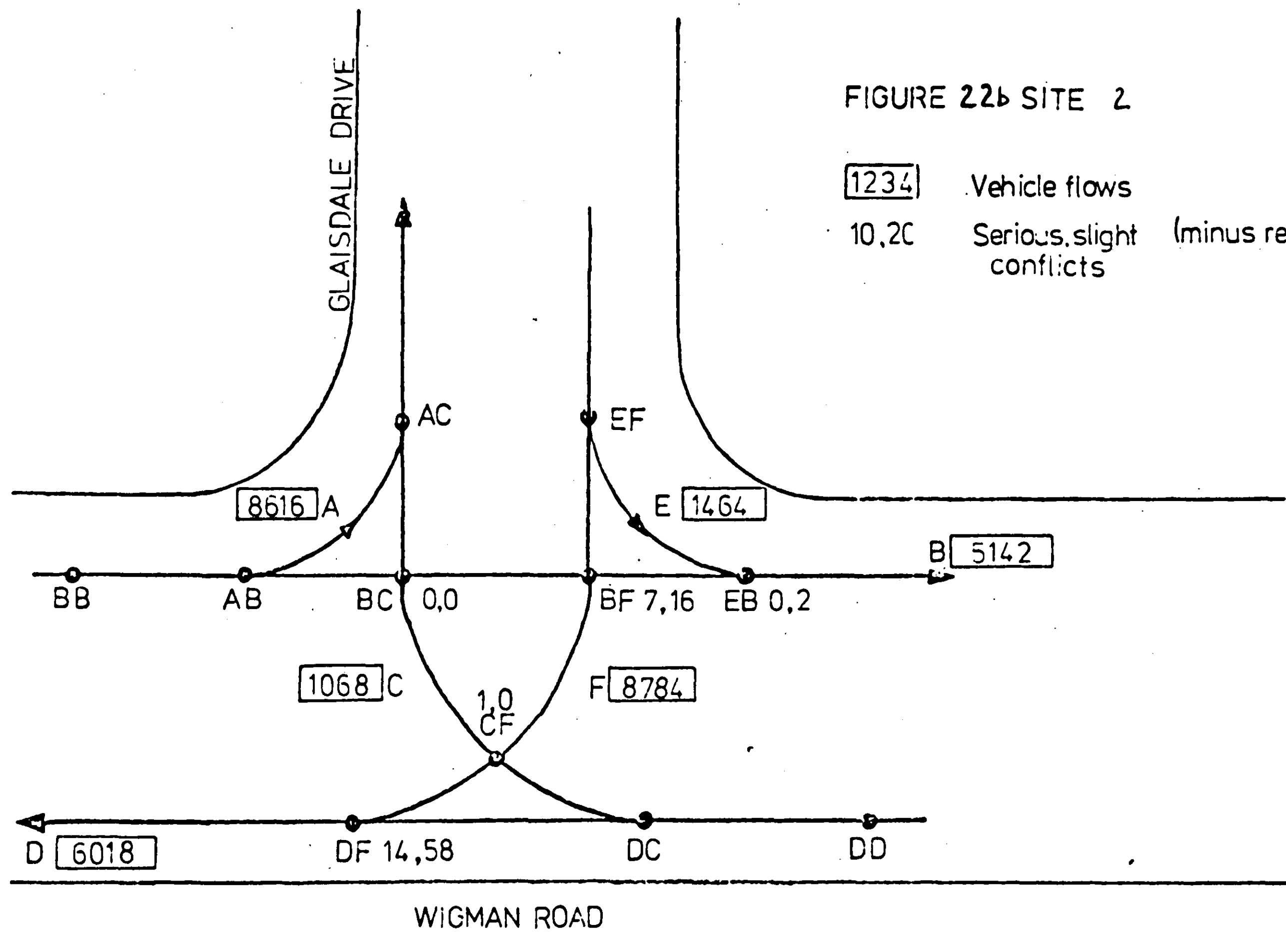


FIGURE 22b SITE 2

1234 Vehicle flows

10,20 Serious,slight conflicts (minus rear end)

