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PROCEEDINGS OF THE SECOND INTERNATIONAL
TRAFFIC CONFLICTS TECHNIQUE WORKSHOP

MAY 1979

edited by

S J Older and J Shippey

Any views expressed in this Report are not necessarily those of the
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1. FOREWORD

The purpose of the Second International Traffic Conflicts Technique Workshop was to up date and extend the valuable exchange of information on the use of the traffic conflicts technique which resulted from the First Workshop held in Oslo in September 1977. Apart from assembling information on the many developments made by the various research groups working with the technique more specific themes of the discussions were the identification of advantages and disadvantages of the different existing operational procedures.

These Proceedings have the same format as the Workshop; Section 2 gives the Workshop programme, Section 3 includes the general papers presented in Session 2 while Sections 4 to 7 give the introductory papers for, and the reports on, the discussion Sessions 3 to 6. An overview and summing up, of the Workshop are given in Section 8. A list of participants in the Workshop is given in Section 9 at the end of the Proceedings.

The Workshop was sponsored and organised by the Transport and Road Research Laboratory of the United Kingdom and was held in Paris on May 10, 11 and 12 1979.

Variations in format between the papers reproduced in these proceedings will be noted. These are due to the original papers having been copied photographically to reduce publication costs.

2. PROGRAMME OF WORKSHOP

2ND INTERNATIONAL TRAFFIC CONFLICTS TECHNIQUE WORKSHOP

Held on 10, 11, 12 May 1979

at OECD Development Centre
94 rue Chardon-Lagache
Paris 16

Chairman Mr S J Older, TRRL, U K

Thursday, 10 May	Session 1	<u>Welcome and opening remarks</u> Objectives and organisation of workshop.
	Session 2	<u>Presentations</u> Short presentations of papers prepared for the Workshop by delegates (discussion at later sessions where relevant)
	Session 3	<u>Observation and recording methods</u> Introducer J Shippey, U K Reporter U Engel, Denmark To include discussion of working definitions; classifications by severity and/or manoeuvre; situations in which technique is used; purpose of use (operational or research); recording aids (cine film etc.)

Friday, 11 May

Session 4

Methodological assessment of techniques

Introducer E Hauer, Canada

Reporter S Oppe, Netherlands

To include discussion of studies made, or needed, of variability, validity and repeatability, reliability of observers and the implications for study design consideration.

Session 5

Training conflict observers

Introducer A Lightburn, U K

Reporter Chr Hyden, Sweden

To include discussion of methods in use or under development for training observers in the assessment of traffic conflicts, and the factors that need to be considered in doing this.

Session 6

Comparative studies of different techniques

Introducer N Muhlrads, France

Reporter W Baker, U S A

To include discussion of the results from the study made by five different national research groups in Rouen and other studies directly comparing different methods.

Saturday, 12 May

Session 7

Summing up and conclusion

Presentation of reports on sessions 3 to 6 by the reporters for those sessions.

Discussions based on the presentations.

Summing up of the findings of the Workshop by M R C McDowell, U K

Closing remarks.

Accident Surrogates For Use In Analyzing
Highway Safety Hazards

By

Tapan K. Datta
Goodell-Grivas, Inc.
Southfield, Michigan
U.S.A.

Introduction

Highway accident statistics indicate that the annual number and rate of fatal accidents has declined to the lowest levels since the early 1960's in U.S. This, along with the fact that annual vehicle-miles of travel have generally increased throughout the same period, gives an indication that positive gains are being achieved from recent highway safety efforts. In general, programs aimed at improving the safety condition of the highway, the vehicle and the driver are responsible for the increase in highway safety.

Highway Safety programs administered by the U.S. Federal Highway Administration (FHWA) are aimed at reducing traffic accident fatalities, injuries and property damages attributable to highway system failures as opposed to those attributed to vehicle or driver failures.

The establishment of an improvement project for highway safety purposes must follow a systematic procedure to identify the safety deficiency, develop and implement a solution and monitor the effectiveness of the implemented solutions. The overall "Process for Safety Improvements" consists of three basic elements.

1. Planning Procedures
2. Development and Implementation Procedure
3. Evaluation and Reporting Procedures

Planning procedures include the identification of hazardous locations. The identification of hazardous locations should be based on analysis of data related to system-wide accidents, hazard potential, geometrics, roadway environment and traffic control devices. Those locations which exhibit abnormal accident experience become candidate locations for future highway safety improvements. Once locations have been identified and prioritized for improvement, each must be examined to determine the most probable accident causes. These factors provide direct input to project development and implementation procedures. Most of the identification and prioritization schemes currently in use are based on historical accident records. While these techniques are widely used, the limitations of accident data (accidents are a rare event and it is almost universally accepted that a significant percentage of total accidents at a location generally are not reported in most communities) often introduces error and may result in suboptimal decisions.

The second element of the highway safety process involves selecting specific countermeasures to remedy locational deficiencies. If more than one improvement or countermeasure is feasible as a remedial measure, a pre-implementation evaluation may be required. This involves a comparison of the expected hazard reduction from alternative countermeasures. Those countermeasures which yield the maximum expected benefit (accident reduction and operational improvement) and which are most cost-effective are selected for implementation.

Evaluation and reporting procedures are performed to provide the entire highway safety process with quantifiable evidence of the effectiveness of implemented projects. First, the evaluation information facilitates decisions in planning procedures and data analysis by providing the analyst with the types of data which are most indicative of specific types

of deficiencies, thereby making future identification of hazardous locations more efficient. Secondly, the evaluation provides direct input to project development activities. This is done by allowing the analyst to specify those projects and countermeasures which maximize the reduction of hazards while avoiding projects with marginal effectiveness.

The dependence of the entire highway safety improvement process solely on accidents, as is currently being practiced, is somewhat questionable when we consider the limitations of accident data. Researchers have long realized such limitations, and have worked on the premise that the identification of hazardous locations, review of planned improvements and evaluation of completed safety improvements should consider measures other than just accidents. The need for such an approach is particularly important for:

- . Identification of hazardous locations on low-volume highways where the frequency of accident occurrences per year is very low.
- . Assessment of safety improvement plans (design plans) in terms of potential benefits.
- . Evaluation of completed highway safety improvements. Some safety engineers strongly believe that it is unreasonable to wait a long time (e.g., three years) to find out whether or not a safety improvement worked.

Thus, the deficiencies in the use of only accident data in the highway safety improvement process, are obvious and require further study and research. While considerable research has been expended in establishing relationships between accidents and various highway and operational characteristics on a piece-meal basis, it is essential that further research be directed toward identifying measures (highway and operational characteristics) other than accidents, which can be used in the overall highway safety

improvement process. The basic goal of the project, entitled "Accident Surrogates for Use in Analyzing Highway Safety Hazards", is to address a series of questions relative to the above problem. The specific questions may include but not be limited to:

- . What are the highway, operational and accident characteristics which describe the hazardousness of specific highway situations?
- . Do the surrogate measures selected on the basis of past research studies, exhibit sensitivity with accident history?
- . Do safety improvements at a location change the accident characteristics as well as the surrogate measures?
- . Can a set of methodologies using surrogate measures be developed for:
 - Identification and prioritization of hazardous locations?
 - Evaluation of completed highway improvement projects?
 - Assessment of effectiveness of design plans and specifications?

This paper presents an outline of the study approach, results of up-to-date progress and planned future direction.

Background

A large number of past studies have attempted to determine the relationship between geometric elements and highway safety in recent years. In fact, one publication alone summarizes 150 such studies conducted since 1953 (Traffic Control and Roadway Elements, Chapter 7, 1970). The basic premise in these studies is that accident occurrence generally decreases with the utilization of optimum design standards. Thus, it is assumed that geometric elements play an important role in assessing highway safety, and therefore, can be utilized in the assessment of accident potential.

One problem encountered in several of these studies is the inability to establish a specific relationship between accident occurrence and a particular geometric variable or combination of these variables. For example, Raff¹ (1973) states in his conclusions that:

"The most striking feature of this study is the amount of irregularity in most of the results. Few of the data which have been presented in tables and graphs can be fitted by really smooth curves. There is considerable scatter about the overall trends, and it is quite likely that some subtle relationships have been masked by these irregularities.¹"

Another problem can be observed from the inconsistencies of research results. For example, Raff¹ concluded that pavement width and shoulder width were somewhat related to accident rates at horizontal curves. He also concluded that shoulder width did not correlate consistently with accident rates. Whereas, Billion & Stohner² concluded in a study, that roads when classified by grades, curvature and level tangent sections, indicated lower accident rates for highways with wider shoulders.

Studies of the relationship between traffic operations measures and accident occurrence appearing in the literature are fewer in number than those studies dealing with geometric elements. Nevertheless, there does exist a substantial number of these studies. Operational measures appearing in the literature range from stream characteristics such as average daily traffic (probably the most popular), speed characteristics, volume/capacity ratio, and measures of driver behavior such as traffic conflicts and erratic maneuvers.

Close examination of several of the studies of the operational measures indicate that inconsistencies also exist as in the case of the geometric studies. For example, analysis of several of the more recent traffic conflicts studies point out some very marked differences of opinion re-

1. Raff, M.S., "Interstate Highway - Accident Study," Highway Research Board Bulletin 74, 1953.
2. Billion, C.E. and Stohner, "A Detailed Study of Accidents as Related to Highway Shoulders in New York State," Proceedings of the Highway Research Board, 1957.

garding the validity of this indicator as a basis for predicting accident potential.

Study Approach

The research study has been broken down to the following specific tasks:

Literature Review

The purpose of this task is to perform a review of current and past studies, published papers and reports which investigated the relationships between elements of the traffic system (the roadway, the driver and the vehicle) and accident factors, which have proven relationships to accident occurrences. Due to the intended scope of this research project, primary emphasis will be placed upon investigation of pertinent prior efforts which:

- . Establish a relationship between some measure or combination of measures, of accident experience and geometric elements and/or major traffic operations measures.
- . Identify methodologies for assessing the effectiveness of various safety improvements.
- . Identify measures or "checks" which can be used in the design phase to identify possible safety deficiencies.

Identify relationship between highway features/operating characteristics and accidents

The purposes of this research task is to:

- . Describe theoretical relationships between highway design and operating characteristics and the probability of an accident occurring

or of increasing the severity of an accident.

- . Identify surrogates for accident experience consistent with the defined relationships.
- . Evaluate surrogates on a number of pragmatic criteria and select those most promising for use in highway safety studies.

Testing selected surrogate measures

Tests will be conducted to determine whether the surrogate measures identified in the previous task are statistically related to accidents prior to the development of the study methodologies.

One of the purposes of this task is to evaluate the relationship between accident measures and values of the surrogate measures identified earlier.

Another purpose of this part of the project is to determine whether a change in the surrogate measure is accompanied by a change in the accident experience at highway locations where a safety improvement(s) have been made.

Develop methodology for using surrogate measures in safety analysis

This task will develop three methodologies for using surrogate measures which are indicators of accident experience for the following type of analyses:

- . Identification and prioritization of hazardous locations
- . Evaluation of completed safety countermeasures
- . Safety analyses of highway construction plans

Test and refine surrogates and methodologies

The purpose of this task is to test the three methodologies developed previously using actual data under real-world situations and modify and refine the methodologies wherever warranted.

Study Results

The project is only about 30% complete and as such no conclusive statements can be made as yet regarding the results of this study. The discussion in this section will be limited to the research tasks which have been fully and/or partially completed to date.

The review of the state-of-the-art and the experience of the project team has been utilized to develop a comprehensive list of the factors which have been found related to accident rates in the past. From this list of factors, which included both geometric as well as operational, an analysis was performed to determine a candidate list of factors to be considered in this study. It is important to point out that, this study did not attempt to develop a set of surrogates which are universally applicable to all situations. As such, a very specific set of situations were selected to be included in this study. 28 specific situations were selected as candidates for this particular study. They have been presented in Table 1. For each of these situations, an analysis was performed to find out which factors, both geometric as well as operational, have been related to or construed to be related to accident rates in the past. From this list of factors, it was obvious that it is not possible to pare it down to a manageable number of factors which can be used in performing further analysis. As such, five different safety indices under which all of these factors can be categorized were defined. These are; information index, human factors index, vehicle control index, congestion index and recovery index. The indices were defined as follows:

Information Index

This index will be a measure of the information system deficiencies which detract from the drivers ability to select a safe speed and path as roadway conditions change. The absence of lane markings and inadequate advance

TABLE 1 - Candidate Situations

<div>Situation</div> <div>Category</div>	Intersection Related	Roadway Section	Others
Urban	<ul style="list-style-type: none"> - Urban Signalized Intersection - Urban Unsignalized Intersection - Pedestrian-Highway Grade Crossing 	<ul style="list-style-type: none"> - Urban Undivided Tangent Section - Urban Divided Tangent Section - Urban Undivided Winding Section - Urban Divided Winding Section - Continuous Two-Way Left Turn Lane 	
Rural	<ul style="list-style-type: none"> - Rural Signalized Intersection - Rural Unsignalized Intersection 	<ul style="list-style-type: none"> - Rural Undivided Tangent Section - Rural Divided Tangent Section - Rural Undivided Winding Section - Rural Isolated Horizontal Curve 	
General			<ul style="list-style-type: none"> - Long Downgrades - Long Upgrades - Exit Gore Area - Merge Area - Weaving Area - Tunnel - Narrow Bridges - Bridges - Rail-Highway Grade Crossing - Toll Booth

warning signs are examples of factors that would contribute to a high information index.

Human Factors Index

This index will be a measure of the factors that increase the probability that a driver will enter a situation requiring evasive actions which exceed the man-machine response capabilities. A sharp horizontal curve following the crest of a vertical curve is an example of a factor that would contribute to a high human factor index.

Vehicle Control Index

This index will be a measure of the geometric and environmental characteristics which constrain the driver's ability to maintain control of the vehicle in a traffic stream. Inadequate sight distance and icy pavements are examples of factors that would contribute to a high vehicle control index.

Congestion Index

This index will be a measure of the operational characteristics which constrain the driver's ability to avoid an accident through a controlled vehicle maneuver. Congested flow and excessive number of driveways and parked vehicles along a roadway are examples which would contribute to a high congestion index.

Recovery Index

This index will be a measure of the roadway and roadside characteristics which inhibit the driver's ability to avoid an accident or to reduce the severity of an accident resulting from partial or total loss of vehicle control. Narrow shoulders and roadside objects are examples of factors which would contribute to a high recovery index.

The relationship of these indices can be described with the help of Figure 1. The information system provides data to allow the driver to select both the proper speed and path to negotiate a specific set of highway situations. A proper information system results in the driver identifying conditions on the roadway similar to the actual physical conditions. Similarly, a deficiency in the human factor index may result in drivers confronting a situation, to which they may not be capable of responding. When both of these indices are appropriate, the accident potential is minimized.

Individual vehicle control and traffic congestion may result in either a non-accident or an accident situation. The factors in these two indices with certain values determine whether a specific automobile on a roadway will end up in an accident situation or not. Once a situation occurs that vehicle control is lost or congestion characteristics become such that the vehicle approaches an accident, the driver may or may not be able to avoid the accident. The values of the factors under the recovery index represent the motorists' ability to steer the car back into control and/or reduce the severity of a crash.

Within each of the indices, the general category of factors were outlined for specific situations. It was observed that it is necessary to have these general category factors prioritized and also the individual indices prioritized for each specific situation because no consensus could be found directly from the literature. It was decided that a group of experts from across the nation would be selected to conduct a workshop to identify those factors and those groupings of highest importance for each specific situation. A workshop was conducted in the form of modified Delphi session to achieve this objective. The results of this workshop session assisted in identification of specific indices which are more significant and more

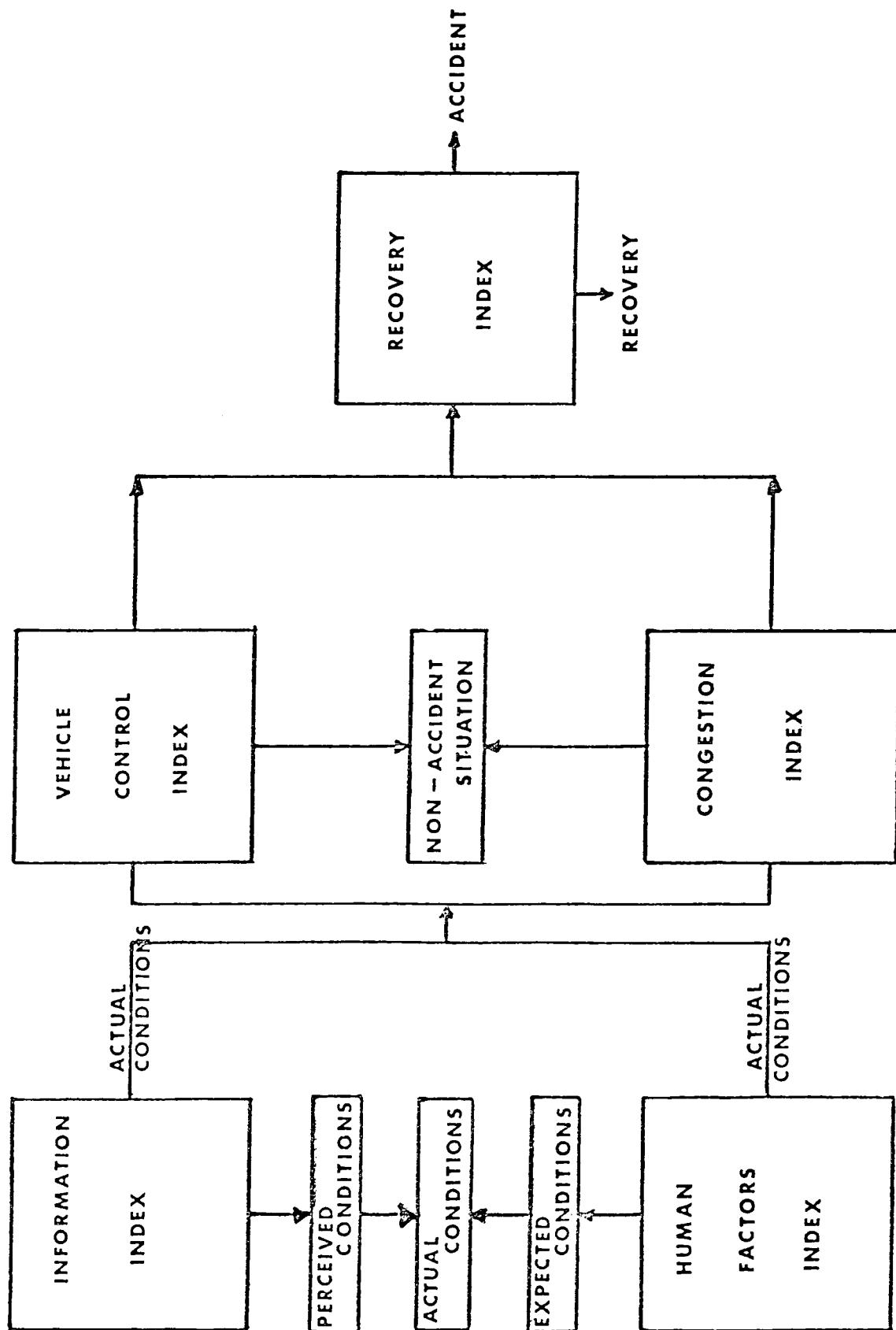


Figure 1

important for a specific situation and also within each indices the specific factors which are of more importance than the others.

The workshop session included participants ranking: 1) the situations which have most potential for analysis using surrogate measures, 2) the indices for each situation, and 3) factor groupings within each index for specific situations. A sample factor ranking form for urban signalized intersection (Figure 2) indicates how the factor groupings with influencing factors within parenthesis have been categorized under each safety index.

After the situations were identified by the workshop participants, an analysis was performed, identifying the type of most frequent accident for each particular situation and then searching through the literature as well as the experience of the research team to identify the probable causes of those accidents. These probable causes lead to the identification of the factors which had been identified through the workshop session as well as the state-of-the-arts review. Finally, these factors either singly or in combination with other factors, were identified as surrogate measures which can be used in highway safety analysis. It is important to point out that, all types of situations and surrogate measures are not amenable for all three types of analysis process (identification of hazardous location, review of the design plan, evaluation of safety improvements). A preliminary list of some operational measures which will finally be developed in the form of surrogate measures after adequate testing has been presented in Table 2. The next step of the study involves finalizing the list of surrogate measures and then performing analysis to relate measures to accident rates. The data base, which is planned for use includes 9,000 miles of highway network in the State of Michigan. Several sites will be selected for each of these situations to relate accident experience to the measures which have been identified through this study. Two types of statistical

RANKING FORM

Instructions: Under each index, rank order the list of categories according to the relative importance of the category in characterizing the degree of hazard for the situation listed below. The types of similar geometric, operational, traffic control and environmental factors which typically makeup each category are also provided in parenthesis for your reference. A ranking of one (1) indicates that the category and its factors are most important. Rank the remaining categories in descending order of importance.

Situation: URBAN UNSIGNALIZED INTERSECTION

INFORMATION INDEX	HUMAN FACTOR INDEX	VEHICLE CONTROL INDEX	CONGESTION INDEX	RECOVERY INDEX
— Pavement Marking (Channelization, Lane Lines, Marking Visibility)	— Distractions (Visual Clutter)	— Laneage (Left-Turn Lane, Right-Turn Lane)	— Traffic (Traffic Volume, V/C Ratio, Peak Hour Factor, Available Gaps, Traffic Mix)	— Vehicle Speed
— Signing (Street Name Signs)	— Channelization (Unexpected Lane Assignment)	— Sight Distance (Stopping Sight Distance, Cross Traffic Sight Distance)	— Control (Intersection Control, Pedestrian Control, Parking Regulation)	— Skid Resistance
— Control (Pedestrian Control, Parking Regulations)	— % Non-Local Traffic	— Weather (Amount of Rain/Fog, Amount of Snow/Ice)	— Bus Stop Location	— Geometrics (Number of Lanes, Curb and Gutter)
	— Sight Distance	— Curb Radius	— Side Friction (Parking Turn-Over Rate, Pedestrian Volumes)	— On-Street Parking
		— Skid Resistance	— Land Use	
		— Demographic Characteristics (Population)		
		— On-Street Parking		

Figure 2

TABLE 2 - Preliminary List of
Surrogate Measures (Operational Type)

Situations	Surrogate Measures
Exit Gore	Erratic maneuver, Mean speed of exiting vehicles at gore, Information system deficiency rating, Tire marks at gore, Crash barrier hits or dents
Narrow Bridge	Driver expectancy, Guardrail or bridgerail dents or marks, Physical evidence of encroachment, Information system deficiency
Rural Un-divided Winding Section	Shoulder encroachment (physical evidence), Number of speed change cycles
Urban Un-divided Tangent Section	Curb cut related conflict rates per mile
Urban Un-signalized Section	Cross traffic conflict, Critical speed, Gap distribution
Lane Drops	Information system deficiency, Driver expectancy, Average speed differential, Erratic maneuvers (run-on-shoulder, sudden lane change, sudden braking), Merge conflict, Physical evidence of driver error
Rural Iso-lated Horizontal Curve	Information system deficiency, Driver expectancy, Average speed differential, Erratic maneuver, Physical evidence of driver error
Rural Signalized Intersection	Traffic conflict, Mean approach speed, Information system deficiency, Measure of traffic volume

TABLE 2 - Preliminary List of
Surrogate Measures (Operational Type)
 (con't.)

Situations	Surrogate Measures
Rural Un-divided Tangent Section	Physical evidence of encroachment
Rural Un-signalized Intersection	Cross traffic conflict, Ratio of mean speed over critical speed, Other types of conflicts, measure of traffic volume

tests will be performed. The first test will consist of comparison of paired groups of sites which are similar except for differences in one selected surrogate measure. The study will also include performing regression analysis to relate specific surrogate measures with accident rates.

Conclusions

Since the study is only partially complete, it is not possible to make any specific conclusions, however, the following generalized conclusions can be drawn from the progress of this study.

1. Though there is evidence of inconsistencies amongst various research studies, it is also clear that certain geometric and other operational characteristics of highway traffic have a good possibility of correlating with certain types of accident or severity of accidents.
2. It can also be concluded that it is possible to identify specific set of factors which constitute the most probable cause of certain types of accidents at specific situations.
3. The use of modified delphi techniques utilizing a team of professionals, experienced in the highway traffic safety area in the workshop session, did provide a significant input to the study by identification of the various factors.

3.2 RISK EXPOSURE

A structure of needs of risk exposures for road accident analysis
by

Goran Nilsson

National Swedish Road and Traffic Research Institute

ABSTRACT

In the continuous R&D work, carried out at the National Swedish Road and Traffic Research Institute, different measurements for road accidents are tested in order to find measurements to be used in different decision procedures, intended to result in measures. The first requirement is that the accident measurements shall allow relevant comparisons between different groups of road-users and/or different road and traffic conditions.

When developing accident measurements it is essential to define and to deduce traffic measurements, that show strong correlations with the number of accidents. These traffic measurements are called risk exposures.

Editors note: The full report, number 144A, 1978, can be obtained from the National Swedish Road & Traffic Research Institute, Fack S-58101 Linköping, Sweden.

3.3 A QUANTITATIVE DEFINITION OF THE NEAR-ACCIDENT CONCEPT

by

D. Balasha, A.S. Hakkert, M. Livneh,
Transportation Research Institute,
Technion-Israel Institute of Technology.

INTRODUCTION

This paper is a continuation to the report prepared for the first workshop on traffic conflicts, held at Oslo, (Hakkert, Balasha, Livneh & Prashker, 1977). In the first report, the main features of the models developed were described and some of the early results were presented and discussed. At this time, the study has been completed. The main results will be presented and evaluated, and the complete method will be described.

For reasons of clarity, some parts of the first paper, mainly those concerned with definitions and with the theoretical basis, have been repeated in this paper.

THE THEORETICAL MODEL

In analogy to car-following models describing the motions of following vehicles in a traffic stream, an attempt was made to define the motions of two vehicles following each other through an intersection. Development of such a model could possibly lead to the detection of unusual events, assessment of the difficulty of various vehicle manoeuvres, and to the possible identification of those locations at an intersection where difficulties in manoeuvring are encountered.

The reactions and manoeuvres of vehicles on the approach to an intersection were studied. Manoeuvres were recorded continuously, so that a microscopic model of the traffic flow could be defined in the following way :

$$\text{reaction} = \text{stimulus} \times \text{sensitivity}$$

Most car-following models of this kind, as summarized by Herman (1966), deal with single lane traffic on an undisturbed straight section of highway, and define the reaction as a change in tangential velocity. The present model, however, extends the definition of reaction in order to handle interactions of pairs of vehicles on the approach to and through an intersection. For such cases, two dimensions of motion must be considered, and all terms of the model-reaction, stimulus and sensitivity, are defined accordingly. Two groups of variables are defined, one dealing with motion along the axis of travel, and the other dealing with angular motion, i.e. changes in direction of travel.

The resultant reaction is accordingly composed of a term of change in velocity - Δs and change in direction - $\Delta \theta$, and taking into account the time element, the two parts of reaction become :

$$\bar{a}_T = \frac{\Delta s}{\Delta t} = \text{change in tangential velocity}$$

$$\bar{a}_R = \omega s = \text{change in radial velocity}$$

where :

s = tangential velocity

ω = radial velocity

Δs = velocity change

Δt = time interval

The resultant reaction a_e is defined as :

$$a_e = \sqrt{a_T^2 + a_R^2} \quad (1)$$

In treating the motion of a pair of vehicles on the approach to an intersection, the stimulus and sensitivity have to be defined in terms of the various components of their motion for each manoeuvre and activity. These terms are determined for a pair of vehicles travelling straight through the intersection :

for stimulus : $s_{n+1} - s_n$; $\omega_{n+1} - \omega_n$

for sensitivity : $\lambda_{o1} (x_{n+1} - x_n)^{-1}$; $\lambda_{o2} (\theta_{n+1} - \theta_n)$

where :

n - leading vehicle
n+1 - following vehicle
s - velocity
 ω - radial velocity
x - location
 θ - angle
 $\lambda_{o1}, \lambda_{o2}$ - parameters of sensitivity

It becomes necessary to classify the various activities at an intersection according to the type of disturbance they create. Any situation that is different from the normal flow of travel is termed a disturbance and is defined in terms of stimulus and sensitivity. Table 1 summarizes the various definitions proposed. The present study deals extensively with two types of manoeuvres only; type 1 - following vehicles and type 3 - turning vehicles. It would be possible to extend and continue this line of research in developing and calibrating models for the other types of disturbances.