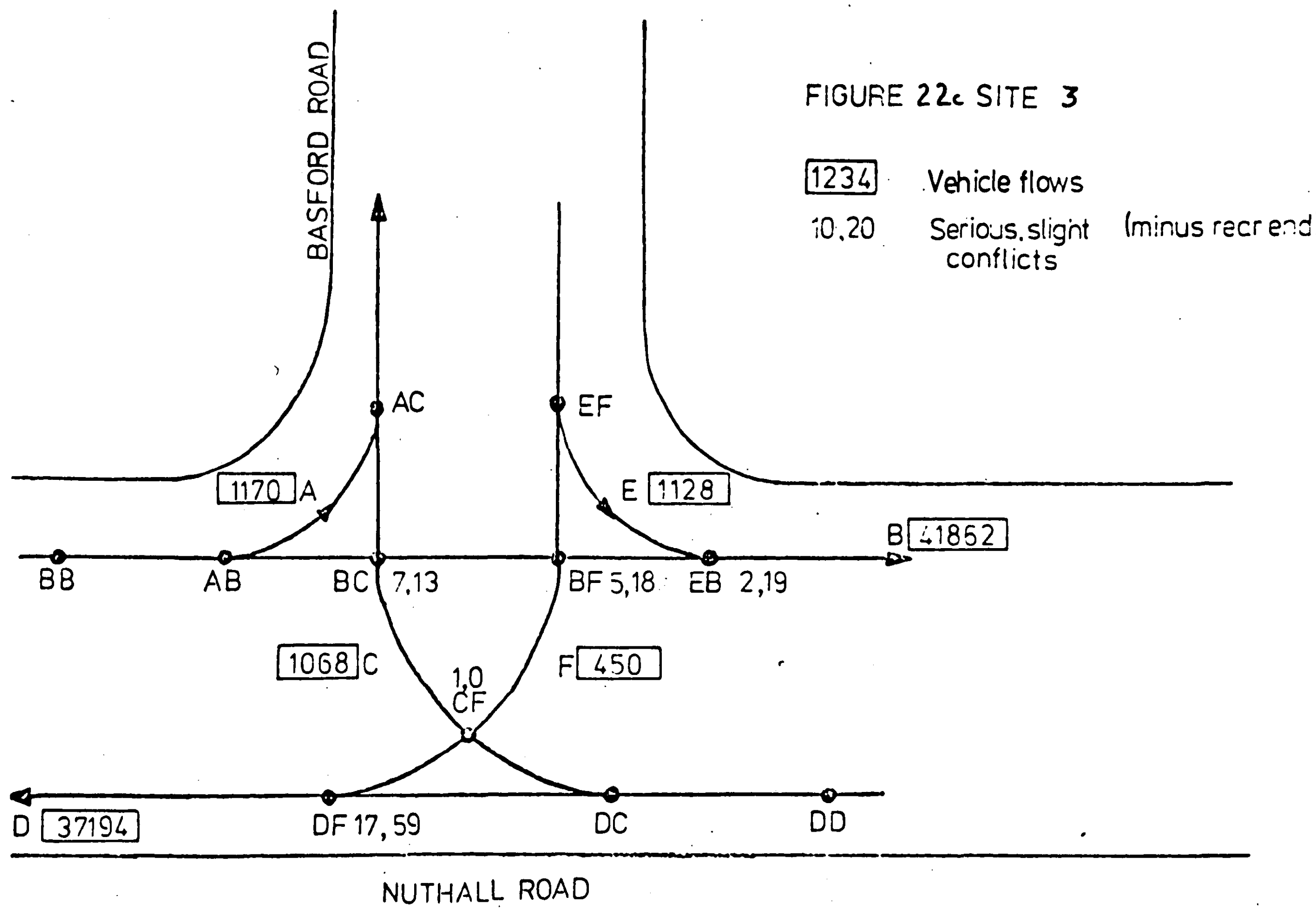


FIGURE 22c SITE 3

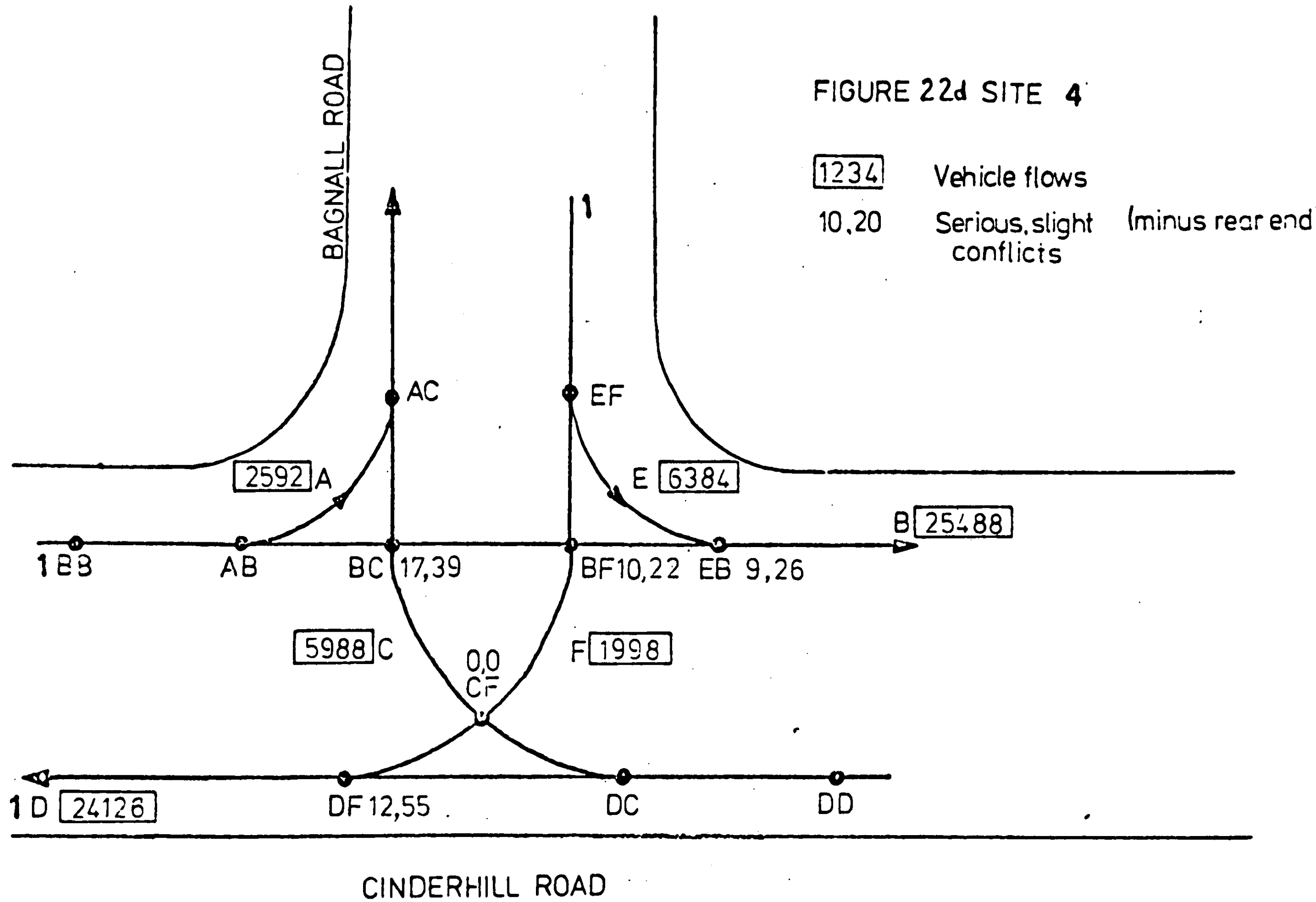


FIGURE 22d SITE 4
1234 Vehicle flows
10,20 Serious, slight conflicts (minus rear end)
BAGNALL ROAD
CINDERHILL ROAD
AC
EF
2592 A
E 6384
B 25488
1 BB
AB
BC 17,39
BF 10,22
EB 9,26
5988 C
0,0
CF
F 1998
1 D 24126
DF 12,55
DC
DD
1

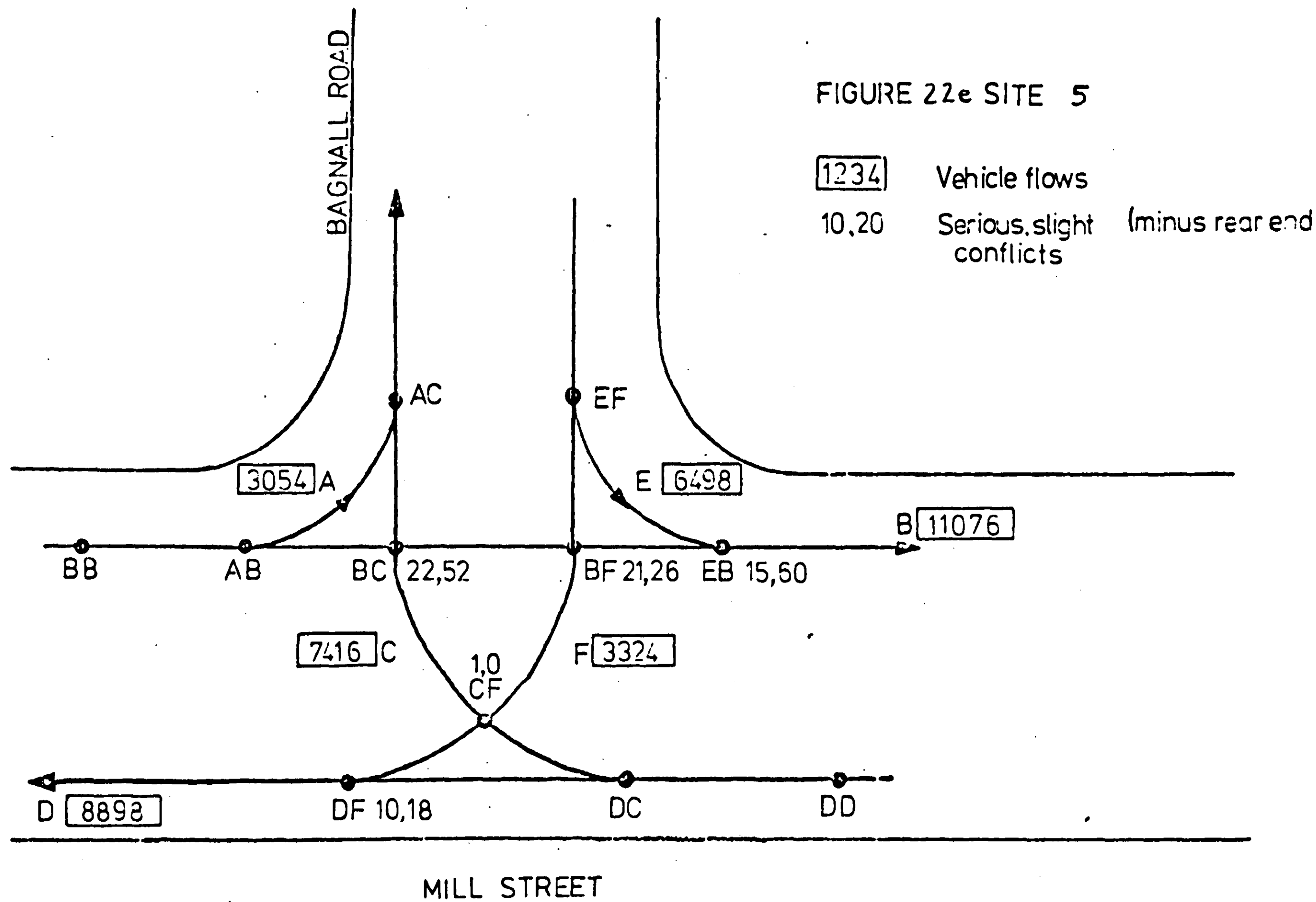


FIGURE 22e SITE 5

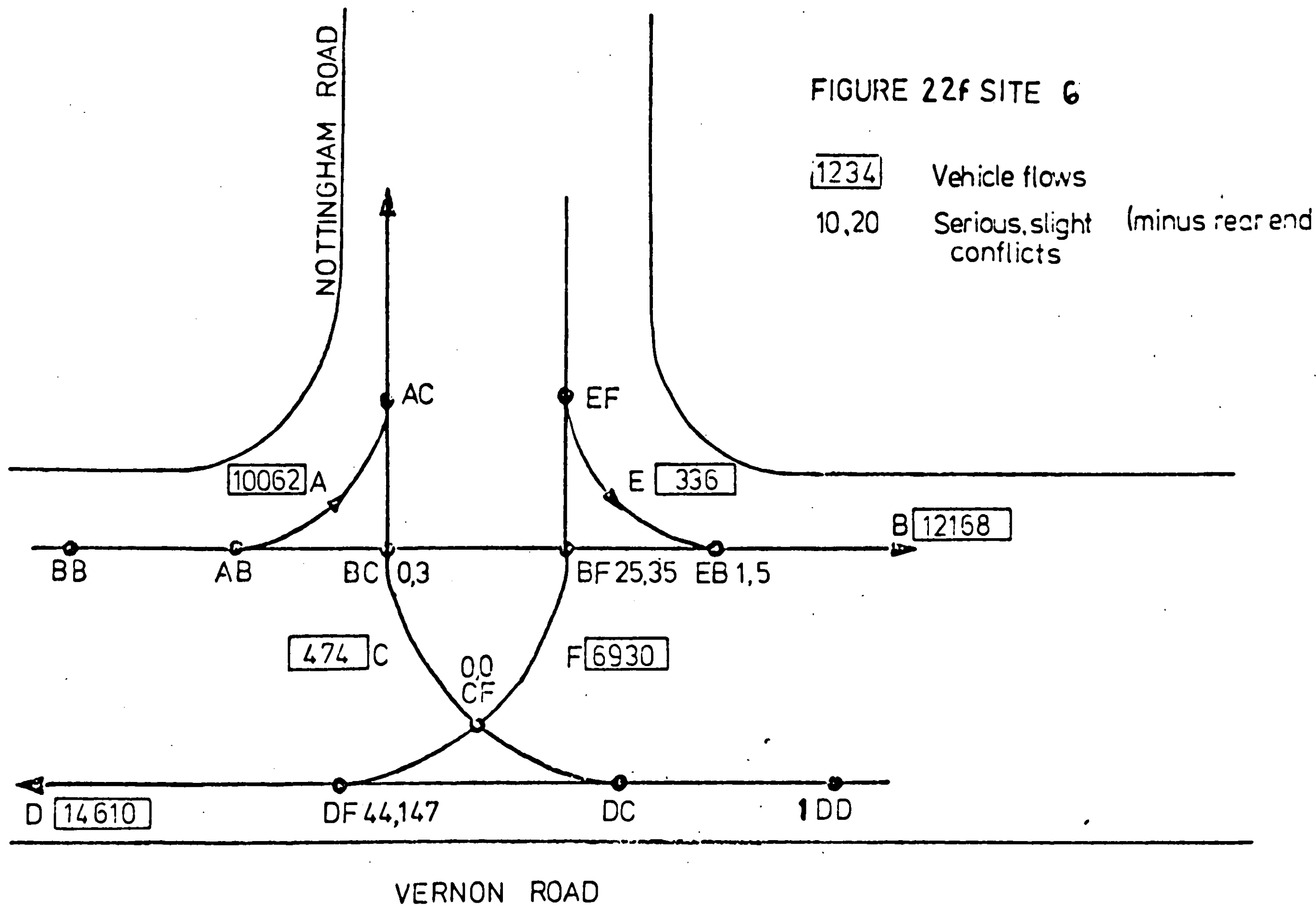