The suggested form of the complete expression for the motion of two following vehicles becomes :

$$(a_e)_{n+1} = \lambda_{oo} + \lambda_{o1} (x_{n+1} - x_n)^{-1} (s_{n+1} - s_n) + \lambda_{o2} (\theta_{n+1} - \theta_n) (\omega_{n+1} - \omega_n) \quad (2)$$

Table 1 : Proposed stimulus and sensitivity terms for various traffic conditions

Sensitivity	Stimulus	Description of disturbance	Flow condition	Type
$\lambda_{o1} (X_{n+1} - X_n)^{-1}$	$S_{n+1} - S_n$	following vehicle disturbed by first vehicle going straight ahead.	Platoon disturbance	1
$\lambda_{o2} (\theta_{n+1} - \theta_n)$	$\omega_{n+1} - \omega_n$			
$\lambda_{o1} (X_n - X_S)^{-1}$	$(y_n - y_S)^{-1}$	Parked vehicle disturbs vehicle going straight ahead	Parked car disturbance	2
$\lambda_{o1} (X_{n+1} - X_n)^{-1}$	$S_{n+1} - S_n$	Following vehicle disturbed by first vehicle turning left or right	Turning vehicle disturbance	3
$\lambda_{o2} (\theta_{n+1} - \theta_n)$	$\omega_{n+1} - \omega_n$			
$\lambda_{o1} (X_n - X_S)^{-1}$	$(y_n - y_S)^{-1}$	Vehicle on major road disturbed by waiting vehicle on minor road	Minor road-waiting vehicle disturbance	4
$\lambda_{o1} (X_n - X_S)^{-1}$	$(y_n - y_S)^{-1}$	Vehicle on major road disturbed by vehicle exiting from minor road	Minor road emerging vehicle disturbance	5
$\lambda_{o2} (\theta_n - \theta_S)$	$\omega_n - \omega_S$			
$\lambda_{o1} (X_n - X_p)^{-1}$	$(y_n - y_p)^{-1}$	Pedestrian crossing the road disturbs vehicle's flow	Pedestrian disturbance	6

distance between vehicle & vehicle on side road	$(X_n - X_S)$	Constants	$\lambda_{o2} \lambda_{o1}$
lateral distance between vehicle & vehicle on side road	$(y_n - y_S)$	headway between follower & leader	$(X_{n+1} - X_n)$
angular difference between vehicle & vehicle on side road	$(\theta_n - \theta_S)$	angular difference between two vehicles	$(\theta_{n+1} - \theta_n)$
angular velocity difference between vehicle & vehicle on side road	$(\omega_n - \omega_S)$	velocity difference between two vehicles	$(S_{n+1} - S_n)$
distance between vehicle and pedestrian	$(X_n - X_p)$	angular velocity difference between two vehicles	$(\omega_{n+1} - \omega_n)$
lateral distance between vehicle and pedestrian	$(y_n - y_p)$		

Most car-following models do not contain a free term like λ_{oo} . However, as there are possibly many other factors determining the following vehicle's behaviour, such a term may not be unreasonable. The term has considerable significance in this study because the free term will be used in the determination of irregular or exceptional events. This term expresses the unexplained fluctuations in the motion of a pair of vehicles. Therefore, any reaction which exceeds the value of the free term in our model may be termed an exceptional manoeuvre. Such a reaction, caused in some way by the stimulus, may be the unusual event, the 'near accident' creating the deficiencies in the traffic and safety situation one is trying to isolate and study.

DEFINITION OF AN IRREGULARITY AND A NEAR ACCIDENT

It now becomes necessary to make a clear distinction between the flow of normal events, as predicted by the flow equation and the irregular events or near accidents. In many conflict studies, this distinction is based on observer evaluation, but in this study, it is attempted to introduce a quantifiable definition, which is to a large extent objective.

The definitions will be based on a number of assumptions :

1. Under undisturbed travel conditions, the values of the terms explained in the flow equation are equal to zero.
2. Other unexplained terms exist, whose value in the flow equation is λ_{oo} .
3. λ_{oo} is the average of λ_{ooi} for individual pairs of vehicles, and can be regarded as the average value for a certain type of manoeuvre.
4. Under normal flow conditions, the reaction equals the unexplained term λ_{oo} .

5. As reference value for the unexplained term - $\bar{\lambda}_{oo}$ will be taken.
6. An irregular event will be defined where the resultant deceleration exceeds $\bar{\lambda}_{oo}$ plus some "safety" margin.
7. The "safety" margin will be based on the standard deviation of λ_{oo} .

An irregular resultant velocity change will therefore be :

$$|(a_e)_L| > \bar{\lambda}_{oo} + K\sigma \quad (3)$$

where :

$(a_e)_L$ - critical value of resultant velocity change.

K - number of standard deviations.

$\bar{\lambda}_{oo}$ - average of free terms in equations of pairs of following vehicles (absolute values).

σ - standard deviation of free terms.

As the reaction in dangerous situations is generally in terms of deceleration, equation 3 can be written :

$$(-a_e)_L > \bar{\lambda}_{oo} + K\sigma \quad (4)$$

In order to bring out those events that continue over a period of time, a further definition will be introduced that is based on the sum of decelerations. A certain critical sum value will be determined for vehicles involved in irregularities, which, when exceeded, will be termed a 'near accident'.

$$-\sum_1^F a_e > (-\sum a_e)_L \quad (5)$$

where :

$-a_e > (-a_e)_L$ for each film frame

$(-\sum a_e)_L$ - sum critical value of decelerations

On the basis of these criteria, determined for each intersection, 'near accidents' will be selected; their exact location within the intersection will be identified, and possible explanations will be discussed.

STUDY METHOD

This section will be very brief, since most details have been presented in the paper presented to the previous workshop.

Two urban intersections were filmed, using a Bolex H16 16 mm. film camera at a rate of 24 fps. The intersection area and the approach were marked with an orthogonal grid of 1 x 1 m. stripes. The film was analyzed using a Hadland Vanguard film analyzer, and in order to translate the film perspective to real coordinates, a polynomial regression of the coordinates was undertaken.

For each individual vehicle, the following values were calculated : tangential velocity and velocity change, vehicle angle, angular velocity and velocity change, resultant velocity change.

For each pair of vehicles, a flow equation was calculated by means of regression analysis. Because of the delay between stimulus and reaction, various reaction times were assumed, and for each vehicle pair that equation was chosen which produced the highest correlation coefficient.

Two urban unsignalized intersections were selected, having fairly similar and intermediate traffic flows. Each had a major road of 11 - 12 metre width. One, an intersection on Herzl street in Tel Aviv, was an X-type crossroad. It had had 24 injury accidents in four years, had unmarked lanes, no pedestrian crossings, and a limited field of vision. It will be termed intersection A in this paper. The second intersection, on Modiin street in Ramat Gan, intersection B, was of a T-type with only 9 injury accidents in four years, well marked, with zebra crossings and a clear field of vision. About 139 vehicles were filmed on intersection A and about 208 vehicles on intersection B, resulting in the analysis of some 60,000 film frames.

RESULTS

For each pair of vehicles travelling through each of the two intersections, motion equations were computed. For each of the two manoeuvres, travelling straight through the intersection - type 1 and turning into the side road - type 3, a general motion equation was calculated of the form

$$\bar{a} = \lambda_{00} + \lambda_{01} \Delta s / H_d + \lambda_{02} \Delta \theta \Delta \omega \quad (6)$$

where :

$$\Delta s = s_{n+1} - s_n \quad ; \quad H_d = x_{n+1} - x_n$$

$$\Delta \theta = \theta_{n+1} - \theta_n \quad ; \quad \Delta \omega = \omega_{n+1} - \omega_n$$

Results are presented in Table 2.

Table 2: Coefficients of motion equations at two intersections studied.

Values of coefficients	Intersection A		Intersection B	
	type 1 - straight ahead	type 3 - turning veh.	type 1 - straight ahead	type 3 - turning veh.
$\bar{\lambda}_{oo}$	0.2116	0.2352	0.0961	0.7906
$\bar{\lambda}_{o1}$	6.2538	5.6845	3.5867	0.0830
$\bar{\lambda}_{o2}$	0.0034	- 0.0025	0.0189	- 0.0016
r	0.87	0.82	0.72	0.59
stand.error S.E.	0.41	0.61	0.22	0.33
no.of data points n.	3015	654	1479	550

For the type 1 manoeuvre, i.e. vehicles travelling straight ahead through the intersection, the values of the free coefficient λ_{oo} and the coefficient of the tangential motion are about twice as high for intersection A as those for intersection B. This must be the result of much more manoeuvring at that intersection, which, as may be remembered, was a cross-road with much more disorder and accidents. The coefficient for the directional motion is much lower in both cases, but was higher at intersection B. This may be a result of the higher approach speeds at that intersection or a result of differences in geometry.

The equations for the type 3 manoeuvres - turning vehicles show some similarity with the type 1 manoeuvre for the free coefficient and the coefficient for tangential motion, but the coefficients for the directional motion are negative for each intersection. This means that an increase in stimulus leads to a decreased reaction. This seems natural, since for turning vehicles a change in direction does not normally necessitate a large reaction.

Analysis of the individual motion equations for vehicles travelling straight ahead revealed that their correlation coefficients were all above 0.7 with a S.E. lower than 0.1 for 80 - 90 percent of the pairs. The tangential term was statistically significant in 90 percent of the equations and the directional term in 80 percent (at the 5 percent level). This proves that both terms are significant and provide a contribution to the explained deceleration. The free term - λ_{00} was different from zero in 88 percent of the cases (at a significance level of 10 percent). The equation of motion was selected in order to give the highest correlation assuming a series of reaction times. The average reaction time was found to be 1.07 seconds with a standard deviation of 0.63 seconds.

THE IRREGULAR EVENT AND THE NEAR-ACCIDENT

On the basis of eq. 4, and assuming a value of $K = 2$, i.e. two standard deviations, the various critical values of resultant deceleration $(a_e)_L$ were calculated. They were 1.63 m/sec.^2 for intersection A and 1.26 for intersection B. These are the limiting values indicating an irregular event and will be studied further. It cannot be said that these values all indicate an emergency or dangerous manoeuvre, but they define the border between usual and unusual or irregular events. According to these values it is now possible to identify vehicles which exceeded these values of resultant deceleration, and it may be said that these are

vehicles associated with some deficiency in the traffic or safety situation. The following table presents the number and percentage of such vehicles.

Table 3: Number and percentage of vehicles exceeding critical value

	Intersection A	Intersection B
Total vehicles observed	139	208
Exceeding critical value	103	74
Percentage exceeding	74.1	35.6

The percentage of vehicles involved is large, particularly at intersection A. It should be emphasized that all vehicles which produced a value exceeding the critical value (even in one frame only), are here included.

A further distinction will now be made, based on eq. 5, selecting those vehicles which contributed to the resultant deceleration both in value and in duration. The further separation was done with the aid of the graphs in Figure 1, on which the absolute cumulative frequency of resultant deceleration is plotted for each intersection. The decision on some critical value - L_2 - resulted in the exclusion of those many vehicles which contributed relatively little to the resultant deceleration. L_2 was chosen at the turning point of the graphs. The remaining vehicles were defined as those involved in 'near-accident' situations.

Table 4: Number & percentage of vehicles involved in near accident situations and their critical cumulative values of resultant deceleration.

Intersection	No. of vehicles involved in 'near accidents'		Critical value of sum of decelerations $\sum (a_e)_L - \text{m/sec.}^2$
	number	percentage	
A	22	15.8	65
B	16	7.7	25

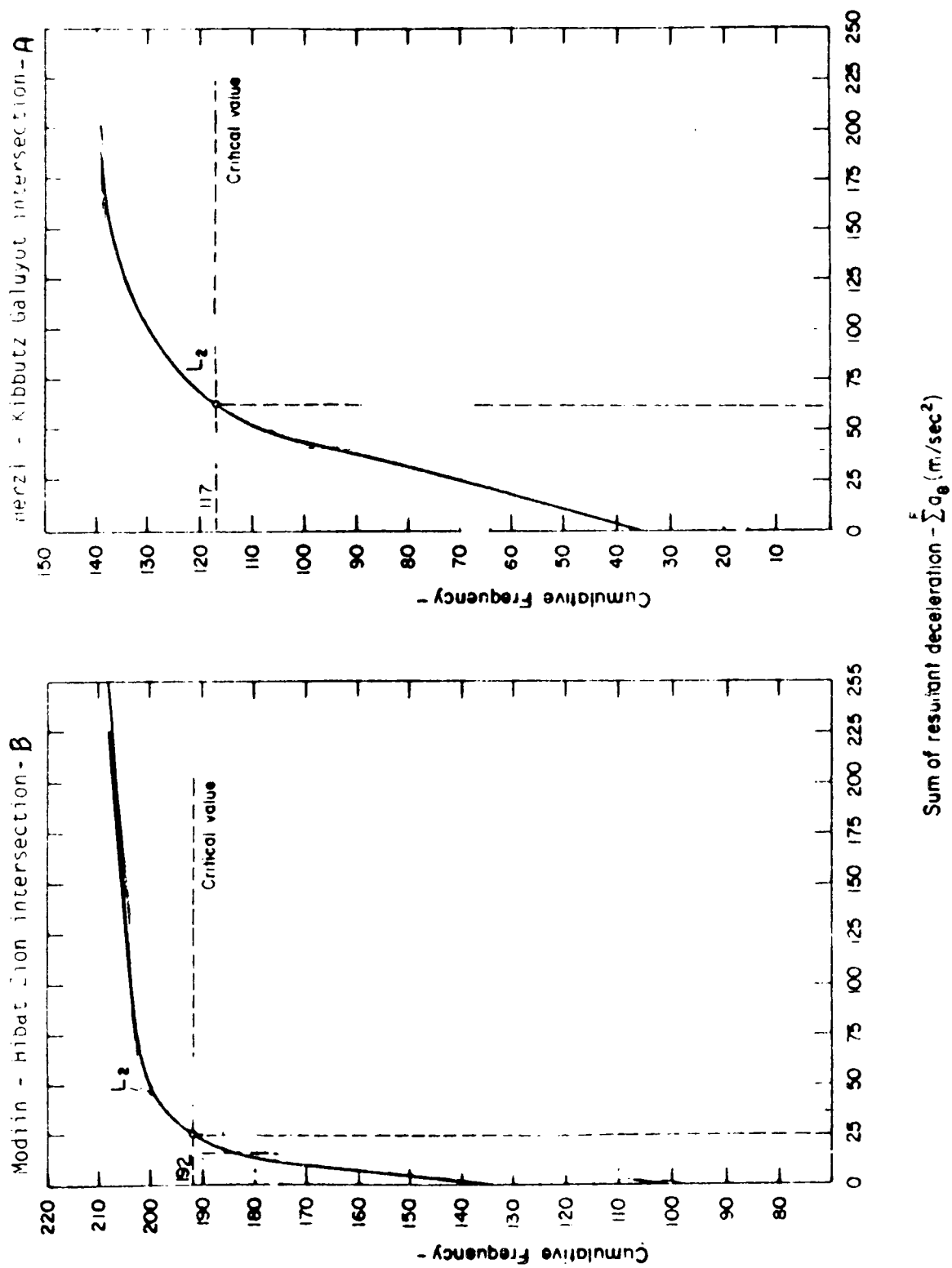


Fig. 1: Distribution of sums of resultant decelerations of vehicles for critical values.

These vehicles contributed 49 percent of the total sum of deceleration in irregular manoeuvres at intersection A and 75 percent at intersection B.

A further study can now be made as to the type of manoeuvres that contributed to the 'near-accident' situations, and what critical values were associated with each type.

Table 5: Number of vehicles involved in near-accident situations and their sum of resultant decelerations - by type of disturbance

Intersection	Parking & platoon		Type of disturbance							
			turning to minor road		waiting in minor road		exit from minor road		pedestrian	
	N	$\sum \sum a_e$	N	$\sum \sum a_e$	N	$\sum \sum a_e$	N	$\sum \sum a_e$	N	$\sum \sum a_e$
A	-	-	4	331	2	158	12	1469	4	334
B	1	33	3	144	1	32	6	474	5	753

N - number of vehicles

$\sum_{l=1}^N \sum_{f=1}^F a_e$ - sum of resultant decelerations (m/sec.²)

F - No. of frames

It is seen that the exit from the minor road is clearly both the most numerous and except in one case, the heaviest contributor to the resultant deceleration. At the two intersections studied, pedestrians are also a major source of risk. Third in importance is the turning manoeuvre into the side road.

A further evaluation of the various manoeuvres will now be attempted according to three types of groupings.

IDENTIFICATION OF COMPOSITE NEAR ACCIDENT SITUATIONS

In many traffic events, including accidents, a number of vehicles are involved. The influence of a disturbance such as a crossing pedestrian or a turning vehicle is therefore, in many cases, felt on more than one vehicle. In this section, vehicles have been grouped according to one composite event and the resultant deceleration studied.

Table 6: Number of composite 'near accident' situations and their sum of resultant deceleration - by type of disturbance.

Intersection	Vehicle exiting or waiting in minor road		Vehicle turning to minor road		Pedestrian	
	No.of events	sum decel.	No.of events	sum decel.	No.of events	sum decel.
A	14	2660	2	237	3	400
B	6	560	2	200	1	759

Again it is clearly demonstrated, both in terms of number of events and magnitude of deceleration, that the major disturbance at the two intersections is the merging manoeuvre of the vehicle from the minor road. The limited number of events presented in this table contribute some 70 - 80 percent of all the irregular decelerations.

ANALYSIS OF TYPES OF DISTURBANCES

Each vehicle passing through the intersection was classified according to the disturbance created. Previous sections dealt with those vehicles involved in near accident situations. A further study will now be made of the disturbances according to their impact on various indices of resultant deceleration. All vehicles involved in irregular events, as described in Table 2 were included.

Five different terms of resultant deceleration have been calculated :

- 1) The sum of the resultant decelerations of all vehicles involved. This indicates the total level of reaction.
- 2) The average resultant deceleration per vehicle. This presents the average reaction, giving equal weight to each film frame.
- 3) The average resultant deceleration per frame, presenting the average reaction per vehicle again with equal weight to each frame.
- 4) Sum of average resultant deceleration per vehicle, presenting the sum reaction per vehicle involved in an irregular event with equal weight per vehicle.
- 5) Average of average resultant decelerations per vehicle, presenting the average reaction per vehicle involved in an irregular event, with equal weight per vehicle.

Table 7 summarizes the results for the five expressions and the various disturbances.

The most marked disturbance per vehicle involved is that of a pedestrian crossing the road. Apparently, this disturbance creates the most extreme reactions. The disturbance of vehicles emerging from the minor road is most felt in the sum expressions (1) and (4), but is also considerable as average per vehicle.

These tendencies can be found back in the accident data for the two intersections, and in accident data at urban intersections in Israel in general.

Table 7: Sums and average values of resultant deceleration in various traffic disturbances at each intersection

Intersection B						Intersection A						Type of disturbance	
(5)	(4)	(3)	(2)	(1)	No. of Veh.	(5)	(4)	(3)	(2)	(1)	No. of Veh.		
$\frac{1}{N} \sum \frac{F \sum a_e}{F-2}$	$\frac{F \sum a_e}{N \sum \frac{F-2}{F-2}}$	$\frac{N \sum a_e}{N \sum \frac{F-2}{F-2}}$	$\frac{1}{N} \sum \frac{a_e}{F-2}$	$\frac{N \sum a_e}{N \sum \frac{F-2}{F-2}}$		$\frac{1}{N} \sum \frac{F \sum a_e}{F-2}$	$\frac{F \sum a_e}{N \sum \frac{F-2}{F-2}}$	$\frac{N \sum a_e}{N \sum \frac{F-2}{F-2}}$	$\frac{1}{N} \sum \frac{a_e}{F-2}$	$\frac{N \sum a_e}{N \sum \frac{F-2}{F-2}}$			
0.2	10.4	1.5	1.62	68.0	42	-	-	-	-	-	-	free flow	.1
0.3	7.1	1.4	2.08	41.5	20	0.9	22.0	1.9	11.16	278.9	25	parked vehicle	.2
0.5	16.4	1.5	2.92	90.4	31	-	-	-	-	-	-	following vehicle	.3
0.5	14.7	1.8	3.43	99.4	29	0.4	9.2	1.9	4.47	93.9	21	parked + platoon	.4
0.5	14.2	1.8	7.39	206.8	28	2.0	47.4	2.2	32.70	784.9	24	vehicle turning to minor road	.5
0.6	10.1	1.5	5.33	85.2	16	2.0	32.6	2.4	32.56	521.0	16	vehicle waiting on minor road	.6
1.2	26.1	2.0	27.22	544.3	20	2.1	91.6	2.4	56.75	2496.9	44	vehicle emerging from minor road	.7
1.6	16.0	2.1	77.59	775.9	10	2.1	19.1	2.2	61.08	488.6	8	pedestrian	.8

Table 8 : Number of accidents by type - 1972 - 1975

Intersection	Pedestrian involved	Front to side	Rear end	Other
A	2	14	2	6
B	3	6	-	-

Table 9 : Distribution of accidents at urban intersections in Israel during 1972. Percentages by type of accident.

Type of accident	Pedestrian involved	Front to side	Rear end	Other
Percent of all accidents	25.9	46.4	8.3	19.4

A further study of the two intersections by sum and average of decelerations of all vehicles also clearly shows that on all accounts, intersection A has much higher reaction values than intersection B, and is clearly deficient.

BLACK SPOT LOCATIONS AT THE INTERSECTIONS

In accident analysis it is usual to try and identify black spots in order to treat them for improvements. A similar attempt can be made in this study, trying to identify irregular events and associate them with certain features of the intersection. The 'black spots' are those locations at the intersection which had high concentrations of irregular decelerations. For each 1 x 1 m. square of the intersection, the sum of resultant deceleration of vehicles involved in irregular events ($> | (a_e)_L |$) was calculated, the assumption being that a location with high values may indicate a location with increased risk, and therefore worth investigating. A map of 'iso-maneuvres' has been prepared for each intersection. The dark areas are those with high values of deceleration. The lighter the areas, the less disturbance they experience. Figures 2 and 3 present the results.

Intersection A - the crossroad experiences a much higher level of disturbance than intersection B.

At intersection A, the black areas are located at the entrance to the intersection area, whereas at intersection B, they are located at the exit and on the approach.

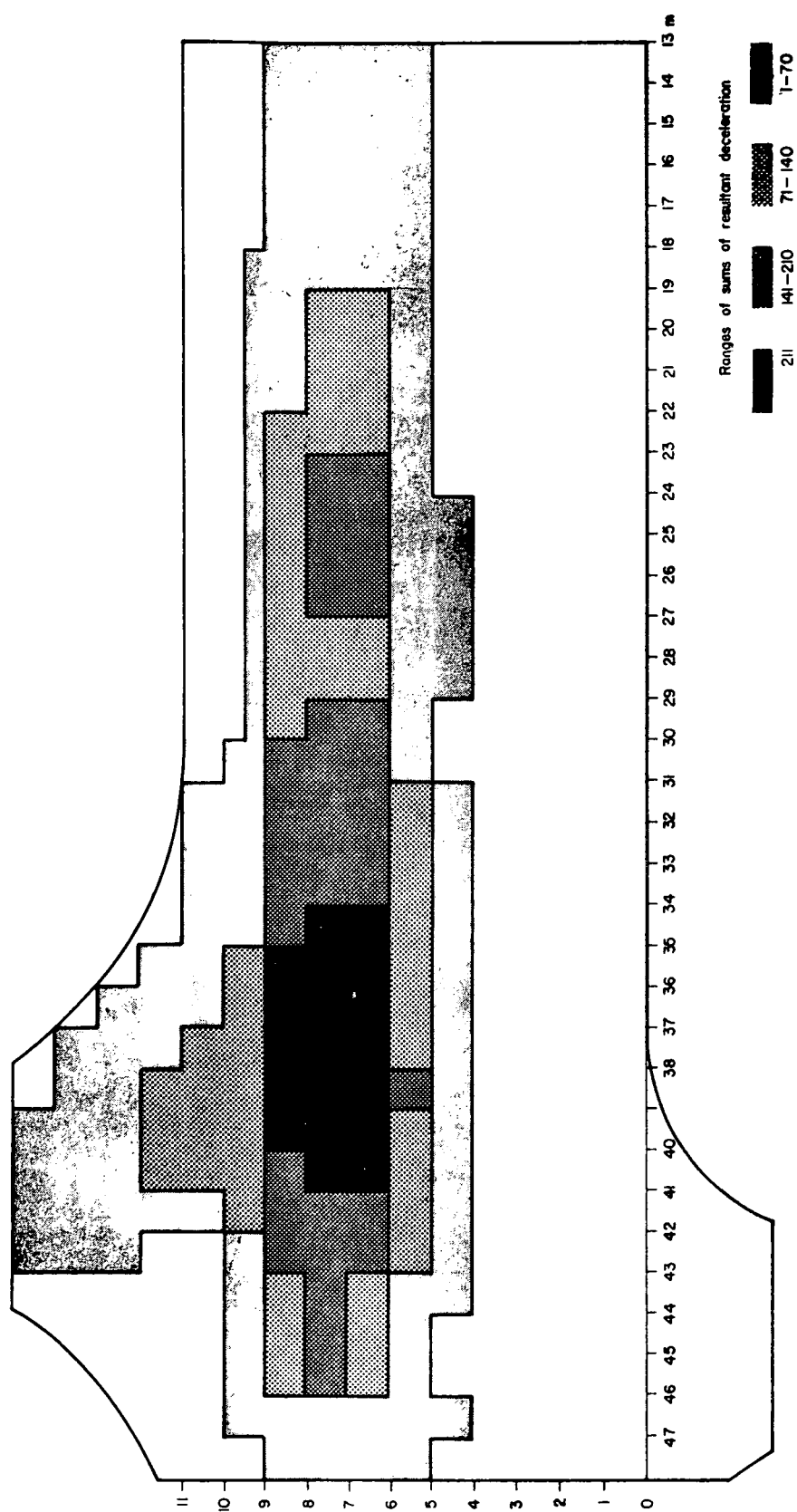


Fig. 2: Iso-manoeuvre areas at Herzl-Kibbutz Galuyot intersection, all vehicles.

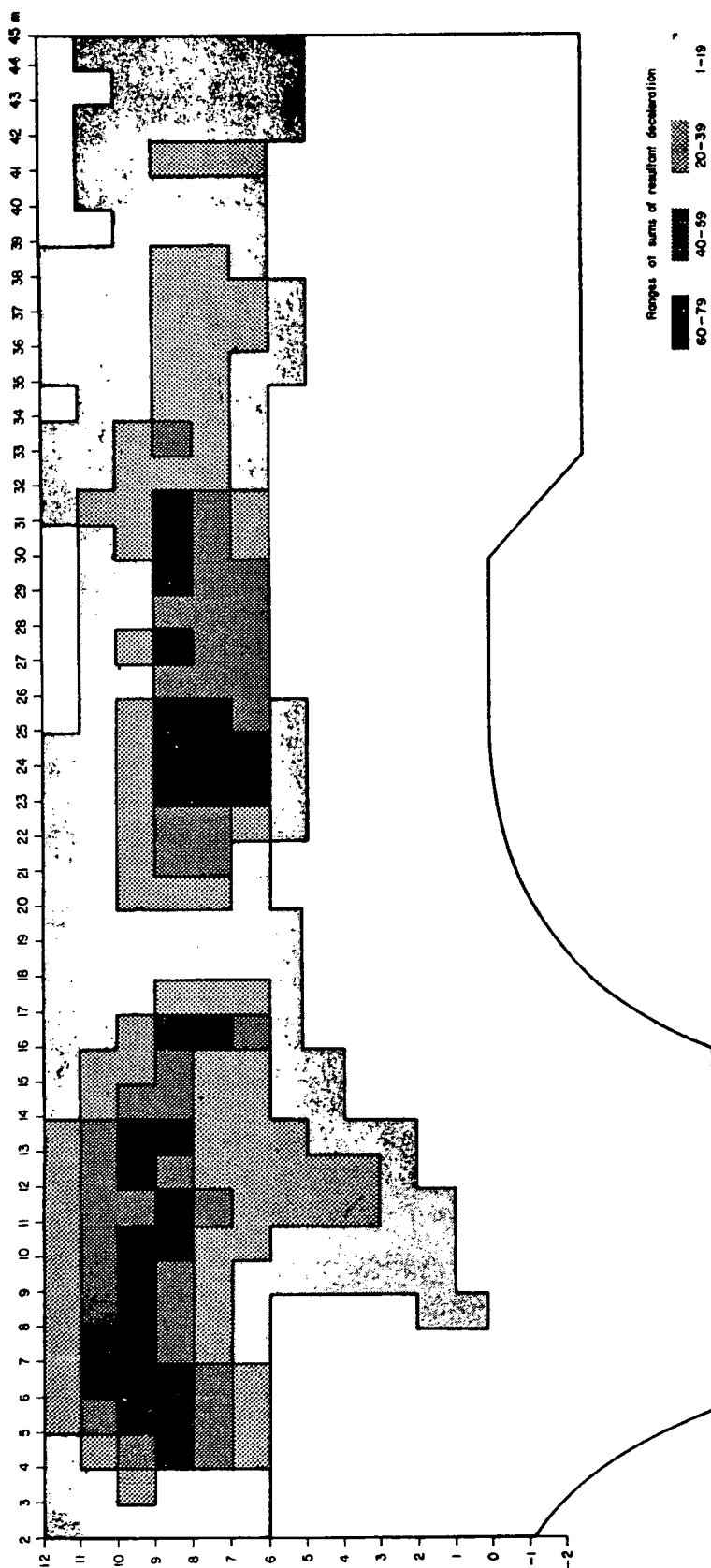


Fig. 3: Iso-maneuvre areas at Modiin-Hibat Zion intersection, all vehicles.

These results can be explained by the differences between the intersections. Intersection A, being a crossroad, vehicles crossing on the minor road cause decelerations to vehicles on the major road at the entrance to the intersection area. Intersection B, being a T-junction, merging vehicles turning left into the major road create a disturbance at the exit of the intersection area. A further area with difficulties is notable at intersection B on the major road approach, caused by left-turning vehicles on the major road. This is reasonable when pointed out that this intersection does not have a left-turn lane.

It can be concluded that a microscopic analysis of the vehicle manoeuvres can lead to an identification of those intersection locations which have a high concentration of decelerations. Various ways of improvement can then be suggested.

SUMMARY AND CONCLUSIONS

This study has presented a quantitative definition of the near accident concepts, and of the level of risk associated with various types of manoeuvres at an intersection. The definition is objective and is not influenced by observer variations. The definition is based on the development of two dimensional equations of motion for vehicles traveling through the intersection, the calibration of such equations, and on the definition of critical values of resultant deceleration. The method needs relatively high speed continuous filming of the intersection area, and necessitates a detailed film analysis. This method could supplement existing methods of conflict analysis techniques in providing an objective measure to which one could compare various methods of subjective observer evaluation.

It has been shown that the vehicle motion through the intersection can be objectively and consistently described by a two-dimensional motion equation.

The various types of disturbances generally encountered at intersections have been evaluated in terms of these motion equations, and near-accident situations have been defined.

The method is also useful in determining specific trouble locations within the intersection area.

The two main shortcomings of the method are :

- 1) The amount of work involved. This amount of work makes the method almost impractical for engineering purposes. It does, however, provide an excellent analytical tool for an improved understanding of the complex vehicle interactions at intersections.
- 2) The near accident concept developed is dependant on the establishment of specific estimates for each intersection studied. A large amount of data on many more intersections is therefore needed before one could produce conclusive and general levels of risk.

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3.4 2nd International Traffic Conflict Workshop

Conflicts and accidents as tools for a safety
diagnosis

Gilles MALATERRE - Nicole MUHLRAD
ONSER, France

I. INTRODUCTION

The conflict-technique developed at ONSER, and the first validation studies that were performed in 1976-77, were described in the proceedings of the last Traffic Conflict Workshop (Oslo, September 1977).

Since then, data-collection was intensified, including conflict observations and analysis of accident-reports on a number of urban intersections, and our conflict technique subsequently underwent some modifications, while its main features were kept the same as before.

At the beginning of 1978, the French technique could be briefly described as such :

- the basic working definition of a conflict had remained unchanged :
"a traffic conflict is a situation where interaction between several road-users (or between 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 collision".
- the severity scale (or urgency scale) was kept a five-step one (1 = conflict with easy evasive action, 2 = medium, 3 = narrow escape or minor collision, 4 = collision with material damage, 5 = injury accident). This severity index was indicative of the probability of a collision occurring, but was not in itself a measure of risk (probability of an injury-accident occurring).
- data-collection was carried out directly by human observers (two teams of two of them for each intersection studied). Data-sheets were codified, and observers were submitted to a two-day period of training before they started on the job.
- the matrix giving the risk-value of a junction where conflicts were observed was based on items slightly different of the ones used before : number and severity of conflicts, type of junction (signalled or non-signalled), types of road-users involved, and the speed at the beginning of the evasive action. Angle of the possible collision, that was taken into account at first, had been eventually abandoned, as this item seemed to have a very different significance according to the type of junction studied ; instead the class of conflict based on the manoeuvres performed by the road users involved was included in the risk-calculation process.

- the risk matrix, which had been at first estimated a priori from national accident-data, was eventually calibrated after successive comparisons of risk-values and accident-data on sixteen intersections. The overall relationship between risk calculated from conflicts and injury-accidents was found good without being perfect.

At this stage, we considered that the amount of data on the basis of which our conflict technique had been developped was sufficient, and we decided to evaluate it as it was without trying for the moment to improve it any further.

II. THE 1978 EVALUATION STUDY

The evaluation study was to answer three main questions :

1. Do we still have a good relationship between risk calculated from conflicts and accidents, on new locations that were not taken into account when calibrating the risk-matrix ?
2. Is this conflict technique a valid tool for use in before-and-after studies to evaluate safety measures on a given intersection ?
3. Conflicts can help understand specific safety problems ; together with field-observations aimed at finding out some characteristics of environmental design or road-user behaviour linked with danger, they can be used to reach a safety diagnosis on a given location ; is such a diagnosis as accurate and informative as one that would have been drawn in the same way from accident-data ?

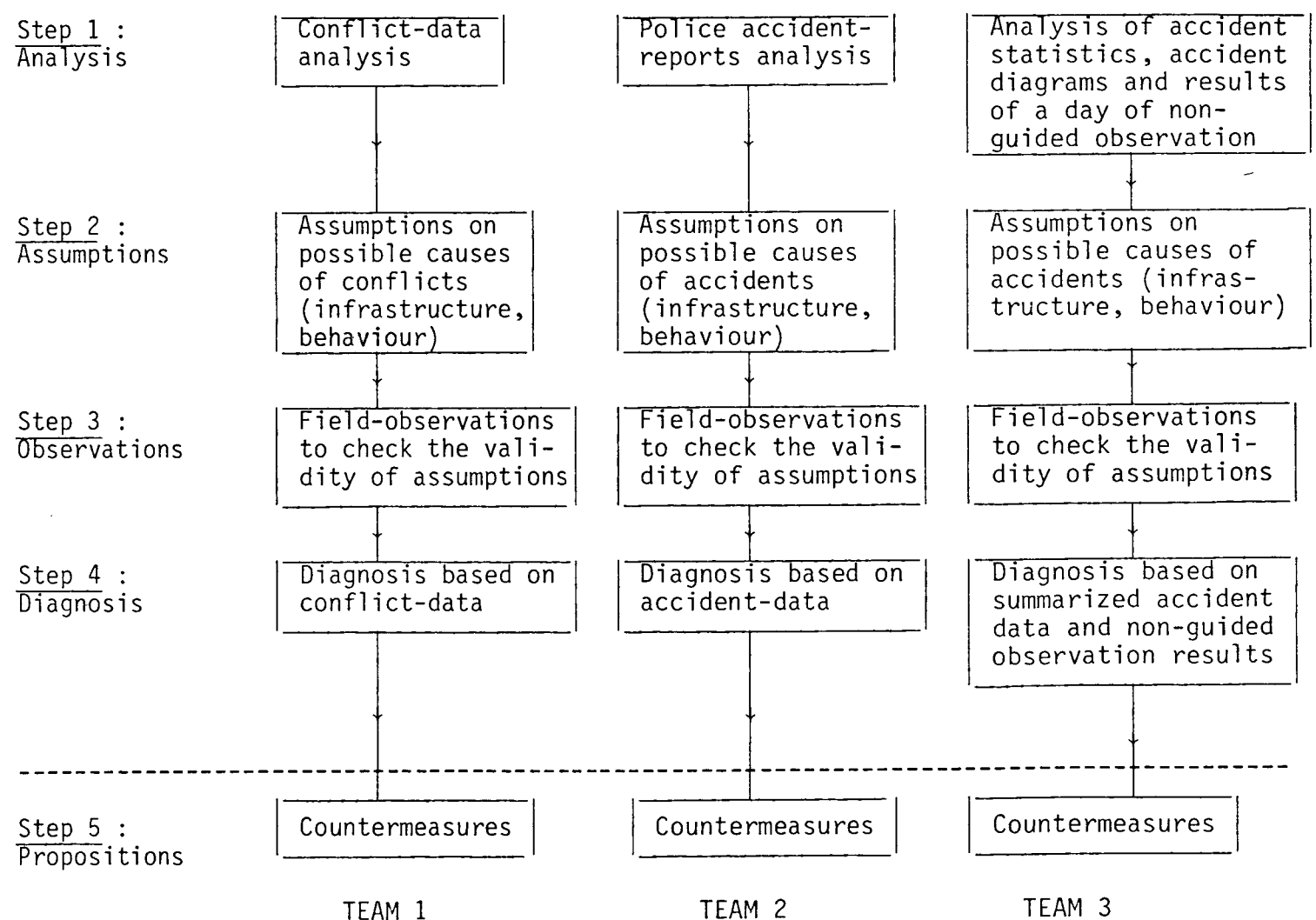
Of these three questions, the third one was considered particularly important as it was directly related to black-spot treatment and the definition of new safety countermeasures.

For the evaluation study, three different teams of ONSER researchers were created, all of them working on the same locations, each one of them being in charge of the safety diagnosis based on one of the following sets of data :

- conflicts observed on each intersection during one day (7 a.m. to 10 p.m.)
- accident-data extracted directly from the police-reports for a period that varied between six years and eighteen months according to the location
- accident-data extracted from statistical files for a period of five years, the corresponding accident diagrams, and results of a day of non-guided observation on the studied intersections.

The approach followed by all teams was well defined and as much as possible identical ; it included five steps :

- a) data analysis (carried out in the office)
- b) assumptions on possible causes of accident or sources of danger, derived from data-analysis. Definition of the corresponding types of observations to be performed on the location
- c) field-observations, carried out as designed by a multidisciplinary team including the ONSER researchers responsible for data-analysis, members of the local police, and representatives of the local branch of the Ministry of Transports
- d) safety diagnosis, drawn mostly by ONSER
- e) propositions of safety countermeasures (not in all cases).



THE APPROACH TO THE SAFETY DIAGNOSIS

as followed on each one of the nine intersections studied.

This approach was an operational one, currently used (with accident-data as a basis) for black-spot treatment. This way, comparisons and results that were drawn from the evaluation study included very practical matters as well as research.

Altogether, nine intersections were studied following this approach, six of them in urban areas, and three on rural trunk roads. The amount of data thus collected by the three teams was considered sufficient to draw valid conclusions. The detailed results presented in this paper as an example correspond to three of the six urban locations and the three rural ones.




In addition, conflict and accident data were also collected on seven more urban intersections. Results were included in the calculation of correlations between conflicts and accidents. overall, seven French cities were represented in our sample of sixteen locations ; all of these were accident black-spots.

III. VALIDITY OF THE CONFLICT-TECHNIQUE WITH REGARD TO INJURY-ACCIDENTS

1. Comparisons between types of accidents and types of conflicts

Accidents that had occurred in the last eighteen months were classified in the same way as conflicts for our 16 intersections :

Type of road-users	Cars only	Lorry involved (no pedestrian no two-wheeler)	two-wheeler involved (no pedestrian)	pedestrian involved
% conflicts	48	14	18	20
% accidents	37	8	39	16
% risk	29	4	57	10

Type of main manoeuvres	rear-end and weave 	right angle 	left-turn 
% conflicts	20	9	11
% accidents	15	34	16
% risk	12	20	36

The distribution of risk-values appears quite different of the distribution of accidents. In particular, risk attributed to the categories "two-wheelers" and "left-turn" is too high ; on the contrary, conflicts with right-angle trajectories are underestimated. This leads to think that the sample of 16 intersections studied here is very different of the sample of equal size that was used to calibrate the risk-matrix.

Further analysis shows that distortion appears mainly for signalled intersections, while the relationship between risk and injury-accidents is acceptable on non-signalled urban ones. The classification of intersections in two categories only is probably too crude, and more work should be done on this matter.

Overall, the correlation between risk and injury accidents is only 0.14 (non significant) while it reached 0.42 on the first sample of intersections (significant at 0.05). Details of risk values and accident figures for six junctions are given in the following table :

Intersection	Number of conflicts in 17 hours	Risk-value	Number of accidents in 18 months
CROISSET City of Rouen. Urban location. Signal- controlled	11	4.46	9
BARRIERE DU HAVRE City of Rouen. Urban location. signal- controlled	7	7.50	12
SAINT PATRICE City of Rouen. Urban location. Non-signal- lised	9	6.50	6
SAINT GAUDENS Rural location Non-signalised	24	14.00	6
MOULIN BLANC Rural location Non signalised	2	1.00	3
SERRES CASTET Rural location Non signalised	20	10.50	4

The low correlation obtained here can be explained in different ways, the most plausible one being that there is no unique linear relationship between conflicts and accidents, but that the function linking the two sets of data varies for each junction studied. If this assumption is verified, then a risk-matrix calculated as it has been here has no meaning, and the only possible solution to the problem would be to calculate matrices for a greater number of intersection categories. (based on presence or absence of traffic-lights, but also on road-design, type of traffic, etc...)

IV. COMPARISON OF SAFETY DIAGNOSIS

Results obtained by the ONSER teams working separately from different sets of data were compared. We give here as an example the conclusions that were drawn on two groups of intersections, three on rural trunk roads in the area of Bordeaux (SERRES-CASTET, MOULIN BLANC, SAINT-GAUDENS), and three urban ones in Rouen (BARRIERE DU HAVRE, CROISSET, SAINT PATRICE).

1. The Bordeaux experiment

Conflict data-collection was carried out by a set of local observers trained by ONSER. The "non-guided" observations, aimed at finding out unusual or inadequate behavioural patterns and environmental features, were performed by technicians of the local branch of the Ministry of Transports who were also members of the multidisciplinary team in charge of the guided field-observations (step 3 of the diagnosis procedure).

The following tables gives the three diagnoses and the three sets of propositions obtained on each location studied :

- SERRES CASTET (see diagram 1)

Set of data used	Accident-reports	Conflicts	Summarized accident data + non guided observation
Diagnosis	<ul style="list-style-type: none"> - bad perception of the junction. - no specific lane for left-turns - violations of the rule forbidding left-turn access to the parking-lot - use of the right-turn lane as an access to the parking lot - no lateral references (marking etc...) on the secondary road - wider part of the junction used as parking spaces - bus-stop badly located. 	<ul style="list-style-type: none"> - bad perception of the junction. - forbidden left-turn often performed by the road-users - right-turn lane used by cars going out of the parking lot ; this lane is in fact only a hard shoulder but is not well delimited as such - use of the right-turn lane to practice left-turn in two times (access to the parking lot) 	<ul style="list-style-type: none"> - bad visibility for users on the secondary road. - forbidden left-turn often performed - the priority rule is not well respected - the secondary roads are too wide at the junction - use of the right-turn lane as an acceleration lane - no protection for pedestrians
Propositions	<ul style="list-style-type: none"> - facilities for left-turn from Pau - integration of access to the parking lot in the overall design of the junction - suppression of the right-turn lane - traffic-islands and STOP signs on the secondary roads - improvement of visibility in the corners of the intersection - better organisation of parking. 	<ul style="list-style-type: none"> - facilities for left-turn - improvement of perception the junction - separation of the right-turn lane and of the exit of the parking-lot by a traffic-island - traffic-islands on the secondary roads - improvement of the right-turn angle at one of the corners of intersection (in front of the shop). 	<ul style="list-style-type: none"> - facilities for left-turn - lighting of the junction - replacement of the right-turn lane by a pedestrian route - elimination of parking from the junction - improvement of the design of the junction narrowing the secondary roads.

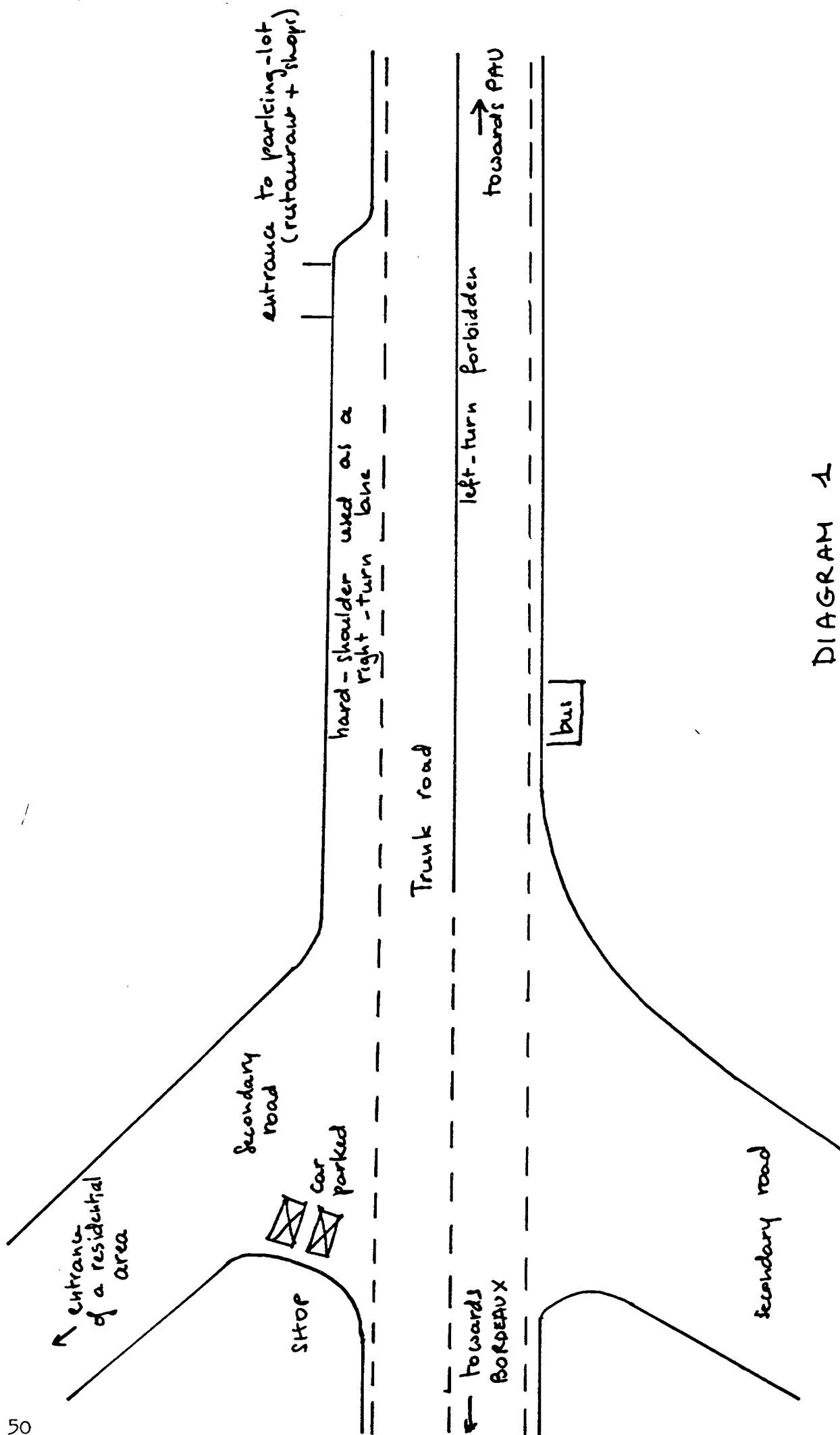


DIAGRAM 1
SERRES - CASTET

- MOULIN BLANC (see diagram 2)

Set of data used	Accident-reports	Conflicts	Summarized accident-data + non-guided observation
Diagnosis	<ul style="list-style-type: none"> - high speed on main road - secondary roads sloping down from the junction making it difficult to start for light two-wheelers - waiting-space for left-turners too small to enable two-wheelers to cross the main road in two times - intersection only visible at a short distance (main road hilly) 	<p>only two conflicts were observed in a whole day.</p> <p><u>No diagnosis</u></p>	<ul style="list-style-type: none"> - high speed on main road - secondary roads sloping down from the junction, making it difficult to start for slow vehicles. - intersection only visible at a short distance (main road hilly)
Propositions	<ul style="list-style-type: none"> - replacement of the YIELD sign by a stop sign on the secondary roads, and addition of a painted STOP line - protection of the left-turns from the main road by islands, enabling the two-wheelers on the secondary roads to cross the junction in two times - levelling of the roadways - improvement of the perception of the intersection. 	<p><u>No propositions</u></p>	<ul style="list-style-type: none"> - improvement of the road-markings, extending it past the hill-top

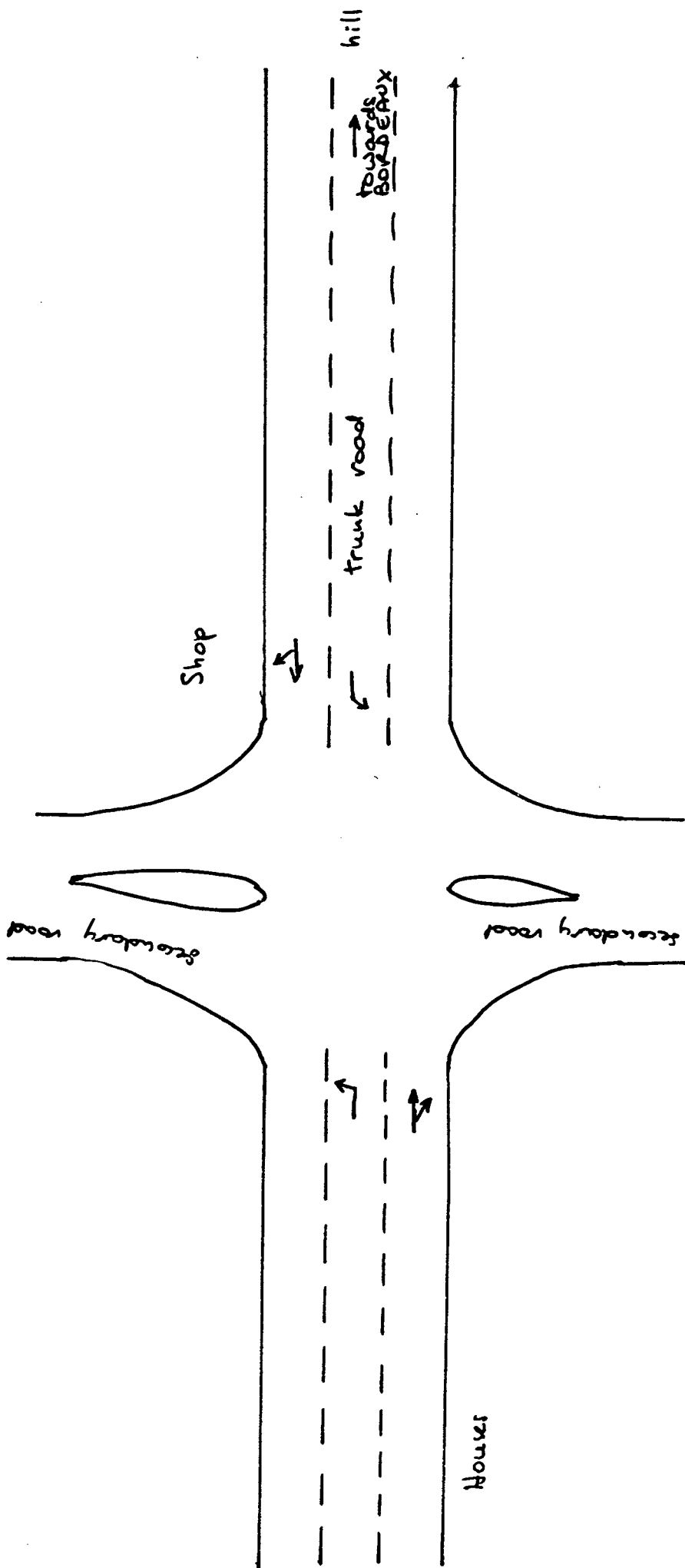


DIAGRAM 2
MOULIN - BLANC

- SAINT GAUDENS (see diagram 3)

Set of data used	Accident-reports	Conflicts	Summarized accident-data + non-guided observation
Diagnosis	<ul style="list-style-type: none"> - bad visibility at the junction - road-users from the secondary roads cross the junction in two times, even though the waiting space in the center is insufficient - some cars can be hidden from the road-users on the side-roads because of two lanes in a curve with a gradient 	<ul style="list-style-type: none"> - bad visibility at the junction ; road users from the secondary roads have to stop past the STOP line - road-users from the side-road cross the junction in two times in spite of insufficient waiting space in the middle 	<ul style="list-style-type: none"> - bad visibility for vehicles on the secondary roads - vehicles going up the curved branch of the main road use the two-lanes to overtake ; lorries are frequent on the right-hand lane. So speed is high and cars can be hidden from users on the side-roads.
Propositions	<ul style="list-style-type: none"> - improvement of visibility - central island and creation of waiting space to protect users crossing in two times - improvement of the design of the curve with a gradient to encourage drivers to keep to the right - narrowing of the secondary roads at the junction 	<ul style="list-style-type: none"> - improvement of visibility by moving some signs, hedges, poles etc... - protection of central waiting space : traffic island with two-times crossing mandatory (STOP sign) 	<ul style="list-style-type: none"> - improvement of visibility - suppression of the lane for slow vehicles in the sloping-up curve, in order to slow down cars coming to the junction. (but this could result in new accidents further down). - possibly add a traffic-light with adequate warning before the curve of the main road.