FIGURE 22f SITE 6

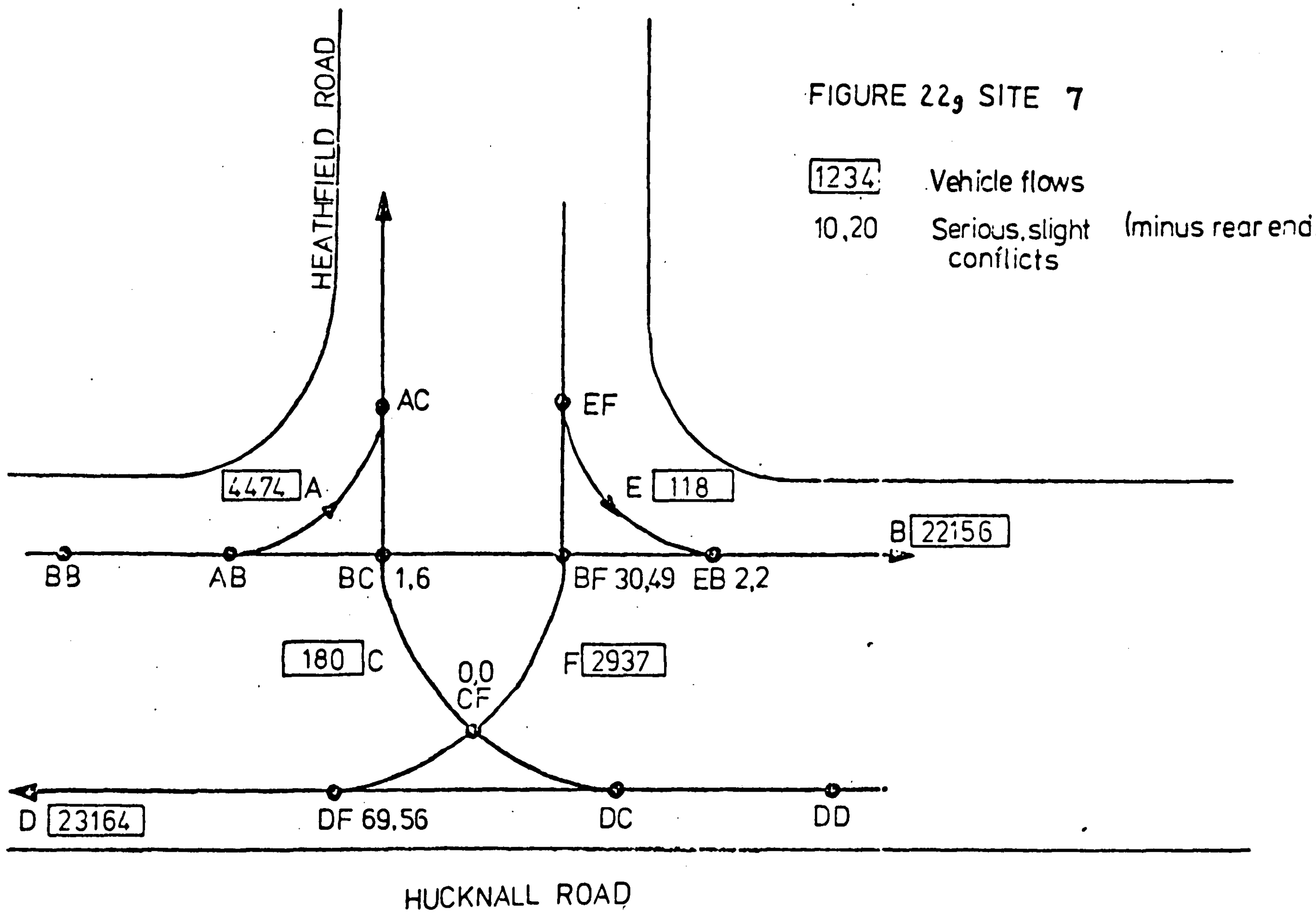
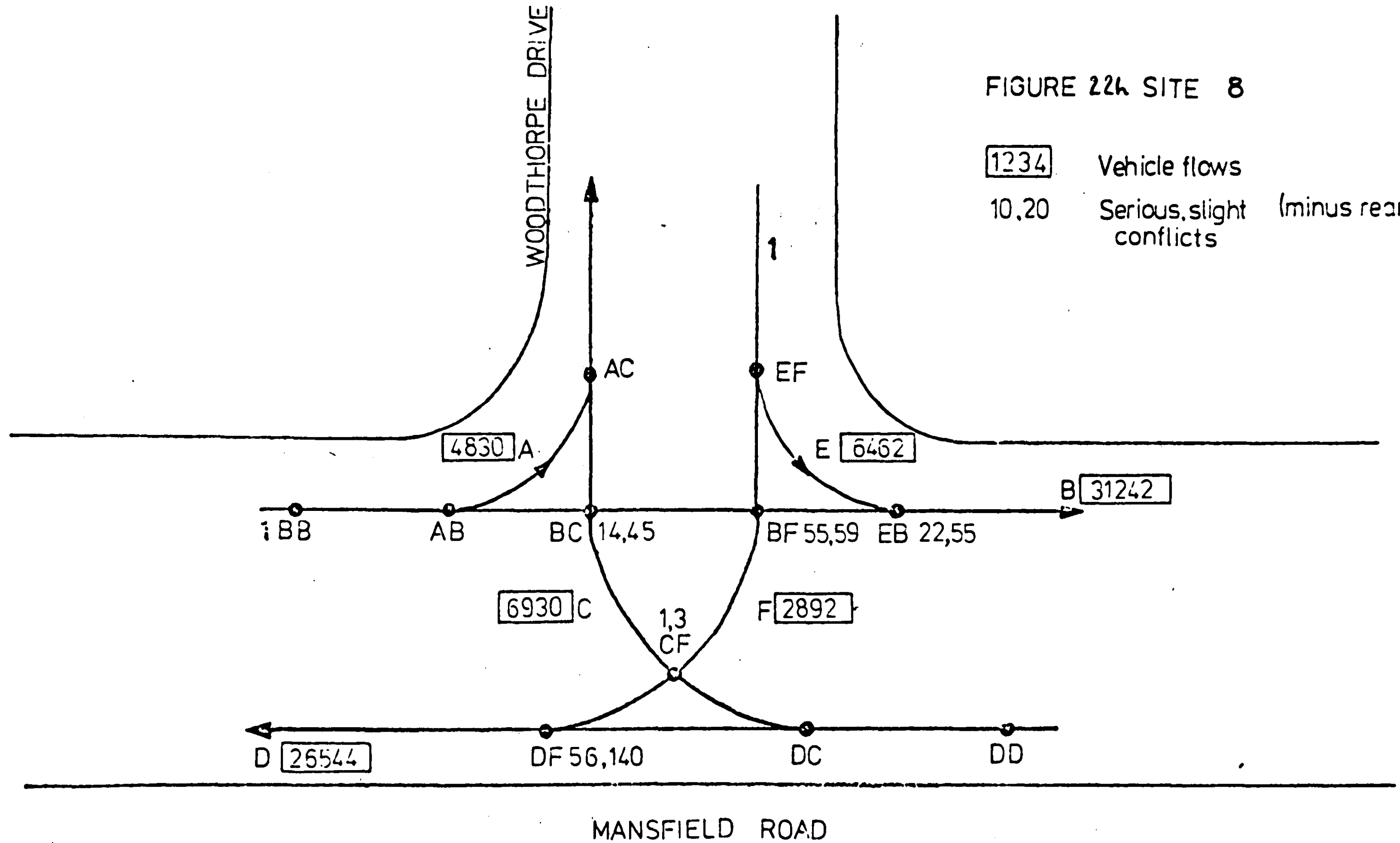