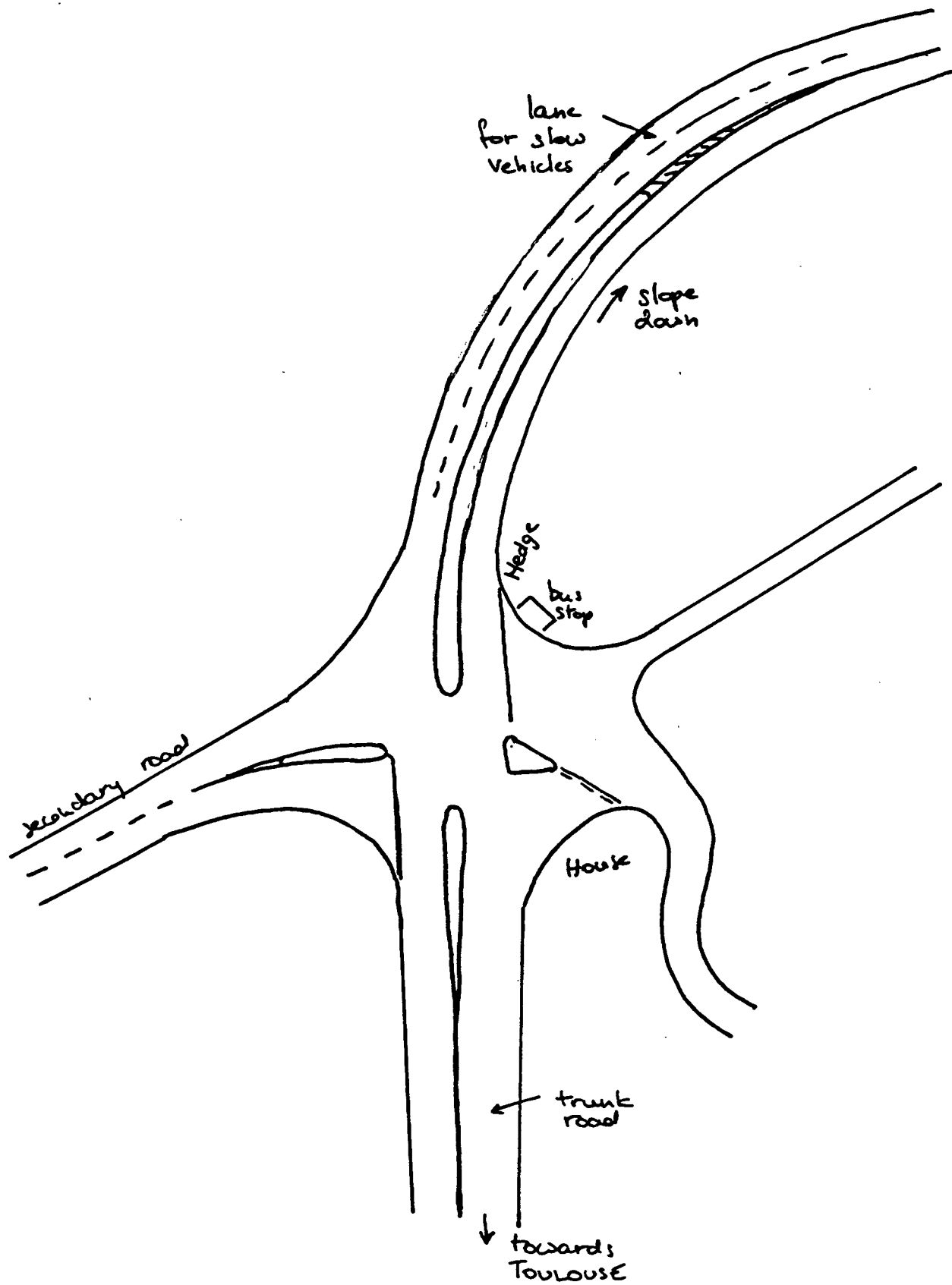


DIAGRAM 3
SAINT - GAUDENS

These tables have been necessarily simplified. The three teams responsible for the diagnoses met to discuss the detailed results and the problems having appeared during the experiment. Their general conclusion is that accident-reports provide the safest basis to reach a valid diagnosis.

The best example to prove it is the third junction, Saint-Gaudens : declarations of the road-users involved, as found in the accident report, show without any doubt that car-drivers coming from the side-road cross the junction in two times, even though they are unprotected while waiting in the middle, and also that, while waiting, they could not see properly road-users coming up on the priority road. Field-observations confirmed these facts.

The team working from conflict-data also detected the problem during the observation period, but few elements in the conflict-analysis could in fact orientate their observations in the right direction ; the concording results with the accident team seem to be due more to the experience of the researchers in the field of black-spot treatment than to the informative value of conflict-data...

The team working with simplified accident-data was not aware of the problem ; most of the results of non-guided observation were in fact linked to traffic-problems which had no bearing on accidents, and they did not help the diagnosis very much.

2. The Rouen experiment

Only two of the three ONSER teams worked on the intersections studied in Rouen ; basic data were accident-reports and conflicts. Conflict data collection was performed by the regular ONSER group of four observers.

Main results are summarized in the following tables :

- BARRIERE DU HAVRE (see diagram 4)

Set of data used	Accident-reports	Conflicts
Diagnosis	<ul style="list-style-type: none"> - coordination of traffic-lights and road-design are an encouragement for the car-drivers to go through an orange light or a red light at its beginning ; there is a risk of collision with road-users starting at the beginning of the green phase on the other road - the intersection is not very visible at a distance - high speed - all-round red phase too short 	<ul style="list-style-type: none"> - risk-value is low on this junction and conflicts are not sufficient to orient the diagnosis, even though field-observation shows unusual behavioural patterns (numerous car-drivers going through an orange light)
Propositions	<ul style="list-style-type: none"> - moving the traffic-lights forward or increasing the duration of all-round red - coordination of traffic lights on both legs of the junction, in order to avoid : <ul style="list-style-type: none"> . cars going through orange lights on one direction . cars anticipating the green phase on the other one 	no propositions

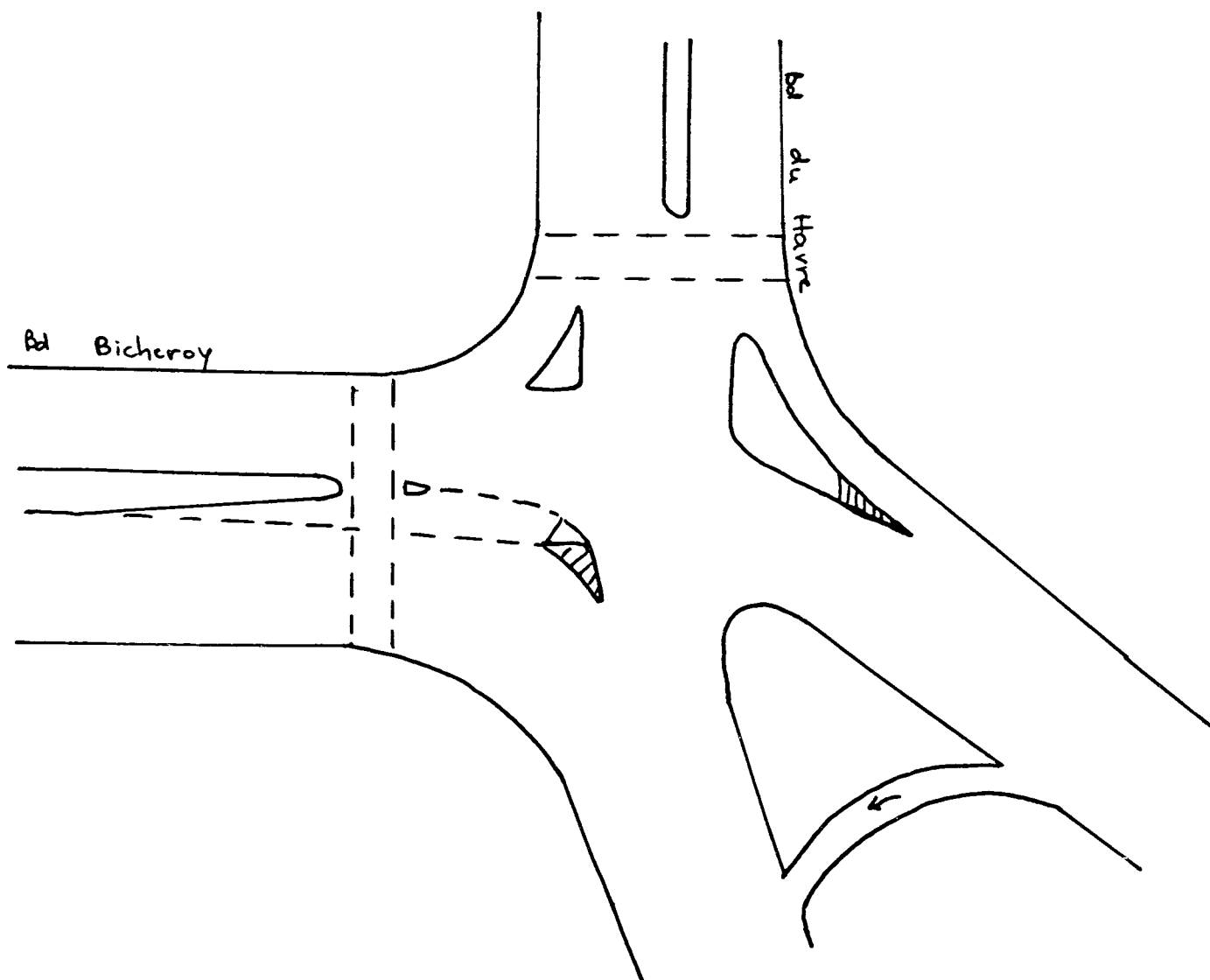


DIAGRAM 4

BARRIÈRE DU HAVRE

- SAINT PATRICE (see diagram 5)

Set of data used	Accidents-reports	Conflicts
Diagnosis	<ul style="list-style-type: none"> - bad visibility for cars at the STOP sign : they have to stop and wait past the line - heavy traffic at peak-hour : road-users from the side-street have to force their way through - the first traffic-line is hidden by the second one for the drivers coming out of the side-street - one pedestrian-crossing is missing - the junction is not very perceptible for road-users on the main street 	<ul style="list-style-type: none"> - bad visibility for cars at the STOP sign : they have to wait past the STOP line - it is difficult for road-users from the side-streets to find a break in traffic long enough to cross the junction (peak hours) - the junction is not very perceptible for road-users on the main street
Propositions	<ul style="list-style-type: none"> - suppression of some parking-spaces in the vicinity of the junction - addition of a pedestrian-crossing (which will also increase drivers' mutual visibility) - if possible, turn rue St Patrice into a one-way street (entrance from the junction), or add a traffic-light, coordinated with the lights existing at the nearest junction 	<ul style="list-style-type: none"> - improvement of mutual visibility for car-drivers : suppression of some parking spaces - simplification of the manoeuvres at the junction by turning rue St Patrice into a one-way street (entrance from the junction) - or else, add traffic lights (which would also decrease pedestrian problems)

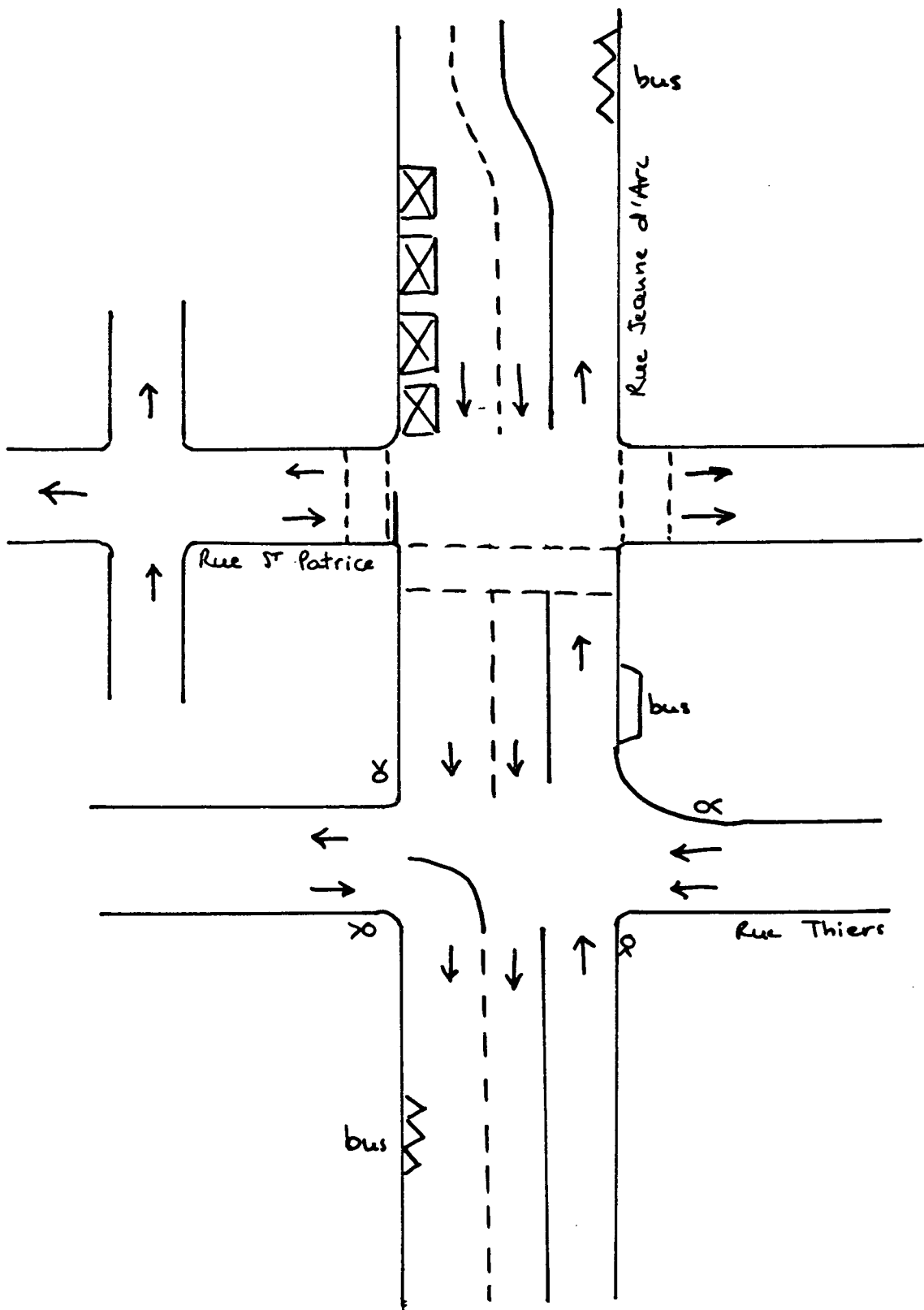


DIAGRAM 5

SAINT PATRICE
and its surroundings

- CROISSET (see diagram 6)

Set of data used	Accident-reports	Conflicts
Diagnosis	<ul style="list-style-type: none"> - left-turn angle unusual - no waiting area in the middle - small-radius curve, with roadway sloping on the wrong side - the chemin de Croisset is very narrow - high speeds 	<ul style="list-style-type: none"> - conflicts are distributed all over the junction, with no particular emphasis on any of the possible manoeuvres
Propositions	<ul style="list-style-type: none"> - redesign of the junction to increase the radius of the curve - protection and facilities for left-turns - sloping of the roadway towards the inside of the curve 	<ul style="list-style-type: none"> - redesign of the whole junction (curve, left-turns, etc...) <p>However, risk-value is low and may not justify such a proposition.</p>

Comparisons between the results obtained by the two teams show great variations, essentially on Barrière du Havre : the main problem detected there through accident-analysis has not appeared at all in conflict data ; field-observations performed by the second team gave a hint, but the problem remained badly localised : the dangerous manoeuvre could not be identified. Moreover, the risk-value of the junction was very low, while Barrière du Havre is a very serious accident black-spot...

Agreement between the two diagnosis was better on Saint Patrice. However, the location of the critical point of the intersection was not the same for the two teams : from accidents, it appeared that the critical moment for cars coming out of rue Saint Patrice was at the beginning of their crossing of the junction, while the conflicts showed it was at the end...

On Croisset, risk-value was low and conflicts too distributed in space to be of great help for the diagnosis ; field-observations were mostly non-guided.

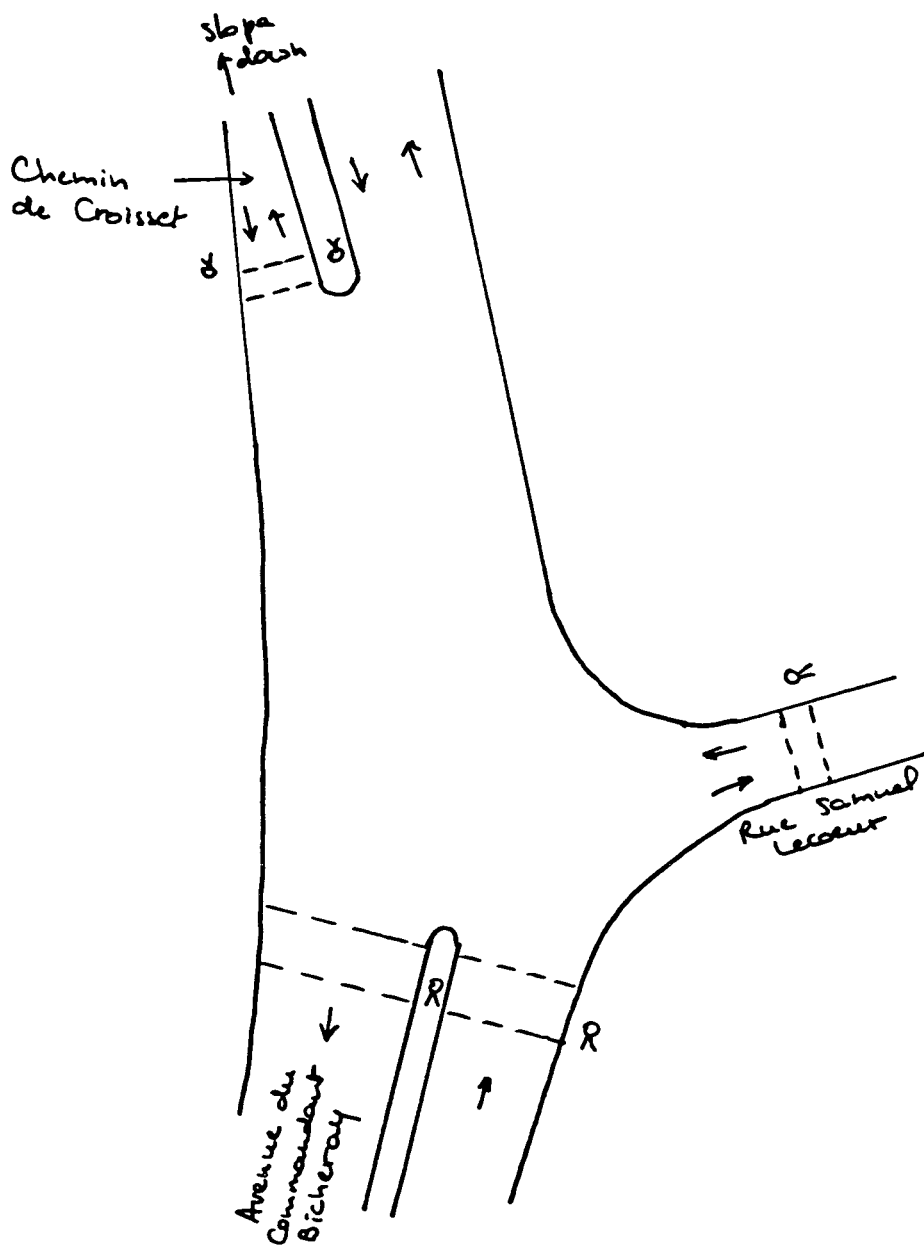


DIAGRAM 6
CROISSET

If we try to evaluate conflict use in safety diagnoses on the basis of the Rouen and the Bordeaux experiment, it appears that conflict data was far too little informative to help drawing an accurate diagnosis, taking into account the actual most dangerous manoeuvres. This is particularly true for the urban junctions studied. Results of comparisons of the same type carried out on three more intersections in the Paris area confirm these results.

The differences that arise when comparing accident and conflict based diagnoses are surprising, considering that results obtained previously were a lot more encouraging. We have already assumed that the relationship between conflicts and injury-accidents might vary according to the type of location ; it is worth noting that the sixteen junctions studied in 1976-77 and at the beginning of 78 were picked-up randomly, while the results described in this paper concern only accident black-spots which were moreover very difficult to treat. (Safety problems difficult to find out). An assumption is that conflicts can be well adapted to understand safety problems and draw diagnoses in average or simple cases, but cannot help finding out dangerous manoeuvres in more complex situations, in particular when these manoeuvres are due to coincidences of events occurring rarely, but with a high probability of collision.

V. CONCLUSIONS

The results of our evaluation study throw light upon a number of difficulties arising when using the conflict technique :

- on the practical side, data-collection is always a heavy task ; it requires the definition of objective or subjective criteria to detect or grade conflicts which are never simple : as a consequence, the observers must have been thoroughly trained if sufficient reliability is to be reached.
- the relationship between conflicts and accidents is not constant ; it varies not only according to the type of conflict, which can be taken into account quite easily, but apparently also according to the type of junction studied. In some cases, it is even impossible to find a qualitative connection between the two sets of data : conflicts and accidents are of a different type and located on different parts of the intersection. If it is verified that the relationship between conflicts and accidents is actually different for every intersection, then the use of a conflict technique would become utopian...
- we are in fact convinced that the high proportion of severe accident black-spots in our sample of locations is responsible for the low validity results that we got through our 1978 evaluation study : the relationship between conflicts and accidents is much better on more simple intersections or on a set of locations picked up randomly. It is possible that this explains the differences between our results and some others obtained with different techniques (C. Hyden, Sweden, for instance), rather than factors characteristic of the techniques themselves.

Considering all those conclusions, we feel that, for the time being, the conflict technique should be applied only in restricted situations :

1. In before-and-after studies : conflicts are a relative measure of risk variation. If the safety measures to evaluate are not major ones changing radically the design of the junction, it is assumed that the relationship between conflicts and accidents will not vary before and after, and that the two periods of data-collection can be validly compared. It will be necessary however, to check that the specific safety problem treated actually appears in conflict-data for the before period ; otherwise the evaluation study would be limited to the detection of possible side-effects of the studied countermeasure.
2. For diagnoses on black-spots when the measures planned must take into account, not only safety of the road-users in a strict sense, but also "comfort" of their journeys : injury-accidents will be the data-base for the safety part, conflicts will be a valuable complement as they are indicative of various traffic malfunctions, including minor collisions.
3. In area-wide studies when accidents are distributed instead of concentrating on particular locations. Conflict-information added to accident-data will be a great help in designing countermeasures ; the use of conflicts is here justified as countermeasures on this sort of area are aimed not only at increasing safety, but also at improving the general amenity of the environment and various factors of traffic and urban life.
4. For research purpose, to help explaining some items of behaviour that are cause of the occurrence (or on the contrary the disappearance) of injury-accidents ; in this field, feeling of safety of road-users is being particularly studied at the moment, ^{and} seems to be linked with conflicts at least as much as with injury-accidents ; more work remains to be done here...

N.B. Accidents as mentioned in this paper are always injury-producing ones.

3.5 A microprocessor based system for traffic data collection.

P. Storr, J. Wennell, M.R.C. McDowell; Royal Holloway College, U.K.

INTRODUCTION

For some time, the Operational Research Group at Royal Holloway College has been studying driver behaviour at non-urban T-junctions. During this research, we have been involved in a number of data collection exercises using video-tape recordings of traffic behaviour at the junction. We are particularly interested in deriving gap acceptance parameters from the data to use as input to a simulation model^{1,2}.

To obtain gap acceptance functions and to study their dependence on other traffic parameters, we need detailed records of the events which occur at the junction, and the times at which they occur. Events of interest are the arrival time of turning and non-turning vehicles at the junction, the commencement of a turn and the completion of a crossing manoeuvre. We also record the type of vehicle, the speed of main road vehicles and, on occasions, various other descriptions on the vehicle and its occupants.

In our previous work^{3,4,5}, video tapes of the T-junctions were made and a digital clock image incorporated later. The tapes were analysed by running them in slow motion, stopping them at an event of interest and noting the event and clock time. The final output from this process was a list of events and the times at which they occurred to the nearest tenth of a second. This information was transferred to punched cards and analysed by computer.

Video techniques have the advantage of providing a complete record of events. However, the extraction of detail from the video tapes and the subsequent transfer to punched cards is extremely time consuming and may be very tiring for the analyst. The time required for this phase of the analysis is of the order of twenty times the observation period.

This paper describes the design and construction of an alternative

system to collect traffic data and transfer it to a central computer for processing. The use of this new system in recent observations of traffic behaviour at T-junctions is discussed and compared with the video techniques described above.

REQUIREMENTS FOR THE DATA COLLECTION SYSTEM

We wished to develop a system of traffic data collection which would be capable of recording detailed data on driver behaviour over periods of several hours to cover for example morning and evening peak periods. For this purpose, the system must incorporate some of the properties associated with our previous video techniques. It must be portable, having its own power supplies, and be physically small enough to be transported in a car. It must provide an accurate time base so that traffic parameters of reasonable accuracy can be obtained from the data. It must be able to record the times of vehicles passing points on the road and further information on the vehicle and its occupants. To do this we required inputs of two kinds: data input manually by observers and data from automatic sensors (e.g. pressure tubes, induction loops). In trying to eliminate the serious disadvantage of our video systems - the lengthy analysis phase - we needed to store the data internally and allow later direct transfer of this data to a mainframe computer. Punched paper tape was ruled out as being bulky, noisy, dependent on mechanical parts and easily damaged. Two possibilities remained: random access memory (RAM) or magnetic tape storage. As our intention was to put the raw (unprocessed) data onto a mainframe computer for later analysis, and the quantity of data collected at any one time was expected to be relatively large, permanent storage on RAM would be prohibitively expensive.

CHOICE OF EQUIPMENT

To design and build our own hard-wired system was not possible because we had neither the resources nor the necessary experience. We decided that a microprocessor based system would be more appropriate for our needs, and such a system could relatively easily be altered should our requirements change.

We considered some commercial systems and decided to base our data collection equipment on the Golden River MK4 system which could be used for a variety of traffic applications (for example, see Dalglish and Tuthill⁶). This is a modular system based on a microprocessor. It has facilities for using RAM and Programmable Read Only Memory (PROM), a real time clock, a number of input and output (I/O) facilities and its own power supply. The relevant specifications for the modules used in our system are summarised in Appendix I.

Our choice of I/O port (the MK4/12 I/O Port B) works on an 8 bit byte switch closure input, and an 8 bit byte output. With suitable programming, the system can easily handle eight distinct on/off inputs for each such I/O port in the system.

Some applications of the Golden River MK4 systems have used a digital cartridge recorder. Such devices are costly and a cheaper alternative was sought. Computer Workshop market the SWTPC (Southwest Technical Products Corporation) "AC-30" cassette interface. This is a mains operated unit designed as an interface between a 300 BAUD UART (teletype) port and one or two audio cassette recorders. If a cassette recorder with a remote stop-start facility is used, the AC-30 is capable of stopping and starting the cassette motor according to signals from the connected computer (or micro-processor). Therefore the MK4 could be used to send a signal to start the tape recorder motor, output data to the cassette and then stop the motor on a second signal. Data could be transferred in a continuous mode from

cassette tape via the AC-30, to a UART port on a mainframe computer, provided the mainframe computer could handle the input rate of the data stream. This proved possible on the CDC 6600 we used, and is further discussed below.

A drawback of the AC-30 is that it is a mains-operated unit. However, its specifications showed that only low voltages and fairly low power were needed to run the device. Golden River agreed to modify the AC-30 from the kit provided to operate with a rechargeable battery supply.

INITIAL SYSTEM

The initial system consisted of an MK4 microprocessor-based system including four 8-bit push button input units and a UART I/O port; the modified AC-30 cassette interface; and a National Panasonic portable cassette recorder with a remote stop/start facility. It proved possible to use commercial audio cassette tapes with this configuration. A brief description of the individual modules is given in Appendix 1, and a block diagram of this initial system is shown in Fig. 1.

INPUTS

Data is input to the system via four of the MK4/12 I/O Ports B. Each of these ports has two connectors in parallel. The connectors may be used to receive input from several types of source. We use two, handsets and automatic sensors. Each handset has eight push-buttons as inputs to the MK4; each button has a corresponding LED indicator powered from the MK4. Any type of automatic sensor, such as pneumatic tubes or induction loops may be used provided its output can be converted to a switch closure signal. We have been using coaxial cable and a suitable interface⁷ to detect the passage of vehicles and input the information to the I/O port.

OUTPUTS

Data is output from the system through the UART I/O port. For our

purpose, this output is transferred via the AC-30 to the cassette recorder. The cassette motor is controlled by two output bits of a specified I/O port - the control port.

SOFTWARE

The MK4 system uses the COSMAC microprocessor as its central processing unit (CPU). We have written and documented a program to collect, format and output the data (Golden River kindly allowed us the use of their development systems to write and test the programs). The development systems included an editor, assembler and various debugging aids.

The program was written in assembly language and is described in detail elsewhere⁸. The program begins by initialising counters, registers and constants and clearing memory, which takes about one millisecond. When this process is complete a signal is sent to a designated control handset via the appropriate I/O port as a message to the user that the system is ready to accept data. Subsequently, every 10 ms. the program checks the status of the input lines on those I/O ports to which handsets may be connected. The state of the input lines is shown on the LED indicators of the corresponding handset except for the two bits on the control handset which are reserved for cassette motor control. If, since the previous search, any input bit has changed from 0 to 1 (e.g. a button has just been pressed), the time, the handset number and the button number are recorded in ASCII code. This information, together with a parity symbol, is stored in RAM and forms one record.

Twenty such records form one block of data which is then output to tape. The output line on one bit (bit 7) of the control port is momentarily set high (= 1). This port is also connected to the cassette interface and the signal is used to start the cassette motor. A software delay of 1.25 seconds then occurs to allow the tape to reach its full speed. The program then outputs a START BLOCK message followed by the twenty records, and an END BLOCK message. The output line on bit 6 of the control port is then set high; this signal stops the cassette motor. It takes about eight seconds to output one block of twenty records.

While the output procedure is taking place the program continues to check the inputs and record events in a buffer area in RAM. In the present system the buffer can hold five blocks (100 records) of data. Before beginning to record a new block, the program checks that there is sufficient space in the buffer to record the data. If this is not the case, a signal is output to the control handset to indicate that an overflow has occurred. The program must then be restarted and any data not already transferred to the cassette recorder is lost.

In order for an overflow to occur, the access rate must average more than 150 events per minute. For present purposes the access rate is low enough not to overflow the system. However, the system may be extended to cope with a higher access rate.

DATA ANALYSIS

The raw data is played back from tape via the AC-30 through a UAPT port at 300 BAUD to files on a CDC 6600 computer. The accuracy of the transfer is checked using the parity symbol on each record and the data is reformatted for use with our existing analysis programs.

DISCUSSION

The data collection system described here satisfies all of our initial requirements. Although the equipment is portable, it is larger than was first envisaged - this is mainly due to the size of the AC-30 and the batteries used as its power supply. A second version is being designed which should eliminate the need for the AC-30.

Most automatic traffic detectors in present use are based on induction loops or pneumatic tubes. Induction loops are generally used for permanent installations, and are relatively expensive. Pneumatic tubes provide a cheaper alternative, and may be used with the MK4 system. We have

used coaxial cable (with a suitable interface) in preference to pneumatic tubes because we found them much easier and quicker to install. Trials have shown this method of detecting vehicles to be successful, provided that the vehicles are travelling quickly enough (of the order of 10 mph and above) to "hit" the cables with sufficient force to produce a signal.

An observer presses a button on a handset to indicate that a specific event has occurred. The present system records the time the button was pressed to an accuracy of one hundredth of a second. The accuracy of the data recorded is limited by the accuracy of the observers.

The existing system is very versatile. It accepts data from switch closure inputs, formats it and outputs it to cassette tape. Thus it could be used for many real-time data collection purposes - not necessarily confined to traffic studies - provided analysis programs were available or could be written on a mainframe computer. Indeed a mainframe computer is not necessary. The data could be fed back into the MK4 system and a program written so that the microprocessor could analyse the data. The main limitations are on the data acquisition rate and the data transfer rate.

Although, at present, we use the system merely to collect data, the system could be adapted for many computing tasks. By connecting a teletype, VDU or similar device to the UART port of the MK4 system, one has a self-contained computer system. The cassette interface can accommodate two cassette recorders, allowing program and data storage, and the possibility of developing editing programs.

When using the existing system it is a simple matter to check visually that the cassette recorder is stopping and starting. LED indicators on the AC-30 show when it is receiving data. There is, however, no check that the data is reaching the cassette recorder, or that such data is meaningful.

An external earphone can be connected to the cassette recorder to check that some sort of signal is reaching the recorder. To check that the data is meaningful it would be necessary to connect some form of digital display between the interface and the recorder or to the output socket on the recorder. This is not thought to be worthwhile for our present purposes as data can be quickly checked on return from the field, and the site can always be revisited. However, if the system is used for other tasks, such a check may be required.

The data collection system, as described in this paper, has been used at several T-junctions. As with almost all new systems, there have been some problems. These have arisen primarily from two sources: bad connections between the cassette interface and the cassette recorder; the power supplies on the cassette interface and cassette recorder have sometimes become too low to operate effectively. The latter problem is caused by human error in leaving power switches on or in not keeping the equipment fully charged. The second version of this equipment (now being designed) will eliminate both these shortcomings, as the cassette interface and cassette recorder are being replaced by a cassette unit within the MK4 system, thus eliminating the need for connecting wires and separate power supplies.

Despite the "teething troubles", we now have a considerable amount of data on the files of a mainframe computer. This new system of collecting traffic data requires, as was expected, much less time between observations and results, than the previous video methods.

CONCLUSIONS

- (1) The system has been used to collect traffic data from several T-junctions.

Analysis of this data is comparatively easy, and much quicker than using video techniques.

(2) The accuracy of the data is limited by the accuracy of observers in a real-time situation.

(3) The equipment, although fairly bulky, is portable; a second version is being designed which will be physically smaller than the initial system.

(4) The system can be used for other data collection purposes or, with modifications, it can be used to perform many computing tasks.

(5) At present, data collected on site cannot be checked there. Checking the data on site is thought to be feasible but not necessary for our present purposes.

ACKNOWLEDGEMENTS

The authors wish to thank the Golden River Company for considerable assistance with the hardware design, for software advice and for use of their software development systems. They would also like to thank Mr. Martin Meyer of the Physics Department, Royal Holloway College, for his significant contribution to the development of the coaxial cable sensors. Mr. John Darzentas and Miss Mary Woodcock, both of the Mathematics Department, Royal Holloway College, assisted in testing the equipment. This work was carried out under contract to the Transport and Road Research Laboratory.

APPENDIX I

EQUIPMENT

(a) Golden River Equipment

(i) 1 MK4/1 Card Frame.

This houses and connects all the various modules in an MK4 system up to 17" in total width.

(ii) 1 MK4/2 Case.

This accommodates one MK4/1 Card Frame to provide a finished housing for an MK4 system in a protected environment. An environmental case is also available but the lighter (in weight), cheaper MK4/2 is sufficient for our purposes as we do not intend collecting data in the rain nor do we leave our equipment unattended.

(iii) 1 MK4/4 Power Supply.

This consists of rechargeable Nickel Cadmium Cells. Provision is made for operation and charging from 240 V AC or a 12 V DC supply, such as a car battery.

(iv) 1 MK4/4 Microprocessor.

The microprocessor provides all the logic to perform the instructions stored in program memory.

(v) 1 MK4/6 Random Access (1024) Bytes.

This is used as a temporary data storage space and provides a "working area" for the program.

(vi) 1 MK4/7 Programmable Read Only Memory.

This is used as read only memory for areas of program or data which must not be altered in the course of program execution.

(vii) 4 MK4/12 I/O Port B.

These units each take 8 switch-closure inputs. Outputs are used for LED indicators on the MK4/19 handsets and, in our configuration, two bits of one MK4/12 output are used for the cassette motor control. Each MK4/12 has two parallel I/O sockets.

(viii) 1 MK4/13 RS232C Interface.

This is the UART port which allows for devices such as modems, teletypes, VDU's to exchange data with the processor and memory.

(ix) 1 MK4/18 Real Time Clock.

This provides a time base for maintaining an accurate software based clock by generating an interrupt cycle every 1, 10, 100 or 1000 ms.

(x) 4 MK4/19 Handheld digital I/O units.

Each of these consists of 8 push buttons as inputs to the MK4; 8 LED indicators as outputs from the MK4; 4 toggle switches to control the state of 4 external flag lines (not used); and one toggle to switch off the LED indicators to conserve power.

(b) SWTPC AC-30 Cassette Interface

This is a mains powered unit which has been modified to run off rechargeable batteries. Its purpose is to connect a computer (or microprocessor) to one or two audio cassette recorders for the purpose of program or data transfer. Signals from the computer can be used to stop and start the cassette recorder motors. Software delays must be included in the controlling program to allow the motors to attain full speed before data transfer.

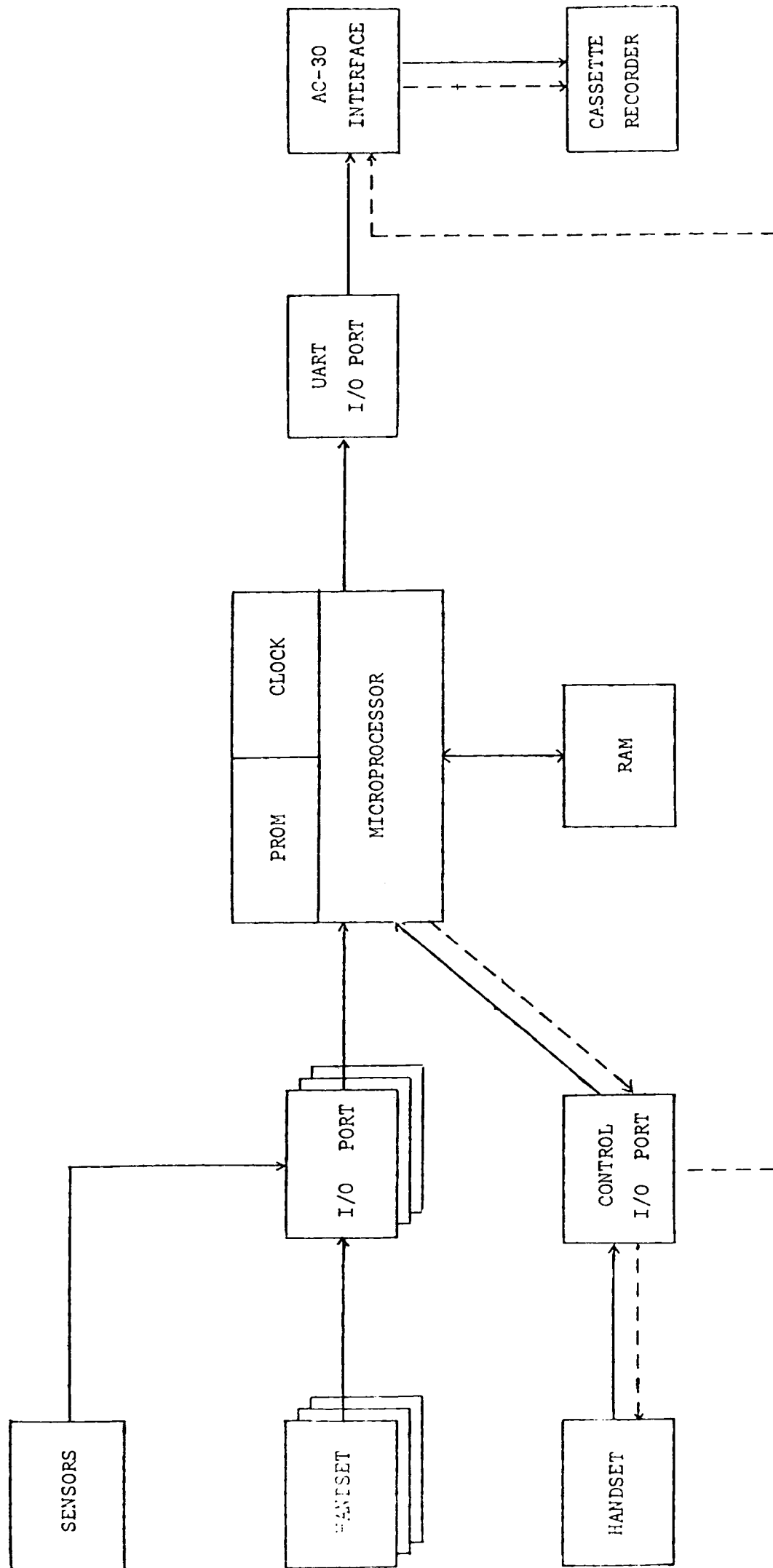
(c) Cassette Recorder

This is a National Panasonic cassette recorder, Model RQ-212DAS; it has a remote jack socket which can be connected to a remote control to stop and start the cassette motor.

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Fig. 1 Data Collection System



→ Data Flow

- - - - -> Control Signals

3.6 Empirical studies of driver behaviour at T junctions & use of a simulation model to study conflicts.

J. Wennell, P. Storr, J. Darzentas, M. R. C. McDowell;

I. Introduction

A simulation model to predict conflicts at a non-urban T-junction has been developed at Royal Holloway College¹ (RHC). A general description of this model, and some preliminary results relating conflicts to flow and speed are presented in §II. If the model is to be used to assess accident risk at junctions², we must be able to relate the conflicts predicted by the model with the injury accident record at such junctions. Empirical data from an appreciable number of junctions must be collected to provide details of the parameters needed as input to the model. An investigation of the relationship between model conflicts and accidents may then be conducted (and hence the model can be calibrated). The methods of collecting the empirical data and the selection of suitable sites for observation are outlined in §III. Details of associated work at RHC are given in §IV, and our current research program is discussed in §V.

II. The conflict simulation model

Six distinct vehicle movements are permitted at the T-junction (Figure 1), which is assumed controlled by a Give Way sign. The right-of-way rules lead to the formation of queues in the centre of the major road and in the minor road, as vehicles wait for an opportunity to turn. The model assumes an infinite line of sight at the junction, and no overtaking is permitted.

Major road streams of traffic are characterised by a flow

rate, a distribution of preferred speeds (i.e. the speed at which a vehicle would travel if it was a platoon leader), and a distribution of inter-vehicle time headways. Drivers of turning vehicles assess the gap available in major road traffic, and make their decision of whether or not to turn according to a gap acceptance function derived from empirical data. If a turning driver makes a poor gap acceptance decision and accepts a gap which is shorter than the time required to complete the manoeuvre, vehicles in the major road are forced to slow down, and a conflict occurs. The severity of the conflict is measured by the deceleration needed to avoid a collision (lane-changing is not permitted in the model). A detailed description of the model is given elsewhere^{1,3}.

Preliminary results

In the model, conflicts may occur at four positions within the junction (Figure 2). The results quoted here are for conflicts of all grades of severity combined, averaged over a series of trials.

Conflicts and flow

Conflict frequency in any position is proportional to the product of the flows in the interacting traffic streams, e.g. for a fixed turning flow, conflict rate increases approximately linearly with major road flow.

Conflicts and speed

Empirical studies have shown that gap acceptance varies according to the speed of the approaching major road vehicles⁴. In the case of the crossing manoeuvre, the proportion of major road vehicles involved in conflict increases approximately linearly with speed; as approach speed increases the median accepted time gap decreases while the crossing time remains constant, so conflict involvement increases. For merging conflict involvement increases faster than linearly; with increasing approach speed, the median accepted time gap decreases, but the time required to complete the merge and accelerate to the speed of the major road vehicle increases. In addition, the merging driver is likely to prefer to travel more slowly than the major road vehicles with speeds above the mean traffic speed, increasing the chances of a conflict with such vehicles.

III. Observations of T-junctions

Site selection

A T-junction must satisfy several criteria to be suitable for our purposes. It should be situated in a non-urban area, since the model simulates a non-urban environment. The junction should have a high injury accident record in recent years, to provide a reasonable number of such accidents to correlate with model conflicts. In addition, fairly high flows are necessary, so that sufficient data to derive the distributions needed for

input to the model may be collected in a few days. Finally, it must lie within an acceptable distance from RHC to enable daily travel to the site.

Thirteen T-junctions which satisfy the above conditions have been identified. Observations were made at eight of these junctions during last summer, in good weather conditions. Observations at the remaining sites began this month.

Methods of observation

Data was collected using the microprocessor based system developed at RHC⁵. The system receives input from either handsets or automatic sensors. Each handset has eight push-button inputs; when a button is pressed, the handset number, the button number and the time at which the button was pressed are recorded. This data is stored on an audio cassette tape.

In general, each observer uses one handset, and observes one stream of traffic at the junction. He presses a particular button on the handset to denote that a specific event has occurred; for example, the arrival of a vehicle, or the start of a turn. Additional information such as the type of vehicle or the sex of its driver may also be recorded. Automatic sensors are used to detect arrivals in one major road stream of traffic, and to collect data from which speeds of major road vehicles approaching the junction may be calculated.

Data analysis

Data from the cassette tape is transferred to a mainframe

computer via a direct link from RHC. The data is then processed to produce the following results: average flow values; speed distributions of major road vehicles; details of traffic composition and driver population; distribution of exposure times for vehicles turning right into the minor road (the exposure time is the interval between the start of the turn and the completion of the manoeuvre, when the entire vehicle has crossed into the minor road) and tables of accepted and rejected gaps for each turning stream of traffic (from which a gap acceptance function is derived).

So far, results from two particular sites have been used as input to the simulation model. The two junctions are close together, and the majority of traffic passing through one also passes through the other, as the major road is common to both. However, the injury accident records for the two sites are rather different.

IV. Associated research

Double gap acceptance

An important part of our simulation work is the modelling of the driver's decision-making process on whether or not to accept a presented gap in the major road traffic stream. A considerable amount of work has been reported in the literature on gap acceptance where the turning driver is merging with or crossing a single stream of traffic. There appears to be little published work on "double gap acceptance" where a driver has two streams of traffic to consider. Work is in progress to examine the gap acceptance characteristics of the minor road

driver wishing to turn right (U.K.) at a T-junction. Preliminary results are now available⁶.

Sex and age

Using a slightly different model of driver behaviour, based on the concept of a minimum acceptable gap, the simulation model has been used with empirical data to show how risk-taking behaviour varies with the sex and age of the turning driver⁷. It was found that older drivers are more likely to cause conflicts than younger drivers, and males are more likely to cause conflicts than females.

Daylight and dark

Very little has appeared in the literature on differences in gap acceptance behaviour in daylight and darkness⁸. A pilot study to examine the gap acceptance behaviour of merging drivers at one particular T-junction (the entrance to the College) in conditions of daylight and darkness is in progress. Observations have been made on seven dark winter evenings, using similar techniques to those outlined in §III. The use of headlights or sidelights by oncoming major road vehicles was also recorded. Observations in daylight conditions are now being made. The results of this work will be used as input to the simulation model, so that the conflicts predicted for daylight and dark conditions may be compared.

V. Current research programme

Work is continuing on analysis of the observations taken at thirteen non-urban T-junctions. In the first stage, the basic parameters needed to run the model are derived (see §III) and model conflicts compared with accident records for each site. Cluster analysis and other methods will be used to group the sites, and to attempt to identify those parameters most closely related to conflicts.

Data has also been obtained on sex of driver, presence of passengers, type of vehicle and speeds of approaching major road vehicles. At the second stage of the analysis we will examine the effects of each of these parameters in terms of model conflicts.

We intend to extend the model to non-urban priority controlled four way intersections, and to carry out observations at a number of such junctions. The extended model will then be used to predict conflict rates in these circumstances.

Following the pilot study on gap acceptance in the dark, further observations will be carried out during winter evening rush hours at a subset of the original thirteen T-junctions, to extend our knowledge of the difference (if any) in conflict rates in daylight and darkness.

VI. Acknowledgements

The research described here is performed under contract to TRRL, with additional support from London University. This report covers work carried out by Mrs. Jenny Wennell, Mr. P. A. Storr and Mr. J. Darzentas, under the supervision of Professor M. R. C. McDowell. The assistance of Dr. Dale F. Cooper (now at Southampton University) is gratefully acknowledged.

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Figure 1

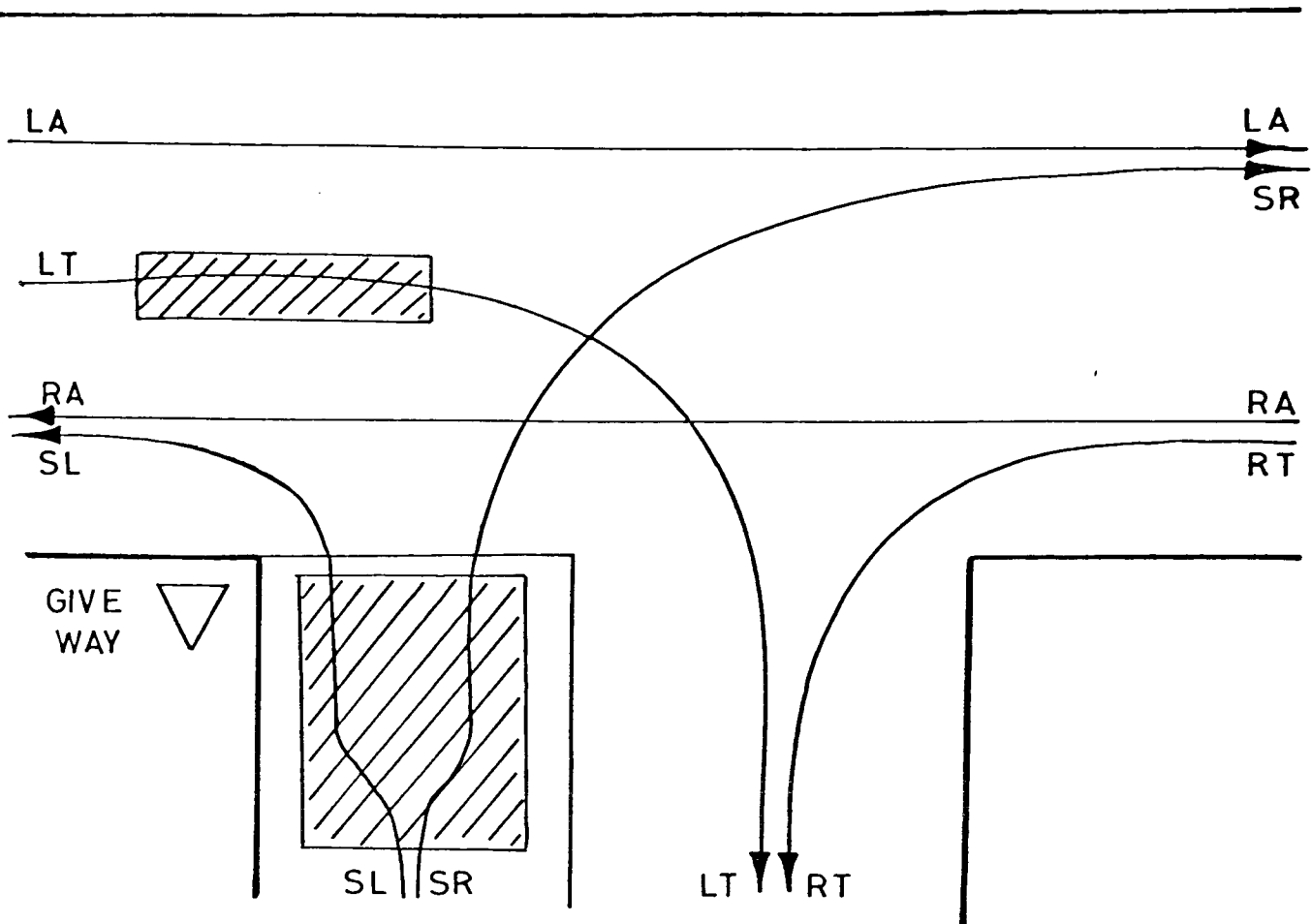
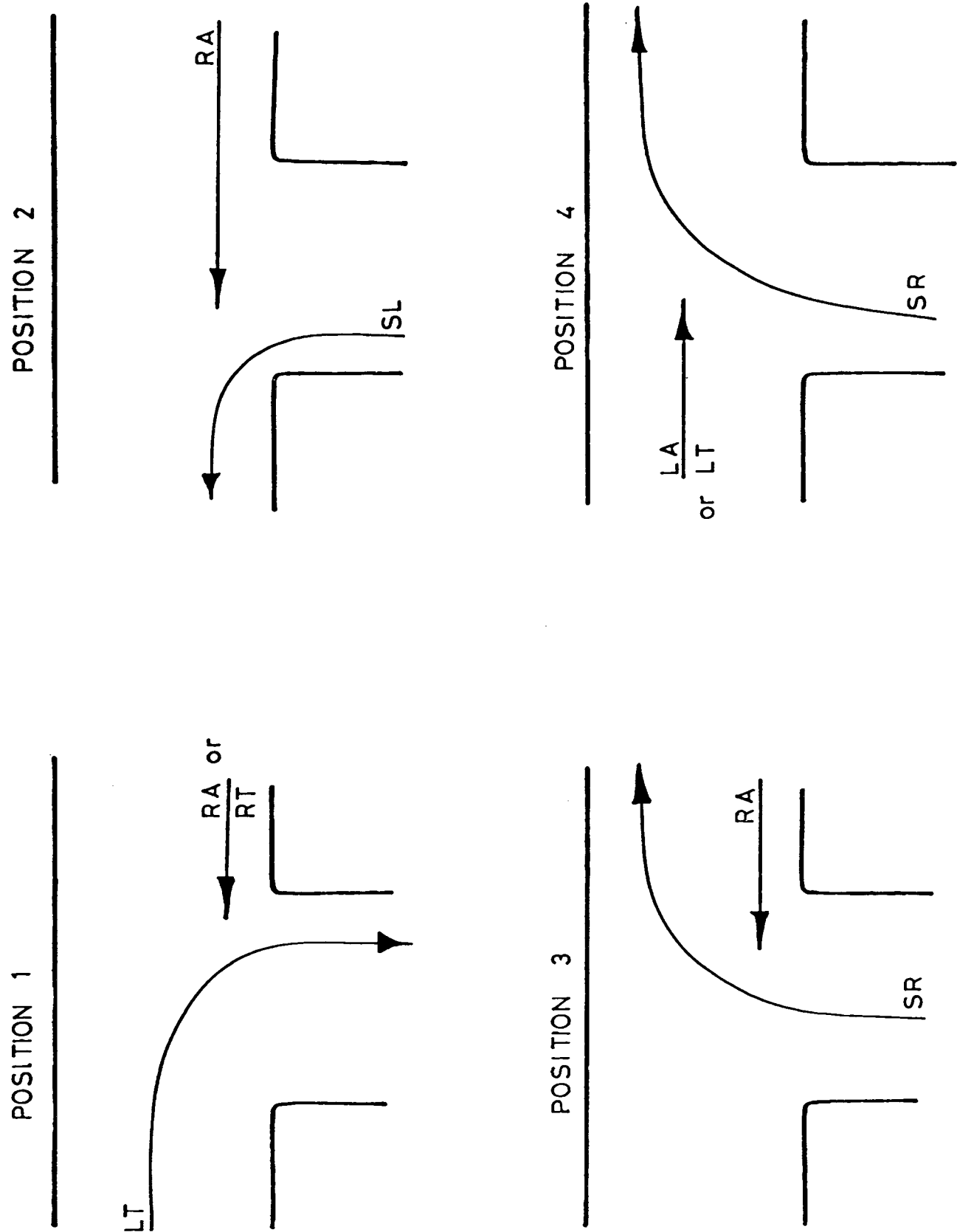


Figure 2



3.7 2nd International Traffic Conflicts Technique
Workshop

May 10th - 12th, 1979

A study of observer variability and reliability in the detection and grading of traffic conflicts

A. Lightburn and C. I. Howarth
Department of Psychology,
University of Nottingham,
England.

Summary of method and major findings

After a one hour training session forty-two observers watched six films, each made up of 12 clips of 16 mm silent colour film (72 clips in all). Each clip was 25 - 30 seconds long and were separated from one another by blank pieces. The films were from three real life traffic situations. The films were shown in a different order on each of three consecutive days. The observers had to identify whether a conflict occurred in each piece of film, and if it did, to make a drawing of it and allocate it a grade between 0 and 4. The definitions of these grades were based on Older and Spicer (1976).

Inter-observer variability on the third day was measured by a correlation coefficient of 0.68. Intra-observer reliability between day 2 and 3 was measured at 0.75. There were large differences among the observers, in their consistency and detection rate.

Concordance rates on day 3 between observers and the criterion set by expert judgement was 0.67. The majority of the observers agreed with the criterion in 66.7% (48) of the 72 situations.

There were no significant differences between male and female observers, or between drivers and non-drivers.

The Theory of Signal Detection was applied to the data obtained, and the benefit of selectively eliminating various percentages of observers was examined.