FIGURE 22g SITE 7

FIGURE 22h SITE 8

1234 Vehicle flows

10,20 Serious, slight conflicts (minus rear end)



APPENDIX TO SECTION C, CHAPTER 9

Table 31 : Calculation of linear regression using the method of least squares
a) DF
b) BF
c) BC
d) BE

a) DF -- Serious conflicts.

x	y	xy	x^2	y^2
3.54	0.44	1.56	12.53	0.19
7.67	1.56	11.97	58.83	2.43
4.09	1.78	7.28	16.73	3.17
6.94	1.33	9.23	48.16	1.77
5.44	1.11	6.04	29.59	1.23
10.06	7.67	77.16	101.20	58.83
8.25	4.89	40.34	68.06	23.91
8.76	6.22	54.49	76.74	38.69
54.75	25.00	203.07	411.84	130.22

$$b_1 = \frac{nExy - Ex\,Ey}{n\,Ex^2 - (Ex)^2}$$

$$= \frac{8\ (208.07) - 54.75\ (25.00)}{8\ (411.84) - (54.75)^2}$$

$$= \frac{1664.56 - 1368.75}{3294.72 - 2997.56}$$

$$= \frac{295.81}{297.16}$$

$$= \underline{\underline{0.995}}$$

$$b_o = \bar{y} - b_1\,\bar{x}$$

$$= 3.125 - 0.995\ (6.844)$$

$$= 3.125 - 6.180$$

$$= -3.685$$

Line of regression of y on x is $\hat{y}$ = $\underline{-3.685 + 0.995x}$

x	$\hat{y}$
3.54	-0.16
7.67	3.95
4.09	0.38
6.94	3.22
5.44	1.73
10.06	6.32
8.25	4.52
8.76	5.03

a) DF -- All conflicts.

x	y	xy	x^2	y^2
3.54	1.22	4.32	12.53	1.49
7.67	8.00	61.36	58.83	64.00
4.09	8.22	33.62	16.73	67.57
6.94	7.44	51.63	48.16	55.35
5.44	3.11	16.92	29.59	9.67
10.06	25.00	251.50	101.20	625.00
8.25	21.22	175.07	68.06	450.29
8.76	21.78	190.79	76.74	474.37
54.75	95.99	785.21	411.84	1747.74

$$b_1 = \frac{nExy - Ex\ Ey}{n\ Ex^2 - (Ex)^2}$$

$$= \frac{8\ (785.21) - 54.75\ (95.99)}{8\ (411.84) - 54.75^2}$$

$$= \frac{6281.68 - 5255.45}{3294.72 - 2997.56}$$

$$= \frac{1026.23}{297.16}$$

$$= \underline{\underline{3.45}}$$

$$b_o = \bar{y} - b_1\ \bar{x}$$

$$= 12 - 3.45\ (6.84)$$

$$= 12 - 23.60$$

$$= -\ \underline{\underline{11.60}}$$

Therefore line of regression of y on x is $\hat{y} = -11.60 + 3.45x$

x	$\hat{y}$
3.54	0.61
7.67	14.86
4.09	2.51
6.94	12.34
5.44	7.17
10.06	23.11
8.25	16.86
8.76	18.62

a) Correlation coefficients for DF.