Introduction

Our objectives in this study were to see whether the identification, classification and recording of traffic conflicts could be adequately carried out by the type of personnel typically employed by local authorities as temporary traffic enumerators. If sufficient ability existed in these people, then we could advocate that these studies in future be carried out by such part time personnel. This would release full time investigators from this time-consuming work and would probably encourage more studies to be undertaken. From the relatively simplistic pool of enumerators which many authorities use, a number could be turned into a useful, objective and sophisticated team capable of carrying out all manner of skilled observation techniques including conflict studies.

The specific issues to be resolved were:

- a) what is the extent of the variability between observers in the detection and accuracy of grading conflicts?
- b) how consistent are observers as regards the detection rate and the accuracy of their gradings?
- c) is there evidence to suggest that conflicts at some locations are more difficult to identify than at others?
- d) are there any sex differences in the ability to detect and grade accurately?
- e) do drivers have any more or less difficulty identifying and classifying conflicts than non-drivers?

Method

Observers

A total of 42 student observers were recruited from within the University. No selection procedures were applied as the whole nature of reliability and variability among observers was under study.

There were 4 separate training sessions with between 7 and 14 people in each. The size of the screens displaying the films limited the maximum size of the groups.

Instructions to observers

After each observer had read the written instructions, the experimenter went through them again verbally in greater detail. They explained what a conflict was and briefly the reasons for studying conflicts

as an aid to accident investigations. The grading system (based on Older and Spicer 1976) was explained and diagramatic examples presented.

A demonstration film was shown to give an example of a conflict in real life and was presented several times with opportunity for discussion and queries. The speed could be reduced and the film stopped on request.

One minute of film of each of the locations was shown and the layouts explained. After each, a number of trial pieces of film of similar length to those used in the experiment proper were shown, and the observers followed the events from pre-prepared example sheets with diagrams and a written explanation of each conflict together with the appropriate grading.

Finally the trainee observers saw 6 trials (2 of each location) to practice drawing and writing down what they had seen. Each trial was repeated in slow motion with the experimenter pointing out the incident and discussion was allowed.

Before each of the 6 films, the experimenter told the observers which site it would be. There were 12 clips in each film, all from the same site i.e., 2 films were of site 1, 2 of site 2, 2 of site 3. The 6 films were shown in a different random order on each day of the experiment. The observers saw 72 clips each day, a small number of these showing traffic but no conflicts.

Results

Inter-observer variability

The degree of correlation between observers increased during the experiment i.e., observers had a higher level of agreement among themselves on the second day when compared to the first, and was highest on the third day of the experiment (Figure 1)

Day	1	2	3
r	0.61	0.67	0.68

FIGURE 1. Average inter-observer correlation coefficients across days

On the final day (Day 3), the overall correlation between observers was 0.68. Although in statistical terms this figure is fairly good ($N = 42$), whether this figure is acceptable in general observation work in the field is questionable.

Intra-observer reliability

Figure 2 shows the average correlation coefficients ($N = 42$) i.e., the degree to which an observer agreed with himself when viewing the same incidents on different days.

Days	1 - 2	1 - 3	2 - 3
r	0.65	0.67	0.75

FIGURE 2. Average intra-observer correlation coefficients across days

The correlations between days 1 and 2 was lowest, but between days 2 and 3 had improved considerably. There were large differences between observers. The highest correlation between days 2 and 3 was 0.91, and the lowest 0.30. Poor quality observers greatly influenced the results and indicate the importance of selection. When observers were ranked for position according to their correlation coefficients and these ranks correlated for Days 1 - 2 and 2 - 3, $r = 0.73$ i.e., those who scored highest on Day 1 were most likely to score highly on Days 2 and 3, and vice versa.

Comparison with criterion

Each conflict was judged by two "experts" and a criterion grade set for each. Each observer's gradings were compared to this criterion. The correlations showed a trend towards better agreement on the third day than on either of the two previous days.

Days	1	2	3
r	0.60	0.65	0.67

FIGURE 3. Average observer-expert correlation coefficients across days. ($N = 42$)

The greatest difficulty for observers appeared to be in distinguishing between grades 1 and 2. 76.5% of those incidents with a criterion grade of 2 were allocated a lower grade by the majority of the observers. Incidents graded by expert judgement as non-conflicts and as grade 1 were correctly graded by 92.3% and 93.3% of the observers respectively.

The problem can be divided into four possible causative factors:

- i) category grades 1 and 2 were not mutually exclusive enough i.e., too subjective.
- ii) genuine misinterpretation of the incident due in part to the form of the presentation (film) and partly to its short and singular presentation.
- iii) a down-grading of the incidents because of the prior knowledge that no accidents occur in the films.
- iv) insufficient awareness of the subtlety of the severity of avoidance manoeuvres, possibly due to insufficient instruction and practice in hazard perception.

If the latter could be improved, then it is thought that this in turn will help counter the problems involved in the first three.

Comparison of locations

There was evidence from the results to suggest that conflicts at one of the locations were

- a) easier to detect than at the other sites and
- b) more reliably graded.

When questioned verbally, most of the observers agreed that incidents at this particular site were easier to identify and record.

Sex differences

No significant differences were found between the results of male observers when compared to female observers.

Driver/non driver differences

There were no significant differences between drivers and non drivers in the grading of the incidents. As the observers were all under 27 years of age, and most were between 18 and 21, the amount of experience among the driver group would be quite small. Most did not own their own car and therefore did not drive regularly. This may account for the result. It is possible that there might be a difference when older observers are considered, where the drivers are regular motorists with some years experience.

Observer selection

As poorer quality observers greatly influenced the overall results of the group, we examined the effect of eliminating various percentages from the data.

Figures 4 and 5 show the results of

- i) looking at performance on Day 3 and eliminating various percentages of observers
- ii) looking at performance on Day 1 and then eliminating the poorer percentages of observers from Day 3 according to their results on Day 1.

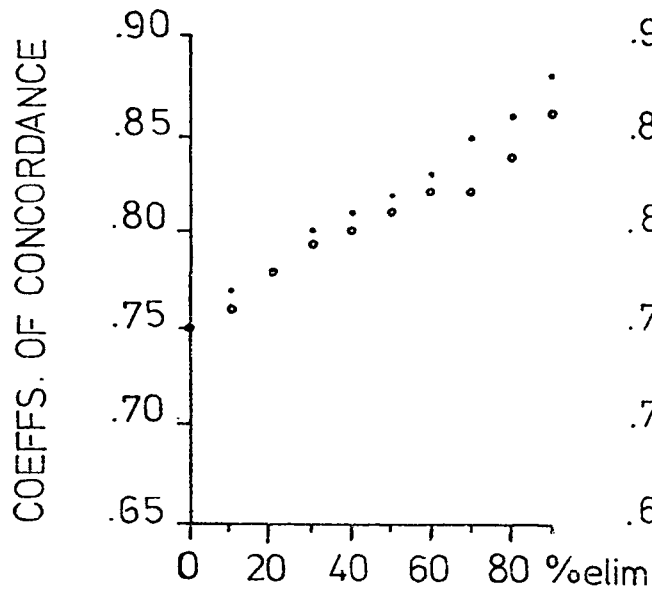


FIGURE 4. Intra-observer correlation coefficients

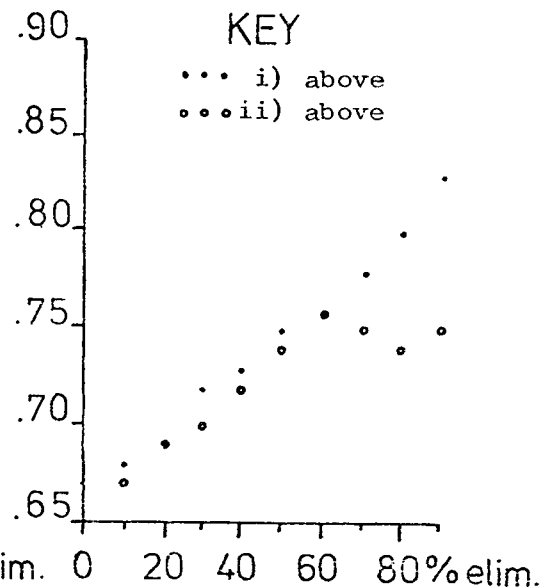


FIGURE 5. Observer-expert correlation coefficients

This would indicate that it is better to take the trainees through the entire training programme rather than eliminate right at the beginning. Some observers take longer to assimilate the ideas involved in the technique. Nevertheless quite effective selection can be made on the basis of one test after training.

The signal detection theory approach

The Theory of Signal Detection was originally developed to describe the reception characteristics of communication systems, particularly with respect to radar. Tanner and Swets (1954) suggested that it might also be relevant to the detection of signals by human observers in a variety of perceptual tasks. Basically the theory relates the detectability of the signal by an observer to the physical characteristics of the stimulus. A signal is either present or not present and the observer makes a response indicating, according to his judgement, whether the signal is present. Newsome (1974) examined the Theory of Signal Detection concepts of sensitivity and bias as a

possible way of usefully discussing risk taking as a decision process in driving. The detection task for our observers was to correctly identify from the vehicle manoeuvres when corrective or avertive action had been taken. For our purposes

a hit was defined as the correct observation that a conflict had occurred (regardless of grade subsequently given)

a miss was defined as the incorrect grading of a piece of film as not including a conflict when a conflict had occurred according to expert judgement

a false alarm was defined as the identification of a conflict in a piece of film when no such incident had occurred according to expert judgement

a correct rejection was defined as the correct identification and subsequent grading of a piece of film that did not show a conflict situation

The overall distributions from this study are shown in Figures 5 and 6

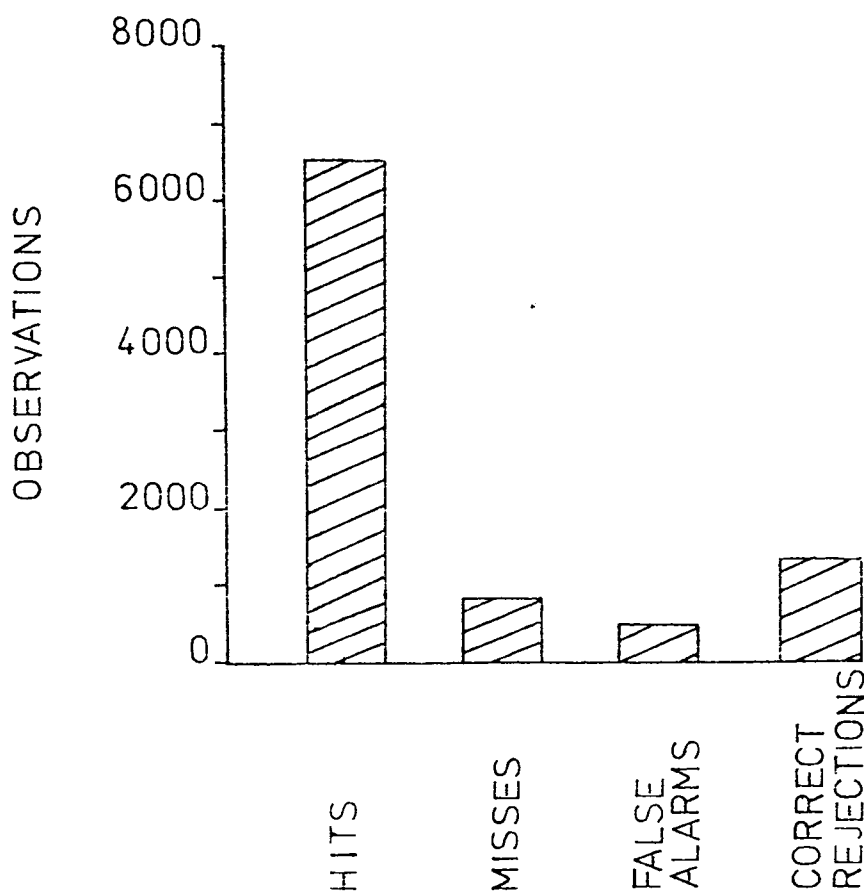


FIGURE 5. Overall distribution and proportions of hits, misses, false alarms and correct rejections.

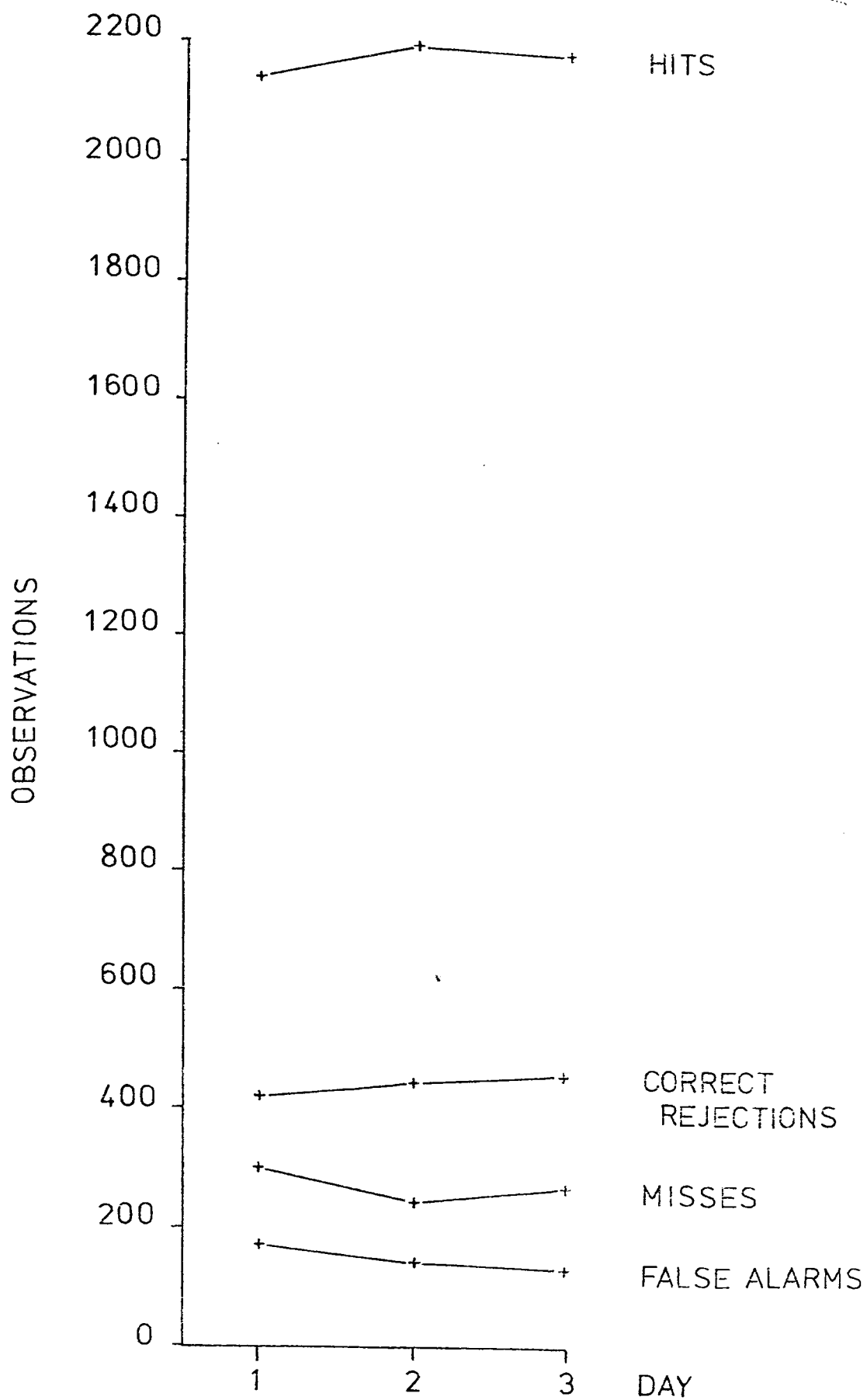


FIGURE 6. Distribution of hits, misses, false alarms and correct rejections across days.

Conclusions

- a) With no prior experience, observers can be trained to detect, record and classify those situations known as traffic conflicts.
- b) Observers differ considerably in their ability to identify, record and classify traffic conflicts from film, but improved over time and with practice to a maximum of 0.68 (N = 42).
- c) Observers are reasonably consistent with themselves. Viewing of the same situations on subsequent days yielded a correlation coefficient of 0.75 (N = 42). This could be improved by observer selection.
- d) There is evidence to suggest that conflicts at some locations are easier to detect and grade accurately than at others.
- e) No sex differences were observed in the ability to detect and grade conflicts.
- f) The question of whether drivers have any more or less difficulty identifying and classifying conflicts than non drivers remain unanswered.

Implications

It would seem that it is feasible to use part-time personnel to carry out conflict studies. This project has demonstrated the levels achieved given a brief (one hour) introduction and training period.

It has provided much valuable information and has helped pinpoint areas which still need to be investigated. It has contributed to our ultimate aim, which is to produce a training manual and associated visual aids for use by local authority traffic and road safety departments to train personnel to carry out traffic conflict observation studies. The results obtained would help in identifying problems precisely and should ensure that remedial measures are more soundly and economically based.

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3.8 VARIATION IN VEHICLE CONFLICTS AT A T-JUNCTION AND COMPARISON WITH RECORDED COLLISIONS (Summary)

by B R Spicer, A H Wheeler and S J Older, TRRL, U.K.

A six-month long study has been made of vehicle conflicts occurring at a semi-urban T-junction where two main roads meet. At this junction, between A404 (Stanley Hill) and A413 at Amersham in Buckinghamshire, repeated daily and hourly conflict counts were made on weekdays during this period, from 0800 to 1800 hours each day.

In all, conflict data for 27 days including 15 successive Tuesdays and three complete five-day weeks were collected by observers at the junction. This data was backed up by regular flow counts and a continuous time-lapse cine-film record from an automatic camera overlooking the junction. This film provided the collision data.

Day to day variation in daily conflict counts has been shown to exist but demonstrates no consistent day of week or seasonal effects for counts made at the site on weekdays. (The mean daily conflict count was 125, including 21 serious).

There is evidence of daily conflict numbers being closely related to vehicle flow levels in the intersection. The relation is less strong if serious conflict numbers alone are used. Vehicle flow levels themselves showed no obvious day of week or seasonal effects.

Considerable variation in the hourly counts of conflicts has been shown to exist during the day and the number of conflicts are closely related to vehicle flow levels for the same hours. A relation is found for the number of conflicts in each manoeuvre type with the levels of flow in the particular manoeuvres concerned. The exact form of the relation differs between conflict types but in each case is effectively linear over the range of variables concerned (see Fig 8(c)).

The flow dependent relations in the preceeding paragraph could be demonstrated for total numbers of conflicts but not so clearly if serious conflicts alone were considered.

At this intersection the manoeuvres producing the most conflicts in total (see Fig 4) also produced the most conflicts per unit of vehicle flow involved, ie they were the more 'dangerous' manoeuvres. The most frequent and 'dangerous' manoeuvres were turning right from the minor road: (a) merging with the farside stream of traffic and (b) crossing the nearside traffic stream; in that order. (69% of conflicts of all severities and 77% of serious conflicts involved these right-turning vehicles).

The day to day variability in conflict counts varied with the size of the mean daily count. An empirical relation between the variance of the daily counts (S^2) and the mean daily count (\bar{x}) was represented by the formula:-

$$S^2 = \bar{x}^{1.2}$$

The data show that at this intersection a two to three day count of conflicts would give a prediction of the long term daily mean conflict number which would usually be within about 10% of the true value.

The location of serious conflicts showed as close a relation to the location of reported injury accidents at the site as could be expected from the small number of accidents available. The location of the most frequent serious conflicts

identified the three interacting manoeuvres which were involved in the reported accidents involving vehicles other than two-wheelers.

Recorded collisions at the site (other than reported accidents) showed a number of nose-tail or shunt incidents which were not apparent to any marked extent in the conflicts or the reported accidents. Again small numbers of recorded collisions made valid comparisons difficult.

This study shows that traffic conflict counts, as made in this type of situation, have adequate repeatability to make them a useful research technique.

The work described in this digest was carried out in the Road User Characteristics Division of the Safety Department of TRRL.

Editors note: The full report can be obtained from the Transport and Road Research Laboratory, Crowthorne, Berkshire, RG11 6AU, United Kingdom.

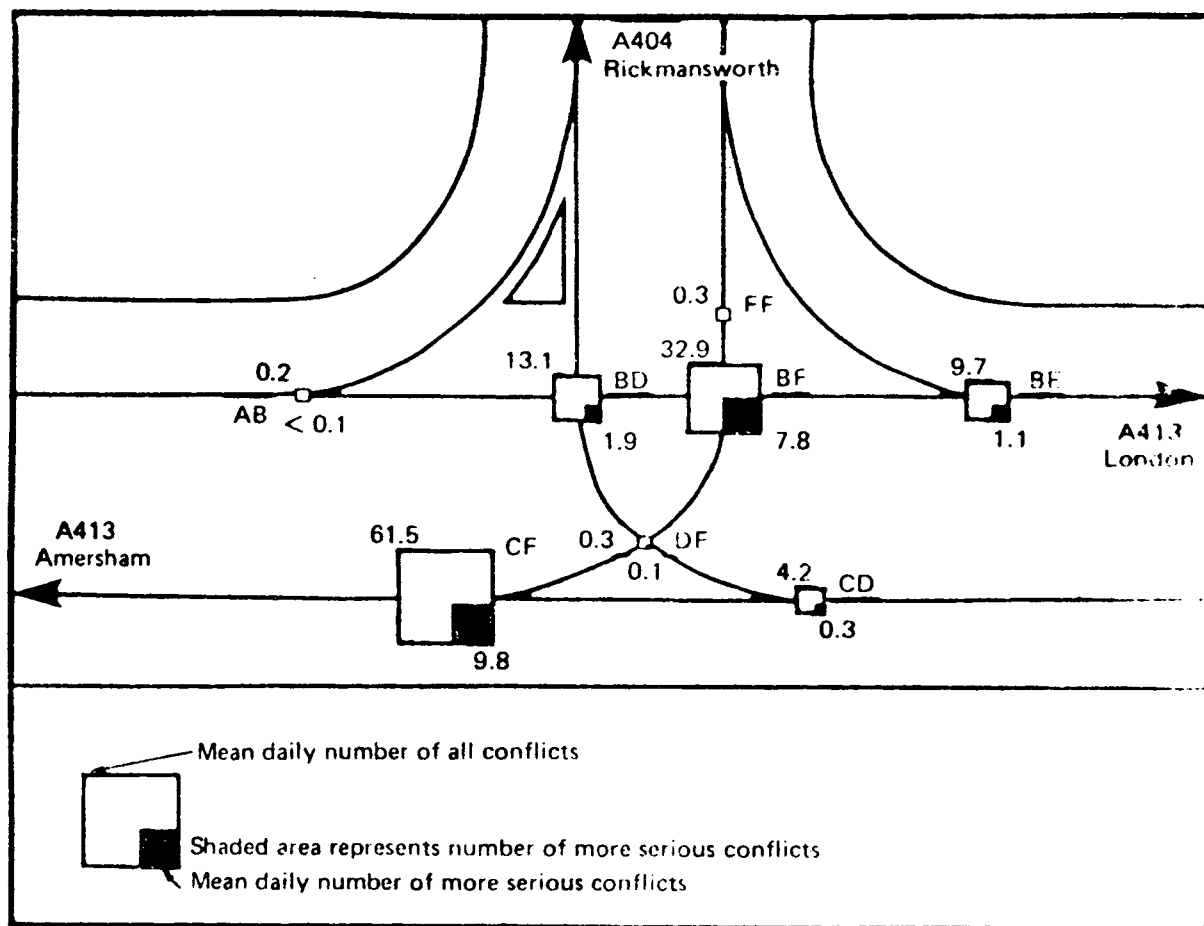


Fig. 4. MEAN DAILY NUMBER OF CONFLICTS OF DIFFERENT TYPES FOR ALL DAYS (08.00 – 18.00hr)

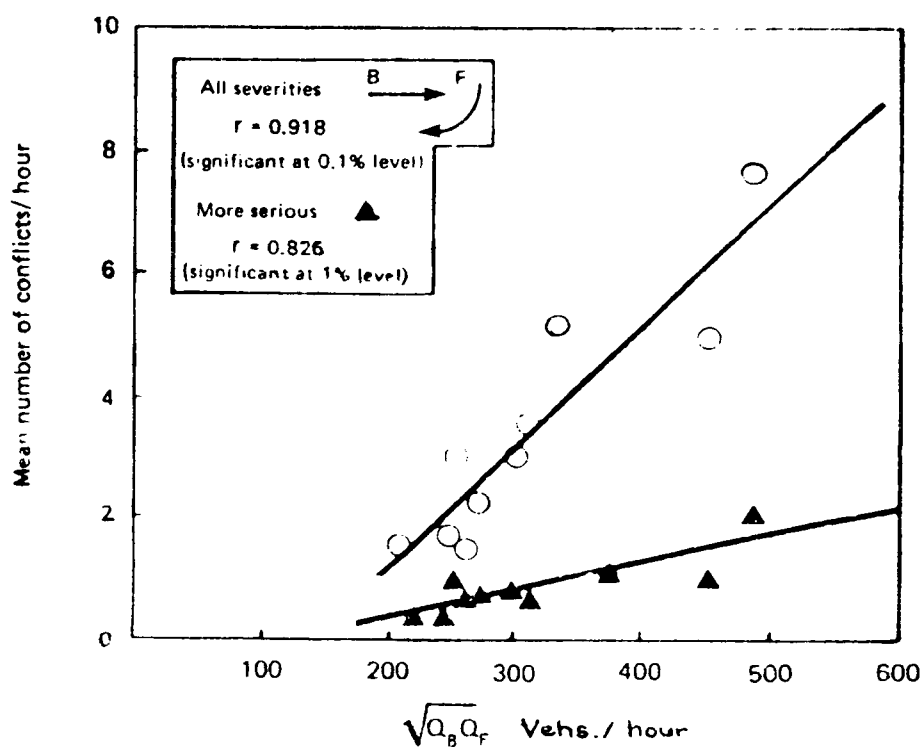


Fig. 8.(c) Conflict type BF

3.9 The validation of a conflict observation technique for child pedestrians in residential area's. Some impressions of ongoing research. Contribution to the 2nd International Traffic Conflict Technique Workshop.

Viktor A. Güttinger

At the last meeting in Oslo I summarized the results of our efforts .

to develop a reliable and valid conflict observation technique that could be used as a tool to predict accidents of child pedestrians in residential districts.

At that moment I only could say that we possessed a fairly reliable instrument with which it was possible to get an amount of information in a reasonably short period, of what happened in residential precincts in terms of "encounters" (from "contact" up to "serious conflicts").

I also mentioned that we were trying to test the validity of our instrument that is: can we use serious conflicts to predict accidents?

Although the results of this study are not yet published and I therefore can not give very detailed information, I will try to give an impression of this validity study and some of the results.

The first problem we had to face - and presumably all researchers in this area - is that the reason of trying to find a tool for predicting accidents, limits profound validity research. Why are we developing conflict observation techniques?

Because accidents are often badly recorded and in most situations infrequent.

But in testing the validity of our instrument we have to use these accidents.

We tried to meet this problem by:

- selecting locations in municipalities of which we believed that their accident-registration was fairly accurate,
- working with accidentdata based on a period of 5 years (1972-1976),
- not selecting locations if there was any doubt about correctness of the registered accidents, or if relevant information was lacking,
- not selecting locations where - in the period mentioned above - changes (of road or surrounding) evidently took place,
- interviewing the population in the surroundings of the selected locations, to get an impression of accidents that were not registered.

We finally selected 25 locations (or spots) with a maximum length of \pm 100 meters. The accidents with child pedestrians (0-15 year) varied from 0 to 5 (in 5 year). Each location was observed (by trained observers) for 34 hour (two weeks observation on working days after schooltimes).

Before mentioning any result, the question should be stated: "If you find a relation between serious conflicts and accidents how strong must it be, to be acceptable?".

We meant that the relation to be found had to fulfil two demands:

- 1.st the relation between serious conflicts and accidents must be stronger then the relation between traffic volume and accidents.
- 2.nd the relation between serious conflicts and accidents must be stronger then the relation between people's opinion regarding road safety and accidents.

Both, traffic volume and people's opinion, are used in Holland in deciding to take measures regarding to road safety: they are, in practice, used as an alternative criterion for accidents, to express opinions about road safety, to decide whether or not taking measures to improve safety

and to evaluate taken measures.

An additional reason to take into account traffic volume in our research, was the experience that in some studies traffic volume seemed to be the main explanation for the relation between conflicts and accidents. Because both correlated with traffic volume, they were related with each other.

The population in the surrounding of the locations was not only interviewed with respect to accidents, but we also asked them questions to get an impression of people's opinion of the road safety of the selected locations, for child pedestrians.

At first sight the results of our observations seemed rather disappointing. The (pm) correlation of serious conflicts between wheeled traffic and child pedestrians, with registered accidents was: $r = .51$, $p < .01$. That is, only a quarter of the variance of accidents could be explained. However: accidents in Holland are only registered if there is personal injury or damage ($> \text{Hfl. } 1000,-$).

Our conflict counts include serious conflicts between cyclists and pedestrians.

A collision between a cyclist and a pedestrian rarely will result in an accident with personal injury of the pedestrian. In fact all the registered accidents we worked with, consisted of collisions between fast moving traffic and pedestrians.

Leaving serious conflicts between cyclists and child pedestrians out of our data, we find a correlation of $r_{pm} = .82$, $p < .001$, a much more promising result.

Of all possible indicators of traffic volume (counts of wheeled traffic, counts of fast moving traffic, counts of protected and unprotected child-pedestrians (that is with or without the presence of adults) products of

the different counts, etc.), merely the counts of unprotected child pedestrians passing the locations under study, yielded the best result as possible predictor of accidents based on some indicator of traffic volume: $r_{pm} = .44$, $p < .01$ considerably below the mentioned $r = .82$ of the serious conflicts.

Multiple correlations of serious conflicts and the various indicators of traffic volume with accidents did not yield correlations above the .82 and the partial correlations showed that only a small proportion of the variance of accidents was explained by traffic counts.

For example:

Multiple correlation of serious conflicts and counts of unprotected pedestrians with accidents: $r = .82$

Partial correlation serious conflicts with accidents: $r = .77$

Partial correlation counts of unprotected pedestrians with accidents: $r = .11$

People's opinion about road safety as possible predictor of accidents yielded one remarkable result. We found a positive correlation between indulgence of parents towards young children and accidents: $r_{pm} = .40$, $p < .05$. That is, on those locations where relatively many children of 0-4 years were allowed to play without any supervision of parents, there were more accidents registered.

Although this relation is interesting, people's opinion regarding road safety, is no better as predictor of accidents than serious conflicts.

Our efforts to supplement registered accidents with unreported accidents did not yield very much success. Of course we realized that by interviewing people in the surroundings ($\sqrt{10.000/2}$ m) of the locations, we only would be able to detect a small proportion of unreported accidents, since children living at a greater distance than 100 meter could have had an accident at the locations of our interest.

That this seems to be true, is indicated by the fact that only 20% of the registered accidents we based our research on, was reported by the people we interviewed.

However this proportion is not constant and varies per location. The data are too little to calculate correction figures per location.

The correlation between serious conflicts with the total of registered and not-registered accidents was $r = .76$, $p. < .001$.

Finally we checked if the conflict-technique was sensitive for variations in different characteristics of the locations. Of course our technique has already an important limitation: child pedestrians in residential areas, but within this limitation variation is possible: there are broad and small roads, broad and small sidewalks, location with and without junctions, with and without crossing facilities, with and without specific and unspecific attraction points (play facilities, shops). Comparing the distributions of serious conflicts and accidents on locations, distinguished on base of these kind of road characteristics, we noticed that the relation between serious conflicts and accidents was not sensitive to these distinctions.

As I mentioned, the report on this study is not yet finished so I will not draw too many conclusions at this moment. The results of the analysis of the data up to now, confirm our previous idea that this technique could be a good instrument for road safety research in situations earlier mentioned. The generalization of the technique to other situations and other road users can be a subject for new research.

As will have appeared from the first seminar on traffic conflicts in September, 1977, in Oslo, no appreciable research had been instituted into traffic conflicts in Denmark. However, great interest has been taken in the development in other countries in the hope that some of the techniques being advanced would turn out sufficiently operational to be applied in practice.

The Secretariat for Safety Road Improvements wishes primarily to use the conflicts technique for establishing the effects of different road safety installations quickly with a view to advising the local highway authorities and to enable these authorities to utilize the restricted road investment resources to their maximum benefit for road safety purposes.

At the seminar in Oslo, the conflicts technique, advanced by Christer Hydén of the University of Lund, Sweden, seemed to yield promising results. It was decided that this technique should be tried out in Denmark. Today 2 analyses have primarily been carried out.

1. An intersection analysis made by Swedish observers in Denmark.
2. Analysis of a number of intersections made by Danes, trained in the Swedish observation technique.

The traffic conflicts technique is based on the following principles: (cf Christer Hydén: "A traffic conflicts technique for examining urban intersection problems" - presented in Oslo 1977).

A conflict is defined as a situation which would have led to an accident if none of the road users involved had taken any evasive action. The degree of severity of conflicts is determined by focusing on the moment when one of the road users, involved in the conflict situation, starts taking evasive action. The degree of severity is defined as the remaining time to an accident (in the following TO) if both road users involved had continued with unchanged speeds and directions.

A serious conflict occurs when the time to accident (T₀) is below 1.5 seconds. The following numerical values should be applied when converting conflicts and accidents, the table values indicating the ratios between accident per time unit and conflicts per time unit.

	Car-car	Car-bicycle Car-pedestrian
Low speed ¹⁾	3.2×10^{-5}	14.5×10^{-5}
High speed ²⁾	13.2×10^{-5}	77.2×10^{-5}

1) All situations in low speed intersections and situations with only turning vehicles involved in high speed intersections and situations with only turning vehicles involved in signalized intersections.

2) Situations with a least one vehicle involved, continuing on the same road, in high speed intersections and situations with at least one vehicle involved, continuing on the same road, in signalized intersections.

1. Intersection analysis with Swedish observers

The purpose of this survey was to study the possibilities of applying the Swedish conflicts technique in Denmark.

A comparison should be made between the risk of accidents ascertained over a number of years and the risk measured by conflicts. Modification of the layout of the intersection should be made, followed by an evaluation of the safety effect of this modification.

The analysis was carried through in a signalized intersection between 2 primary roads. The intersection is located in a small town. Average daily traffic is 6000 for one of the roads and 4700 for the other. Correspondingly, the speed limits are 70 km/h for the major road and 60 km/h for the minor one.

Personal injury accidents in the before period of 4.7 years are shown in fig. 1. Fig. 2 shows the conflicts registered in the before period. The material does not show significant similarities. The estimated risk when applying the Swedish conversion multipliers does not agree particularly well with the risk ascertained in connection with accidents.

Fig. 3 shows the conflicts registered in the intersection after modification of the layout. There have been material changes in the conflicts from the before period to the after period. The total number has been reduced from 37 to 27 which is significant on 5% level. Car-car conflicts have been reduced from 21 to 13. The decrease in car-car conflicts between cars turning left and cars continuing on the same road is significant on 5% level. Car-bicycle/moped conflicts have been reduced from 13 to 8. This change is significant on 5% level. The before period saw 3 registered conflicts between car-pedestrian and 6 in the after period.

The survey questions whether it is justifiable uncritically to apply the Swedish risk calculations to Danish road conditions. The survey indicates that a positive effect may be expected as the result of modification of the layout of the intersection in question. The distribution of the various types of conflict compared with real accidents could indicate the necessity of refinement of the conflicts technique so that the relation can be found between specific types of accident and the corresponding types of conflict.

2. Intersection analysis made by Danish observers

The project was carried out by The Technical University of Denmark. The aim of the project was: "To make a survey and evaluation of the conflicts technique as a means of judging the risk of accidents in unsignalized intersections." The Swedish traffic conflicts technique was applied, but the observers were Danes trained in observation techniques by Christer Hydén. 13 unsignalized intersections in the Copenhagen area were examined. The conflict observations were compared with accident data covering 7.6 years.

The analysis produced the following conversion values between conflicts and personal injury accidents.

	Car-car	Car-bicycle Car-pedestrian
Low speed	1.1×10^{-5}	14.5×10^{-5}
High speed	14.3×10^{-5}	53.3×10^{-5}

The numerical value 1.1×10^{-5} is based on a very slender basis. The values 14.3×10^{-5} and 14.5×10^{-5} fall within the 90% limits for the Swedish values. The 2 values may therefore be presumed to be the same for Danish and Swedish road conditions. But the conversion multiplier for high speed and car-bicycle/pedestrian may be presumed to differ from the Swedish value on the present basis.

At first the analysis was based on personal injury accidents. However, the police knows of quite a number of damage only accidents. Attempts were made at drawing up a model in which the risk measured by conflicts registration was compared with the risk measured by a weighted sum of accidents involving personal injury and damage only.

As subreports bear close relation to the degree of seriousness of the accidents it was decided that personal injury accidents should have multiplier 1, damage only accidents between cars 0.25, and damage only accidents between car-bicycle 0.80.

Given these conditions the following conversion multipliers were found:

	Car-car	Car-bicycle Car-pedestrian
Low speed	2.2×10^{-5}	15.4×10^{-5}
High speed	24.2×10^{-5}	55.1×10^{-5}

This model showed much better adaptation to the risk of accidents than did the original model.

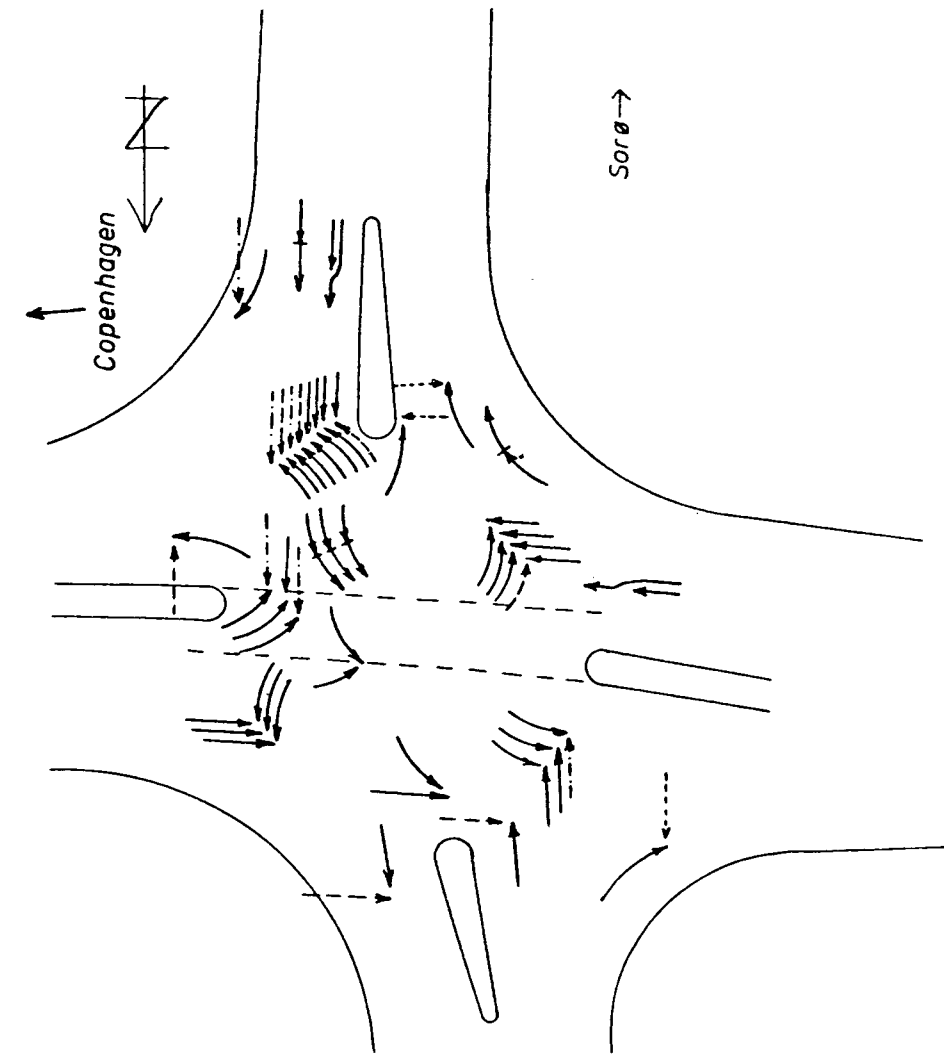
For the same model fig. 4 shows a comparison between expected and actual levels of risk in 10 intersections. An analogous comparison for various accident situations shows considerable larger differences.

Today the method of measurement is thus not applicable in general for an analysis of a specific accident situation. Such applicability will require calculation of specific conversion multipliers between conflicts and accidents for the individual accident situation.

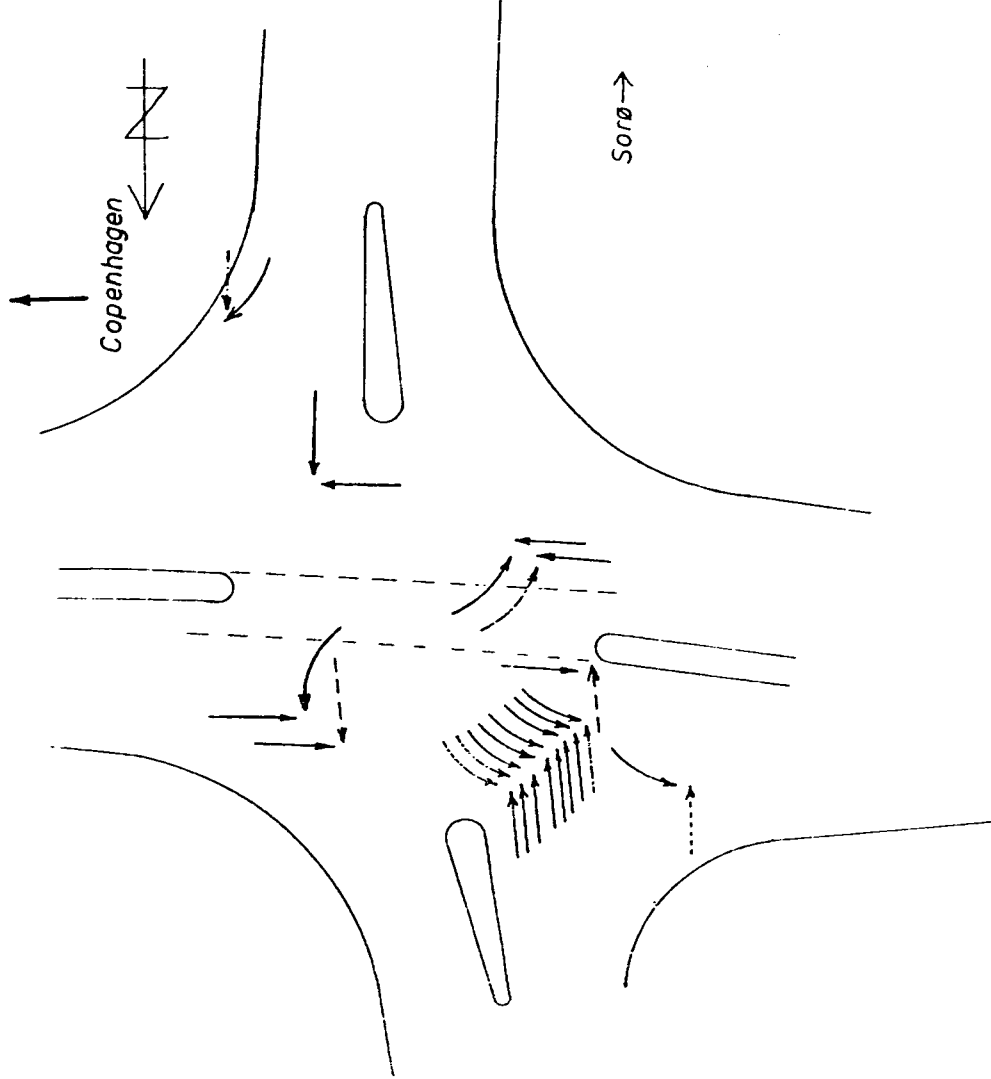
With a view to the general applicability of the technique it must on the basis of the modest Danish analyses be considered expedient to carry on research into the reliability and applicability of the technique. However, the conflicts technique is expected to be able to reflect the level of risk in an intersection.

Experience from analyses also demonstrates the advantage of the application of the technique as a supplement to accident data. In this connection it is desirable to be able to supplement these data with registration of road user behaviour. Frequently incorrect use of the road system is observed. In these situations only mere chance decides whether the misapplication is without consequences, results in a conflict situation or leads to an accident.

Conflicts - before



Personal injury accidents - before



- Car
- - - Moped
- Pedestrian
- . - . Bicycle

Fig.2

Fig.1

Conflicts - after

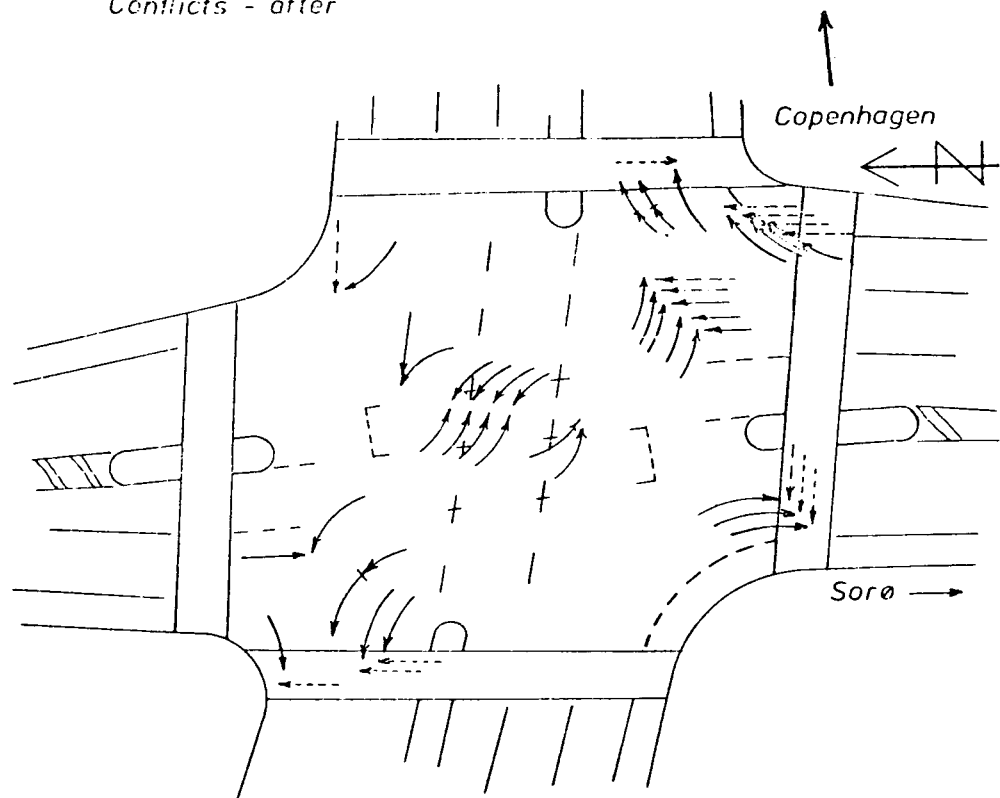


Fig.3

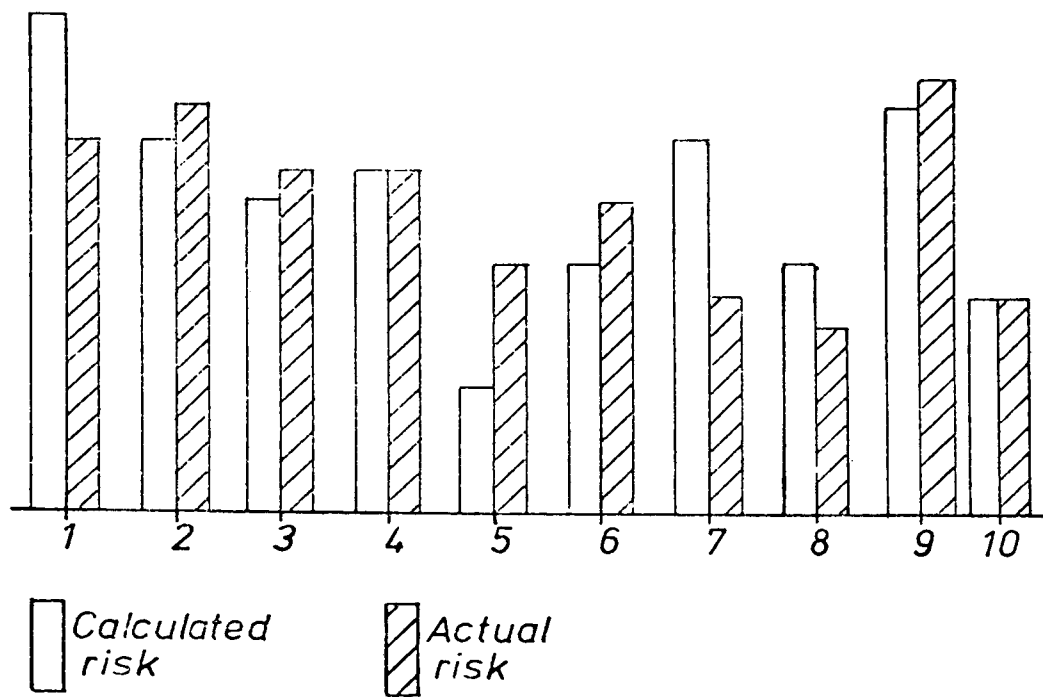


Fig.4

A pilot study of conflicts at a T-junction on
winter evening rush-hours

J. Darzentas, V. Holmes and M. R. C. McDowell

Mathematics Department
Royal Holloway College
Egham, Surrey

The diurnal distribution of reported road accidents in the U.K. (normally those involving personal injury) shows two major and one minor peak⁽¹⁾. The major peaks occur at the morning rush hour and at the evening rush hour, the minor peak at late evening and is probably associated with alcohol usage. These peaks are still present in the data when it is normalised for a given major road to unit traffic flow⁽²⁾. Nevertheless all conflict studies known to us have been carried out in daylight. We are interested in the differences, if any, in driver behaviour in daylight and in darkness. There is one published study⁽³⁾ comparing side road driver gap acceptance at the same junction in daylight and darkness, which found no significant difference. It did not consider conflict involvement. We were surprised at this result, as we would expect the psychological state of drivers returning from work might be quite different from that on going to work, irrespective of any differences in their behaviour in daylight and darkness. In addition the perception of the driver may be affected by the darkness and by the lights of the oncoming vehicles, again suggesting a difference in gap acceptance behaviour.

In the U.K. clock time is reset twice a year with the effect that for the period October-February morning rush hour is in daylight conditions but evening rush hour in darkness.

To separate these effects we chose to look initially at an essentially constant driver population leaving work (1645-1715 hrs) at a single non-urban T-junction on winter evenings (darkness) and in the spring (daylight).

The experiment is being conducted at the gates of Royal Holloway College where there is a priority-controlled exit to the A30 trunk road. Up to 120 cars exit each evening (Monday to Thursday) in the given time period, and comparatively few at any other time. The observations were taken on a sufficient number of occasions to allow us to study the behaviour of individual drivers. We make the assumption that a specific car always has the same driver. We hope it will be possible by identifying the drivers to study age and sex effects. The geometry is illustrated in Fig. 1. There is overhead street lighting but the light intensity in the dark evenings was insufficient to produce a signal on a normal commercial exposure meter.

The measurements are being carried out with the technique described by Storr et al⁽⁴⁾ and are more fully described below. The arrival and speed of each main road vehicle in the near side stream is measured by the signals generated as it passes over a pair of coaxial cables a fixed distance (≈ 50 m) from the junction. On half of the occasions a second pair of cables at 3 meters from the junction gave a second speed measurement to allow a measurement of deceleration of the main road vehicle. Such deceleration may occur as a precautionary measure, or if the junction is occupied, as a conflict avoidance step.

Two observers then note other data of interest by pressing coded buttons on handsets. The incoming data, its channel and the clock time are output onto magnetic tape for later analysis.

The following data is collected:-

Observer A

1. Type of vehicle in main road stream (car/other)
2. Side lights or headlights.

Observer B

1. Arrival of a side road left turner
2. Departure of a side road left turner
3. Middle three letters of number plate

In principle, with a third observer it is also possible to note the sex of driver, the presence of passengers, and the simultaneous presence of a right turning vehicle.

Observations have been taken on seven winter evenings (dark) and daylight observations are now in progress, two sets having been completed. This data has been transferred to a main frame computer and preliminary analysis is underway.

From the measured data we obtain gap acceptance functions for the merging (left-turn) behaviour in daylight and in darkness, and as functions of other factors (e.g. type of oncoming vehicle, whether with side or headlights). We also obtain speed distributions for the main road vehicles. These results are then used in our conflict simulation model to obtain "model conflicts" in terms of enforced decelerations, by severity class. We can then compare results from dark evenings with daylight evening observations.

The first step is to obtain the darkness and daylight gap acceptance functions, main road flows and speeds (irrespective of side-lights/headlights or car/non-car classifications) and use these in the conflict model to obtain a preliminary indication of whether significant differences exist.

In a comparison of this sort questions of the relation between model conflicts and conflicts on the road are largely irrelevant. The first question is "does the model predict significantly different conflict rates using data collected in the two circumstances?"

A preliminary analysis has been carried out on a small subset of the total data available. In preparing the observational data for analysis, much time is required to edit out incompatible events. A suite of programs first eliminates randomly generated signals and then searches for logical errors, e.g. two side road arrivals at the line XY not separated by a departure. The analysis of the first data set is of one set of darkness data (8 November 1978) and a combination of two short observing periods in daylight (26 and 28 March 1979). These daylight observations were each restricted to half the normal period by the onset of rain.

The distribution of accepted and rejected time gaps and lags for each case is given in Table I, there being 394 daylight and 326 darkness presented gaps, with 55 daylight gaps accepted and 58 of the "darkness" set.

Summary statistics of the two distributions are given in Table II. We should emphasise that we regard these results as very preliminary; they represent less than one-tenth of the total data.

The mean accepted gaps in the two cases are not significantly different, but using skewness⁽⁶⁾ as a measure of the two distributions, the daylight observations show a low level of skewness, but the darkness data are significantly positively skewed, i.e. towards longer gaps. The data therefore suggest that night-time behaviour is significantly different, in that drivers more often wait for long gaps.

This result, if confirmed, is rather interesting, and suggests that drivers are less able to judge gap size accurately in darkness, a fact which forces them to be more cautious and accept larger gaps, but the standard deviation of the accepted gaps in darkness (Table II) may reveal a higher degree of inconsistency than the daylight gap acceptance behaviour. Our results suggest that the measures of similarity of day and night gap acceptance probabilities used by Tsongos and Weiner⁽³⁾ were inappropriate, and that further work is required.

Results of the conflict simulation model are given in Table III. This shows that more model conflicts are generated in darkness than in daylight. This difference may be due to the higher standard deviation of the accepted gaps in darkness.