$$r = b_1 \frac{sx}{sy} \qquad \text{Where} \quad sx = \sqrt{\frac{Ex^2 - \frac{(Ex)^2}{n}}{n}}$$

$$sy = \sqrt{\frac{Ey^2 - \frac{(Ey)^2}{n}}{n}}$$

SERIOUS

$$sx = \sqrt{\frac{411.84 - \frac{54.75^2}{8}}{8}}$$

$$= \sqrt{\frac{411.84 - 374.70}{8}}$$

$$= \underline{\underline{2.15}}$$

$$sy = \sqrt{\frac{130.22 - \frac{25^2}{8}}{8}}$$

$$= \sqrt{\frac{130.22 - 78.125}{8}}$$

$$= \underline{\underline{2.55}}$$

$$r = 0.995 \times \frac{2.15}{2.55}$$

$$= \underline{\underline{0.84}}$$

Sig[t] beyond 1% level

ALL

$$sy = \sqrt{\frac{411.84 - \frac{54.75^2}{8}}{8}}$$

$$= \sqrt{\frac{411.84 - 374.70}{8}}$$

$$= \underline{\underline{2.15}}$$

$$sy = \sqrt{\frac{1747.74 - \frac{95.99^2}{8}}{8}}$$

$$= \sqrt{\frac{1747.74 - 1151.76}{8}}$$

$$= \underline{\underline{8.63}}$$

$$r = 3.45 \times \frac{2.15}{8.63}$$

$$= \underline{\underline{0.86}}$$

Sig[t] beyond 1% level

b) BF -- Serious conflicts.

x	y	xy	x^2	y^2
3.43	0.00	0.00	11.76	-
6.72	0.78	5.24	45.16	0.61
4.34	0.56	2.43	18.84	0.31
7.14	1.11	7.93	50.98	1.23
6.07	2.33	14.14	36.84	5.43
9.18	3.33	30.57	84.27	11.09
8.07	2.78	22.43	65.12	7.73
9.51	6.11	58.11	90.44	37.33
54.46	17.00	140.85	403.41	63.73

$$b_1 = \frac{n\ Exy - ExEy}{n\ Ex^2 - (Ex)^2} = \frac{8\ (140.85) - 54.46\ (17)}{8\ (403.41) - (54.46)^2}$$

$$= \frac{1126.80 - 925.82}{3227.28 - 2965.89} = \frac{200.98}{261.39} = \underline{\underline{0.769}}$$

$$b_o = \bar{y} - b_1 \bar{x} = 2.125 - 0.769\ (6.81)$$

$$= 2.125 - 5.237 = \underline{\underline{-\ 3.112}}$$

Line of regression of y on x is $\hat{y} = \underline{\underline{-3.112 + 0.769x}}$

x	$\hat{y}$
3.43	-0.47
6.72	2.06
4.34	0.23
7.14	2.38
6.07	1.56
9.18	3.95
8.07	3.09
9.51	4.20

b) BF -- All conflicts.

x	y	xy	x^2	y^2
3.43	0.11	0.38	11.76	0.01
6.72	2.56	17.20	45.16	6.55
4.34	2.56	11.11	18.84	6.55
7.14	3.56	25.42	50.98	12.67
6.07	5.22	31.69	36.84	27.25
9.18	8.78	80.60	84.27	77.09
8.07	6.67	53.83	65.12	44.49
9.51	12.67	120.49	90.44	160.53
54.46	42.13	340.72	403.41	335.14

$$b_1 = \frac{nExy - ExEy}{nEx^2 - (Ex)^2}$$

$$= \frac{8\,(340.72) - 54.46\,(42.13)}{8\,(403.41) - (54.46)^2}$$

$$= \frac{2725.76 - 2294.40}{3227.28 - 2965.89}$$

$$= \frac{431.36}{261.39}$$

$$= \underline{\underline{1.65}}$$

$$b_o = \bar{y} - b_1 \bar{x}$$

$$= 5.27 - 1.65\,(6.81)$$

$$\doteq 5.27 - 11.24$$

$$= \underline{\underline{-5.97}}$$

Therefore line of regression of y on x is $\hat{y} = \underline{\underline{-5.97 + 1.65x}}$

x	$\hat{y}$
3.43	-0.31
6.72	5.12
4.34	1.19
7.14	5.81
6.07	4.05
9.18	9.18
8.07	7.35
9.51	9.72

b) Correlation coefficients for BF.

$$r = b_1 \frac{sx}{sy} \quad \text{where} \quad sx = \sqrt{\frac{Ex^2 - \frac{(Ex)^2}{n}}{n}}$$

$$sy = \sqrt{\frac{Ey^2 - \frac{(Ey)^2}{n}}{n}}$$

$$sx = \sqrt{\frac{Ex^2 - \frac{(Ex)^2}{n}}{n}} = \sqrt{\frac{403.41 - \frac{54.46^2}{8}}{8}} = \sqrt{\frac{403.31 - 370.74}{8}} = 2.02$$

SERIOUS

$$sy = \sqrt{\frac{63.73 - \frac{17^2}{8}}{8}}$$

$$= \sqrt{\frac{63.73 - 36.125}{8}}$$

$$= 1.86$$

$$r = b_1 \frac{sx}{sy}$$

$$= 0.769 \times \frac{2.02}{1.86}$$

$$= 0.84$$

Sig^t beyond 1% level

ALL

$$= \sqrt{\frac{335.14 - \frac{42.13^2}{8}}{8}}$$

$$= \sqrt{\frac{335.14 - 221.87}{8}}$$

$$= 3.76$$

$$r = b_1 \frac{sx}{sy}$$

$$= 1.65 \times \frac{2.02}{3.76}$$

$$= 0.89$$

Sig^t beyond 1% level

c) BC -- Serious conflicts.

x	y	xy	x^2	y^2
5.10	0.11	0.56	26.01	0.01
2.34	0.00	0.00	5.48	-
6.69	0.78	5.22	44.76	0.61
12.32	1.89	23.28	151.78	3.57
9.06	2.44	22.11	82.08	5.95
2.40	0.11	0.26	5.76	0.01
2.00	0.00	0.00	4.00	-
14.71	1.56	22.95	216.38	2.43
54.62	6.89	74.38	536.25	12.58

$$b_1 = \frac{n\ Exy - Ex\ Ey}{n\ Ex^2 - (Ex)^2}$$

$$= \frac{8\ (74.38) - 54.62\ (6.89)}{8\ (536.25) - 54.62^2}$$

$$= \frac{595.04 - 376.33}{4290 - 2983.34}$$

$$= \frac{218.71}{1306.66}$$

$$= \underline{\underline{0.167}}$$

$$b_o = \bar{y} - b_1 \bar{x}$$

$$= 0.86 - 0.167\ (6.83)$$

$$= 0.86 - 1.14$$

$$= \underline{\underline{-0.28}}$$

Therefore line of regression of y on x is $\hat{y} = -0.28 + 0.167x$

x	$\hat{y}$
5.10	0.57
2.34	0.11
6.69	0.84
12.32	1.78
9.06	1.23
2.40	0.12
2.00	0.05
14.71	2.18

c) BC -- All conflicts.

x	y	xy	x^2	y^2
5.10	0.33	1.68	26.01	0.11
2.34	-	-	5.48	-
6.69	2.22	14.85	44.76	4.93
12.32	6.22	76.63	151.78	38.69
9.06	8.22	74.47	82.08	67.57
2.40	0.78	1.87	5.76	0.61
2.00	0.22	0.44	4.00	0.05
14.71	6.56	96.50	216.38	43.03
54.62	24.55	266.44	536.25	154.99

$$b_1 = \frac{nExy - Ex\ Ey}{nEx^2 - (Ex)^2}$$

$$= \frac{8\ (266.44) - 54.62\ (24.55)}{8\ (536.25) - 54.62^2}$$

$$= \frac{2131.52 - 1340.92}{4290 - 2983.34}$$

$$= \frac{790.6}{1306.66}$$

$$= \underline{\underline{0.605}}$$

$$b_o = \bar{y} - b_1 \bar{x}$$

$$= 3.069 - 0.605\ (6.83)$$

$$= 3.069 - 4.132$$

$$= \underline{\underline{-1.063}}$$

Therefore line of regression of y on x is $\underline{\hat{y} = -1.063 + 0.605x}$

x	$\hat{y}$
5.10	2.02
2.34	0.35
6.69	2.98
12.32	6.39
9.06	4.42
2.40	0.39
2.00	0.15
14.71	7.84

c) Correlation coefficients for BC.

$$r = b_1 \frac{sx}{sy}$$

Where $sx = \sqrt{\dfrac{Ex^2 - \dfrac{(Ex)^2}{n}}{8}}$

and $sy = \sqrt{\dfrac{Ey^2 - \dfrac{(Ey)^2}{n}}{n}}$

$$sx = \sqrt{\frac{536.25 - \frac{(54.62)^2}{8}}{8}}$$

$$= \sqrt{\frac{536.25 - 372.92}{8}}$$

$$= \underline{\underline{4.52}}$$

SERIOUS

$$sy = \sqrt{\frac{12.58 - \frac{(6.89)^2}{8}}{8}}$$

$$= \sqrt{\frac{12.58 - 5.93}{8}}$$

$$= \underline{\underline{0.91}}$$

$$\therefore r = b_1 \frac{sx}{sy}$$

$$= 0.167 \times \frac{4.52}{0.91}$$

$$= \underline{\underline{0.83}}$$

Sig^t at 1% level

ALL

$$sy = \sqrt{\frac{154.99 - \frac{(24.55)^2}{8}}{8}}$$

$$= \sqrt{\frac{154.99 - 75.34}{8}}$$

$$= \underline{\underline{3.16}}$$

$$\therefore r = b_1 \frac{sx}{sy}$$

$$= 0.605 \times \frac{4.52}{3.16}$$

$$= \underline{\underline{0.87}}$$

Sig^t beyond 1% level

d) 8E-Serious Conflicts

x	y	xy	x^2	y^2
5.55	-	-	30.80	-
2.74	-	-	7.51	-
6.87	0.22	1.51	47.20	0.05
12.76	0.78	9.95	162.82	0.61
8.48	1.67	14.16	71.91	2.79
2.02	0.22	0.44	4.08	0.05
1.62	0.11	0.18	2.62	0.01
14.21	2.44	34.67	201.92	5.95
54.25	5.44	60.91	528.86	9.46

$$b_1 = \frac{nExy - Ex\,Ey}{nEx^2 - (Ex)^2}$$

$$= \frac{8(60.91) - 54.25(5.44)}{8(528.86) - 54.25^2}$$

$$= \frac{487.28 - 295.12}{4230.88 - 2943.06}$$

$$= \frac{192.16}{1287.82}$$

$$= 0.149$$

$$b_o = \bar{y} - b_1\bar{x}$$

$$= 0.68 - 0.149\ (6.78)$$

$$= 0.68 - 1.01$$

$$= -0.33$$

Therefore line of regression of y on x is $\hat{y} = -0.33 + 0.149x$

x	$\hat{y}$
5.55	0.50
2.74	0.08
6.87	0.69
12.76	1.57
8.48	0.93
2.02	-0.03
1.62	-0.09
14.21	1.79

d) BE - all conflicts

x	y	xy	x^2	y^2
5.55	0.22	1.22	30.80	0.05
2.74	0.22	0.60	7.51	0.05
6.87	2.33	16.01	47.20	5.43
12.76	3.33	42.49	162.82	11.09
8.48	8.33	70.64	71.91	69.39
2.02	0.44	0.89	4.08	0.19
1.62	0.67	1.09	2.62	0.45
14.21	8.56	121.64	201.92	73.27
54.25	24.10	254.58	528.86	159.92

$$b_1 = \frac{n\, Exy - Ex\, Ey}{n\, Ex^2 - (Ex)^2}$$

$$= \frac{8(254.58) - 54.25(24.10)}{8(528.86) - (54.25)^2}$$

$$= \frac{2036.64 - 1307.43}{4230.88 - 2943.06}$$

$$= \frac{729.21}{1287.82}$$

$$= \underline{\underline{0.566}}$$

$$b_o = \bar{y} - b_1 \bar{x}$$

$$= 3.01 - 0.566(6.78)$$

$$= 3.01 - 3.84$$

$$= \underline{\underline{-0.83}}$$

Therefore line of regression of y on x is $\underline{\hat{y} = -0.83 + 0.566x}$

x	$\hat{y}$
5.55	2.31
2.74	0.72
6.87	3.06
12.76	6.39
8.48	3.97
2.02	0.31
1.62	0.09
14.21	7.21

c) Correlation Coefficients for BE

$r = b_1 \frac{sx}{sy}$ Where $sx = \sqrt{\frac{Ex^2 - \frac{(Ex)^2}{n}}{n}}$

and $sy = \sqrt{\frac{Ey^2 - \frac{(Ey)^2}{n}}{n}}$

$$sx = \sqrt{\frac{Ex^2 - \frac{(Ex)^2}{n}}{n}}$$

$$= \sqrt{\frac{528.86 - \frac{(54.25)^2}{8}}{8}}$$

$$= \sqrt{\frac{528.86 - 367.88}{8}}$$

$$= \underline{\underline{4.49}}$$

SERIOUS

$$sy = \sqrt{\frac{9.46 - \frac{(5.44)^2}{8}}{8}}$$

$$= \sqrt{\frac{9.46 - 3.70}{8}}$$

$$= \underline{\underline{0.85}}$$

Therefore $r = 0.149 \times \frac{4.49}{0.85}$

$$= \underline{\underline{0.79}}$$

Sig^t beyond 5% level

ALL

$$sy = \sqrt{\frac{159.92 - \frac{(24.1)^2}{8}}{8}}$$

$$= \sqrt{\frac{159.92 - 72.60}{8}}$$

$$= \underline{\underline{3.30}}$$

Therefore $r = 0.566 \times \frac{4.49}{3.30}$

$$= \underline{\underline{0.77}}$$

Sig^t beyond 5% level

APPENDIX TO SECTION C, CHAPTER 9

Table 32 : Comparison of offending (Type 1) and offended (Type 2) vehicles in conflicts using t-test
a) Cars
b) Light goods vehicles
c) Heavy goods vehicles
d) Motorcycles

a) Cars

$$Z = \frac{|p_1 - p_2|}{\sqrt{\frac{p_1 q_1}{n_1} \div \frac{p_2 q_2}{n_2}}}$$

where p_1 = proportion of sample

$q_1 = 1 - p_1$

n = population size

Use Z and normal distribution since sample is large.

$$Z = \frac{|0.773 - 0.809|}{\sqrt{\frac{0.773 \times 0.227}{13096} + \frac{0.809 \times 0.191}{13096}}}$$

$p_1 = 0.773$ $q_1 = 0.227$

$p_2 = 0.809$ $q_2 = 0.191$

$n_1 = 13096$ $n_2 = 13096$

$$= \frac{0.036}{\sqrt{\frac{0.175 + 0.155}{13096}}} = \frac{0.036}{\sqrt{0.000025}} = \frac{0.036}{0.005} = \underline{\underline{7.2}}$$

<u>Z = 7.2</u> is significant at the <u>0.01 level</u>

% of cars in Veh. 1 Type = 77.3% % of cars in Veh. 2 Type = 80.9%

Therefore significantly more cars have to take avoiding action than cause other vehicles to take such action.

b) Light goods vehicles

$$Z = \frac{|0.102 - 0.084|}{\sqrt{\frac{0.102 \times 0.898}{13096} + \frac{0.084 \times 0.916}{13096}}}$$

$p_1 = 0.102$ $p_2 = 0.084$

$q_1 = 0.898$ $q_2 = 0.916$

$n_1 = 13096$ $n_2 = 13096$

$$= \frac{0.018}{\sqrt{\frac{0.0916}{13096} \div \frac{0.0769}{13096}}} = \frac{0.018}{\sqrt{\frac{0.1685}{13096}}} = \frac{0.018}{\sqrt{0.000012}} = \frac{0.018}{0.0035}$$

$= 5.14$

<u>Z = 5.14</u> is significant at the <u>0.01 level</u>

% of L.G.V. in Veh. 1 Type = 10.2% % of L.G.V. in Veh. 2 Type = 8.4%

Therefore significantly more light goods vehicles cause others to take avoiding action than have to take such action themselves.

c) Heavy goods vehicles

$$Z = \frac{|0.085 - 0.056|}{\sqrt{\frac{0.085 \times 0.915}{13096} + \frac{0.056 \times 0.944}{13096}}}$$

$p_1 = 0.085$ $\quad p_2 = 0.056$

$q_1 = 0.915$ $\quad q_2 = 0.944$

$n_1 = 13096$ $\quad n_1 = 13096$

$$= \frac{0.029}{\sqrt{\frac{0.0778}{13096} + \frac{0.0529}{13096}}} = \frac{0.029}{\sqrt{\frac{0.1307}{13096}}} = \frac{0.029}{\sqrt{0.000009}} = \frac{0.029}{0.003}$$

$$= \underline{9.67}$$

Z = 9.67 is significant at the 0.01 level

% of H.G.V. in Veh. 1 Type = 8.5% % of H.G.V. in Veh. 2 Type = 5.6%

Therefore significantly more heavy goods vehicles cause conflicts than have to take avoiding action.

c) Motorcycles

$$Z = \frac{0.01 - 0.018}{\sqrt{\frac{0.01 \times 0.99}{13096} + \frac{0.018 \times 0.982}{13096}}}$$

$p_1 = 0.01$ $\quad p_2 = 0.018$

$q_1 = 0.99$ $\quad q_2 = 0.982$

$n_1 = 13096$ $\quad n_2 = 13096$

$$= \frac{0.008}{\sqrt{\frac{0.0099}{13096} + \frac{0.0177}{13096}}} = \frac{0.008}{\sqrt{\frac{0.0276}{13096}}} = \frac{0.008}{\sqrt{0.000002}} = \frac{0.008}{0.0014}$$

$$= \underline{5.71}$$

Z = 5.71 is significant at the 0.01 level

% of M/C in Veh. 1 Type = 1.0% % of M/C in Veh. 2 Type = 1.8%

Therefore significantly more motor cycles have to take avoiding action than cause other vehicles to take such action.

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