TABLE I

Daylight/darkness gap acceptance at a T-junction

Time gap (secs)	Daylight			Darkness		
	ACC	REJ	TOT	ACC	REJ	TOT
1- 2	2	182	190	2	124	126
2- 3	2	78	80	4	58	62
3- 4	5	39	44	5	38	43
4- 5	11	21	32	2	22	24
5- 6	7	9	16	13	13	26
6- 7	7	7	14	6	4	10
7- 8	11	3	14	12	4	16
8- 9	7	0	7	9	4	13
9-10	3	0	3	5	1	6
	—	—	—	—	—	—
	55	339	394	58	268	326

TABLE II

Daylight/darkness gap acceptance at a T-junction

	Daylight	Darkness
μ median accepted gap (secs)	5.67	6.96
m mean accepted gap (secs)	5.49	5.78
$\mu - m$	0.18	0.18
σ_m	2.06	2.18
$\frac{\mu - m}{\sigma_m}$	0.09	0.54
Skewness	0.27	1.62

TABLE III

Number of model conflicts with 95% confidence limits

	Daylight	Darkness
Conflicts	634 (571 697)	946 (888 1004)

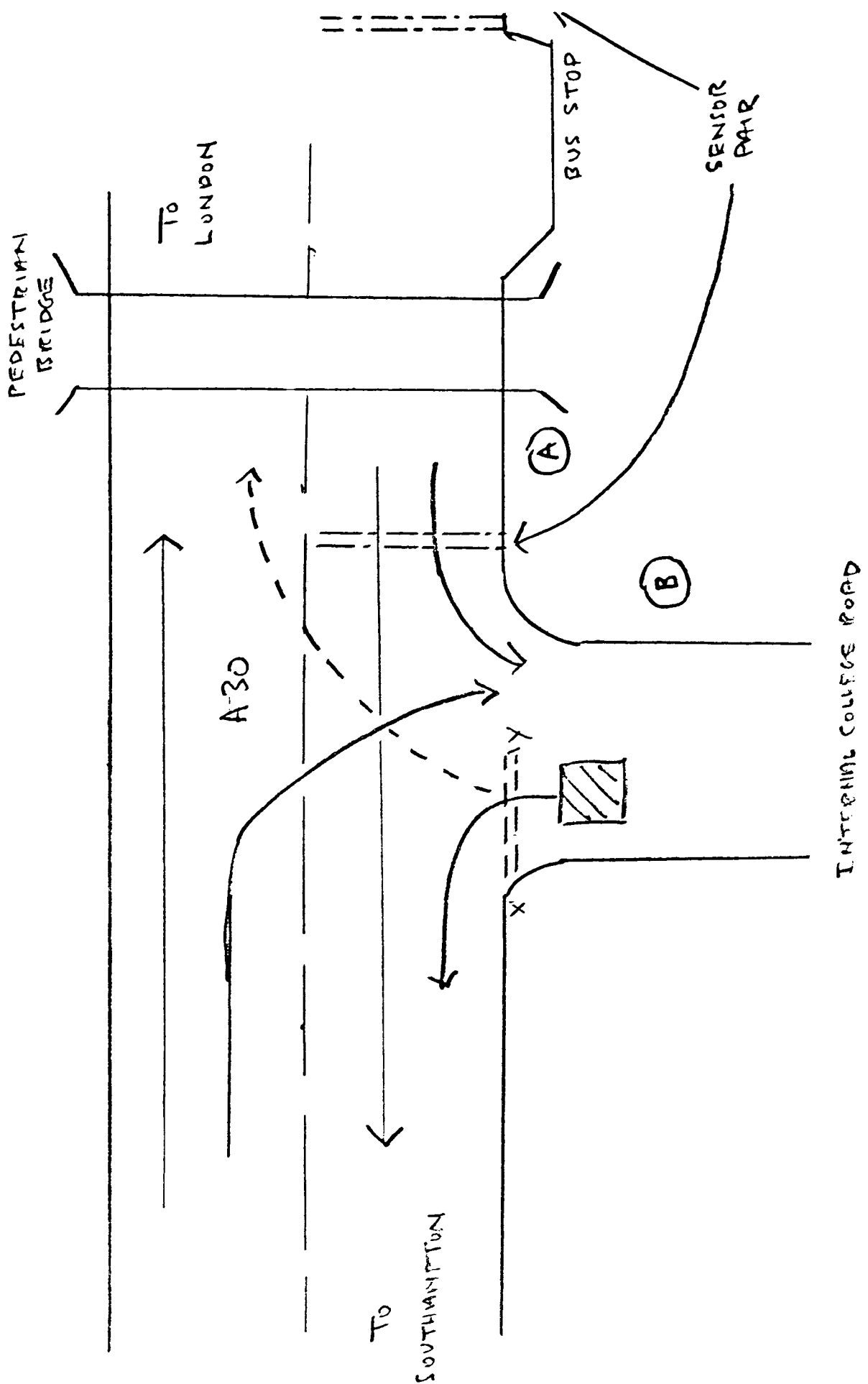
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Acknowledgements

We wish to thank Mr. P. A. Storr and Mrs. Jenny Wennell for helpful advice, and the use of their programs.

FIG 1.



PLAN OF JUNCTION AND FLOW DIRECTIONS

by K.J.HÜFNER and A. SCHÜTZENHÖFER

In the introduction problems of criteria in road-safety-research are discussed mainly by pointing out shortcomings of the accident-criterion. After a historical survey on former conflict-research in various countries the present investigations concerning reliability and validity as well as various possibilities of application are critically analyzed.

For studying conflict-technique and its practical application a very complex intersection which was characterized by an increasing accident rate and poor structuring and which was described in a public-opinionpoll as the spot in town where drivers as well as pedestrians felt subjectively specially at risk was chosen by the Road Safety Board in Graz.

At this intersection conflicts were recorded by a trained observer. The conflict-definition applied is similar to that used by the TRRL and distinguishes between slight and severe conflicts : a slight conflict was defined as controlled, but rather powerful braking or a dodging manoeuvre to avoid a collision; there is enough time before a possible accident to carry out the manoeuvre in a controlled way.

A severe conflict was defined as an abrupt retardation or change of direction which is necessary to avoid an impending collision; there is not enough time for moving in a safe and controlled way.

The study was based on the principle of before-and after-comparison. The observation-period per phase of the project was 8 hours which were distributed over time of day and day of week.

Phase 1 :

Without any changes at the intersection observations of conflicts were conducted and the following conflicts were recorded : The total number was 61, of which 47 were slight and 14 were severe conflicts.

Phase 2 :

In order to reduce the conflicts the following measures - based on the findings of the first observation-phase - were carried out : Channelizing of traffic by lane lines with directional pavement markings and islands delineated by pavement markings as well as improvement of visibility by means of no-parking areas. By this a reduction of conflicts of 57 % was obtained. The total number was 35, of which 31 were slight and 4 were severe conflicts.

Another accumulation of conflicts resulted in consequence of a badly organized area ("swimming traffic area"). Obviously a weaving area still was not clearly defined for the drivers.

Phase 3 :

To reduce conflicts still more streetcar clearance lines as well as an island delineated by pavement markings in the area traversed by the tram were painted as additional delineation and information for traffic-participants. In general, by these measures the number of conflicts could be reduced only insignificantly. The total number was 27, of which 24 were slight and 3 were severe conflicts.

According to the findings of phases 2 and 3 the islands delineated by pavement markings shall be constructed as permanently built in directional channelizing islands.

Summarizing the results of this study it can be stated that by means of the conflict-technique the efficiency of measures of traffic-regulation and -guidance at an intersection can be measured in a short time and therefore modifications can be carried out quickly and systematically and without high costs.

Louis Schützenhöfer

Kuratorium für Verkehrssicherheit
Graz, Austria

The author suggests a modification of the design of pedestrian crossings. This modification refers only to crossings without traffic lights. The present form is marked by longitudinal white stripes on the road surface. The advantage of this design is its easy visibility for drivers. Its disadvantage is the low inhibitory effect. A modification using transverse white stripes increases the inhibitory effect but decreases the visibility. The suggested modification in which two transverse stripes join the ends of the longitudinal stripes of the present form combines the good inhibitory effect and the easy visibility. This type of pedestrian crossing should - in the opinion of the author - be installed at crossings without traffic lights.

In order to test the effects and functioning of this new design of pedestrian crossing in the city of Graz four crossings were chosen - two of these each correspond with respect to the setting and density of traffic (vehicles and pedestrians).

Step one in the investigation is to register conflicts between pedestrians and vehicles of the two pairs of crossings in their usual form (see Fig.1).

In the second step one crossing of each pair is left unchanged, but the other one is modified to the new form (see Fig. 3).

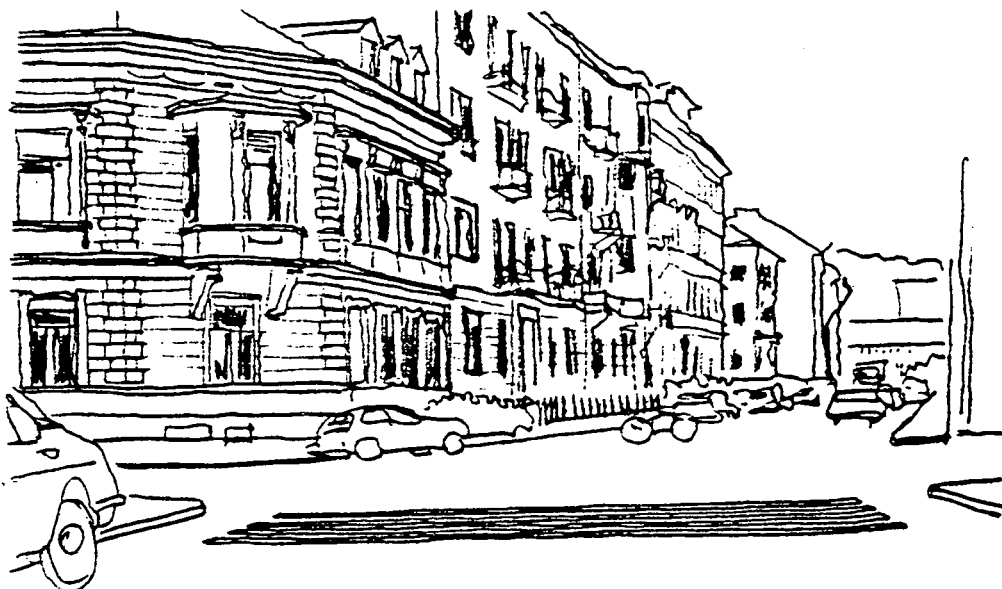
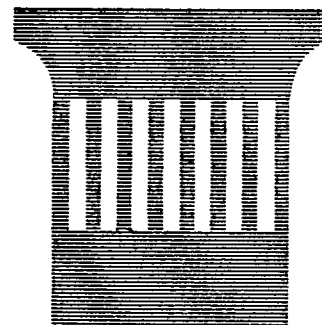
After a period of familiarization conflict registrations are repeated on all four crossings.

The investigation is in its planning stage. The crossings are chosen. The field work will start towards the end of May 1979.



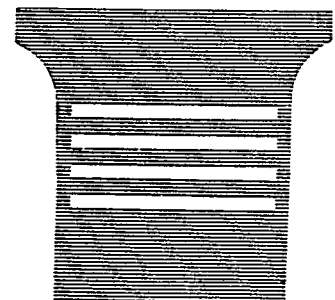
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Fig. 1



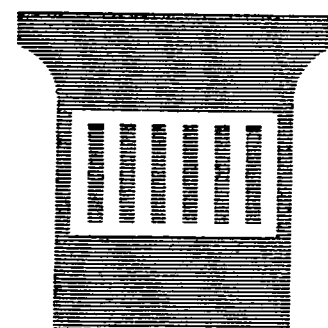
MA
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Fig. 2



MA
K

Fig. 3



Herbert Gstalter
Institut für Psychologie
Technische Universität Braunschweig

- Abstract -

We developed and validated an observation technique with special regard to pedestrian - vehicle conflicts. For validation purposes only conflicts observed at black spots can be handled in a conventional manner. Correlation coefficients between accident and conflict data from 12 marked crosswalks in signal - controlled urban intersections show significant values for through traffic and the total number of car - pedestrian events.

To validate the PCT on road sections with low car - pedestrian accident frequency, we had to compile the number of accidents within comparable road segments over a period of 8 years. After working out a system to categorize different kinds of urban streets, we observed encounters and conflicts on 8 road sections which all belong to the same category. Whereas the conflicts observed failed to correlate significantly with the accident data, the encounters between vehicles and pedestrians accounted for more than 90 % of the accident variance.

Bernhard Zimolong
Institut für Psychologie
Technische Universität Braunschweig

Abstract

The Traffic Conflicts Technique is a device for indirect safety measurement. The basis for the definition of conflicts is a sequence of events which has a finite probability of developing into an accident.

The investigation of TCT in Germany was performed in three stages:

- Development of a standardized traffic observation technique for most kinds of traffic locations and a standardization of observation areas
- Validity studies of conflicts showed for all conflict types a rather close relationship (correlation) to accident types in particular traffic locations
- Successful practical applications of the method depend on the standardization and facility of the technique, on available guidelines for the training of observation personnel and on statistical aids for the interpretation of the results.

1. Introduction

The Traffic Conflicts Technique (TCT) is a device for indirect safety measurement and applicable to a variety of situations, especially as a

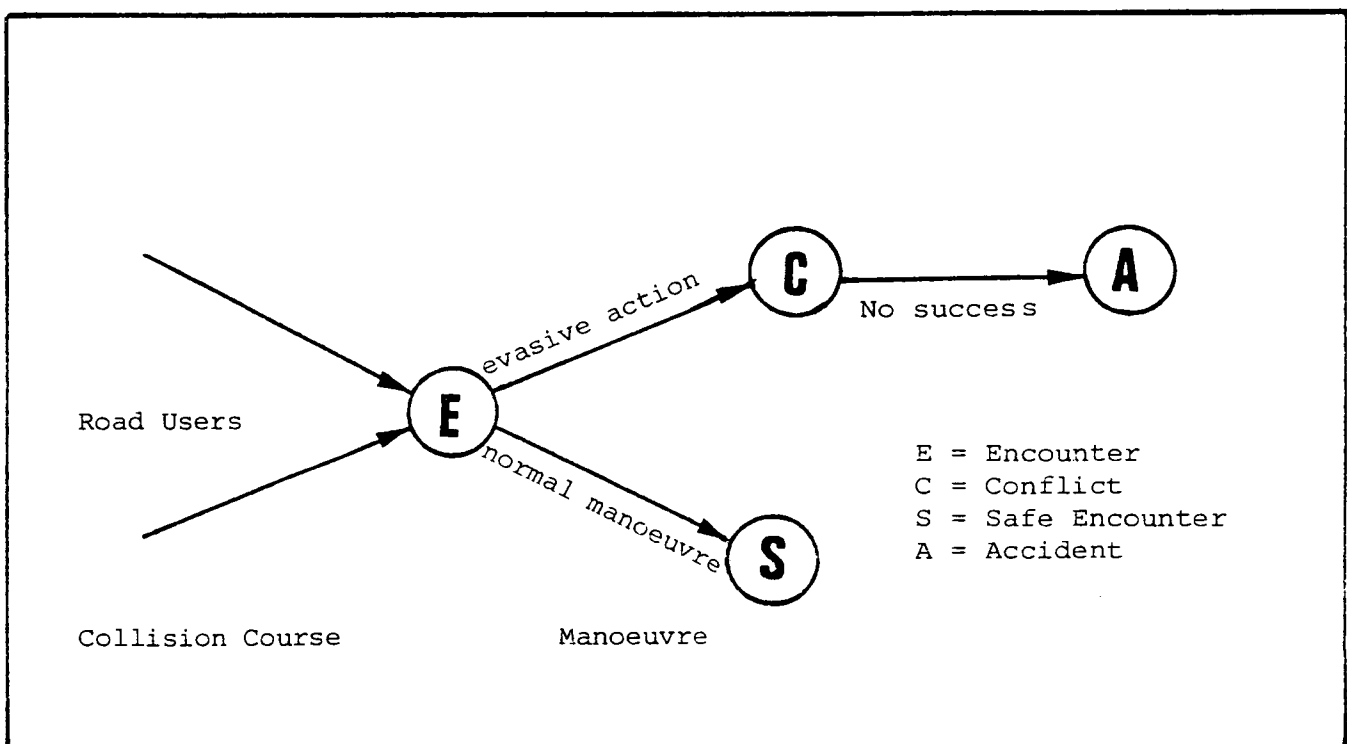
- diagnostic instrument for in-depth analysis of locations with a concentration of accidents. The aim is to identify and localize hazards and to investigate effectiveness of devices, layouts, designs, procedures etc. This should also be possible at locations with low accident potential.

- basis for before and after studies or generally speaking, evaluation studies. In this context, one usually wishes to ascertain whether some treatment, e.g. the installation of automatic traffic control is effective in increasing traffic safety.
- method to forecast accident risks for special groups of road users e.g. pedestrians, drivers, children etc.

It has been pointed out (Amundsen & Hyden 1977) that conflicts are generally considered as a substitute for accidents, because of the drawbacks of accident analysis: accidents are rare events compared with the number of situations involving accident risks, accident records may be distorted, incorrect and incomplete and only a small part of all accidents is recorded.

The time needed to collect adequate numbers of conflicts for statistical processing is relatively small, the reliability is much higher and it is possible to define conflict types in correspondence to accident types.

The basis for the definition of conflicts is a situation or sequence of events which has a finite probability of developing into an accident. Conflicts are related to the chain of events preceding a possible accident. From the road user's point of view the chronological events can be expressed in the following diagram:



All occurrences in the diagram are observable events. The rare event of accidents preceded by no observable evasive action is excluded as well as single vehicle accidents in this diagram. A traffic conflict will be defined as follows:

"A traffic conflict is an observable situation in which two or more road users approach each other in space or time to such an extent that there is an increased risk of collision if their movements remain unchanged". (Amundsen & Hyden 1977, P. 135).

Traffic conflicts are described by a small set of variables, all of which are combinations of a certain kind of manoeuvres and proximity in time and distance. The level of severity is strongly related to the continuous variable 'time to collision' and is classified in our studies by three levels from slight to serious.

Training of human observers with video recordings, training manuals and in field-studies improves the reliability of measuring conflict types and levels of severity. In spite of the subjectivity of the measurement the internal and external reliability of observers proved to be rather good. According to our own results, observers agreed in 80 - 90 % of observed events.

2. The development of Traffic Conflicts Technique

Traffic observations under standardized conditions have a proved tradition. Herwig & Sprotte (1965) registered regular and irregular behavior of pedestrians and drivers at urban junctions and marked crosswalks in order to discover proposals for constructional measures. The observation techniques used in these and other studies do not qualify for general application. They were not sufficiently standardized and the relation between observations and accidents was not investigated thoroughly.

The standardization and generalisation of traffic observation techniques was improved by the development of the TCT (Perkins & Harris 1968)

In many countries the technique has been investigated and applied practically. Recent applications are described by Cooper 1974, Hyden 1975, Amundsen & Hyden 1977).

The investigation of TCT in Germany started in 1976 and was performed in three stages:

- Development of a standardized traffic observation technique for most kinds of traffic locations
- practical applications and guidelines for users.

3. Development of a standardized observation technique

The first aim was to develop an observation technique adaptable for most kinds of locations: urban and residential junctions, signalized and nonsignalized intersections, approach roads with more than one lane etc.

Based on the conflict description of the General Motors Manual the conflict types were defined according to the German official accident causes catalogue to guarantee a detailed investigation of the relationship between accident and conflict types. It was necessary to define new unequivocal categories to account for many actual causes of conflicts observed in approach roads and nonsignalized junctions.

The majority of hitherto existing studies concentrated on junctions that can hardly be compared with big signalized junctions in urban areas as far as traffic guidance systems, lanes and traffic volume are concerned.

Our pilot studies showed that these junctions could not be covered by the usual 2 person team. The observation of the total entrance or the inner area from one angle was impossible.

To guarantee a detailed investigation, a segmentation of the approach roads and the inner area of the junction was developed on the basis of constructional and behavioral criteria (see FIG 2).

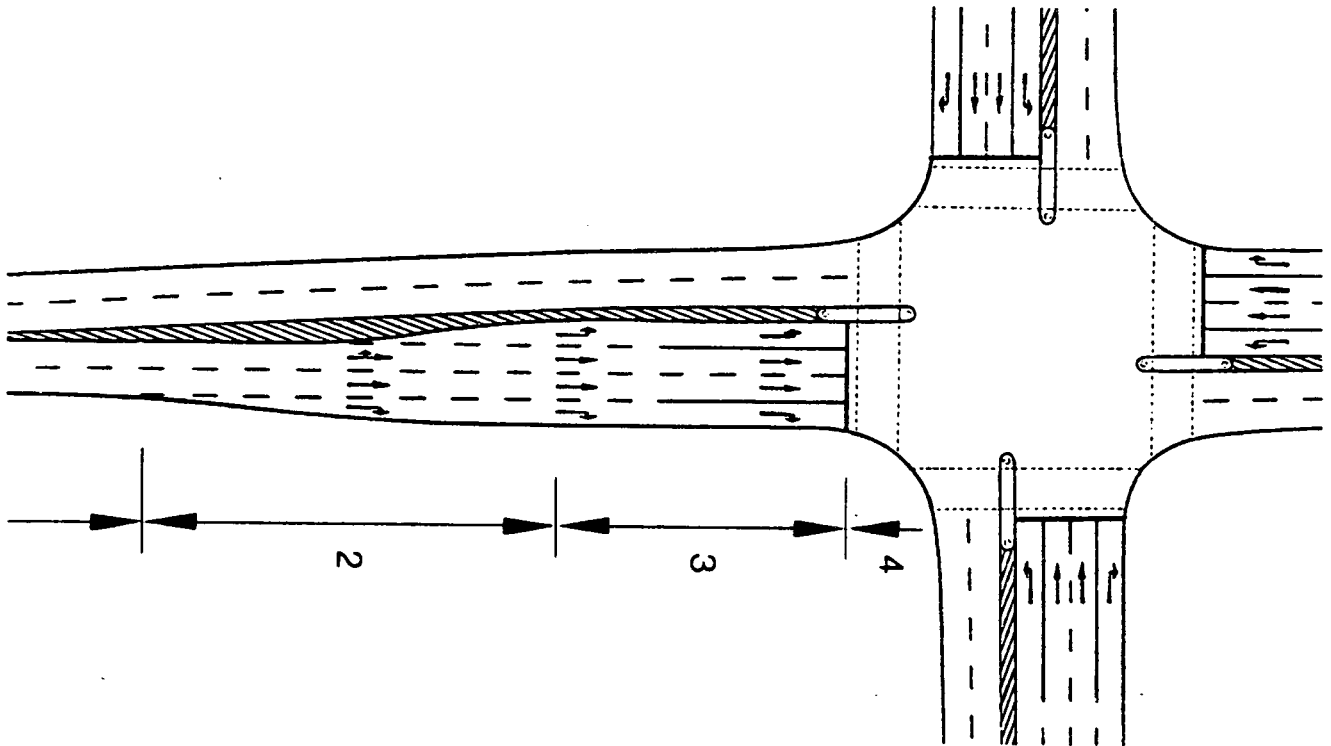


FIG. 2 Segmentation of the approach road of a junction

- Segment 1 from the advance guide sign to the beginning of the widening of the approach road
- Segment 2 from that widening up to the point where all lanes of the approach road are fully built up
- Segment 3 the area up to the stop line
- Segment 4 defines the inner area of the intersection.

According to different tasks and behaviors of cardrivers crossing this area it was differentiated into travel directions: left turn, through and right turn. For detailed investigations the travel directions can be seperated in conflict areas as it is shown for the left turn direction in FIG 3

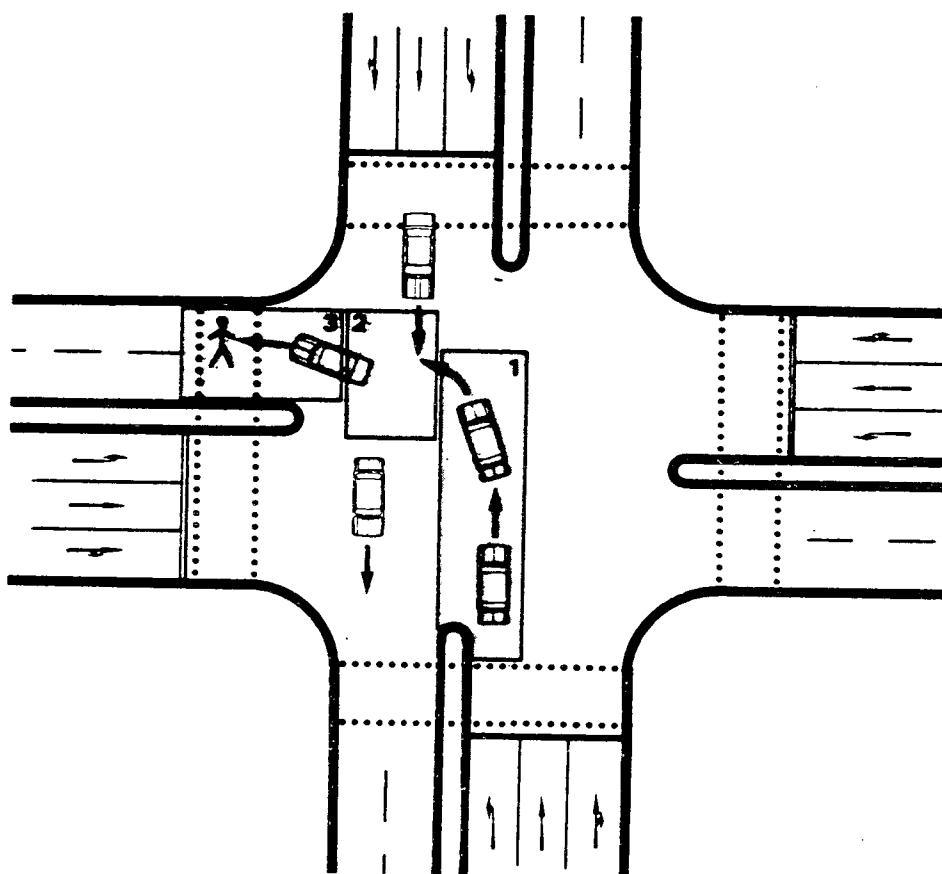


FIG. 3 Observation direction and conflict areas in a junction

This functional and behavioral segmentation of traffic locations has the advantage to be very flexible. It can be adapted unequivocally to the majority of signalized and non signalized intersections and does not depend on special geometric layouts and traffic volumes.

4. Validity studies of conflicts

An important aim of a conflict technique is to use conflicts as a measure of the deficiencies of the traffic system. It appears necessary to validate the technique on the basis of data at accident locations. But this is only possible for a part of urban or residential locations where accidents occur frequently and are concentrated on particular sites. In Braunschweig and Hannover, where investigations were performed, about 60 % of all accidents are located at black spots, most of them being signalized junctions.

A remark on German accident statistics seems to be necessary: All injury accidents and collisions with damages over one thousand Marks are officially recorded. In addition, accident records of damages less than 1.000,- DM (A-accidents) are available if they have been reported to the police.

The ratio between injury and damage accidents (including A-accidents) is about 1 : 10. All accidents occurring in the last three years were compiled on the basis of accident records and collision diagrams. The accident retest reliability proves to be good ($r = .88$) but depends on the accident types. Because of the great number of accidents it was possible to compute correlations between conflict and accident types in order to validate conflicts. This differential validity approach considers conflict types as a substitute for accident types at particular traffic locations. Simple and multiple regression functions are computed for different locations and conflict types.

Detailed investigations at 38 urban junctions and approach roads (all junctions signalized, at least three lanes in each approach road and heavy traffic volume) showed stable relationships between conflicts and accidents (Erke & Zimolong 1978). In general high correlation coefficients between Rear End (REA), Weaving (WEA) and all (ALL) conflicts and accidents were found in the approach roads (Table 1).

In the inner area of the junctions, separated into the travel directions Left, Through and Right, less accident variance could be accounted for by the conflicts. The correlation between left turn accidents and conflicts (LEF) proved to be significant statistically. By a weighted combination of the levels of severity and traffic volume much more variance of the criterion could be accounted for.

Table 1 Simple and multiple correlations of conflict and accident types

Site	Conflict- type	Predictors				
		K1	K2	K1-3	1) K1,K2,K3 K1,K2 only	1) K1,K2,K3,Kfz K1,K2,Kfz only
<u>Approach road</u>						
n = 24						
	REA	.74**	.65*	.75**	.76**	.76**
	WEA	.80	.71	.77	.86**	.87**
	ALL	.86**	.52**	.83**	.86**	.87**
<u>Inner area of junction</u>						
n = 14						
Right	REA	.32	.69**	.40	.69* 1)	.69 1)
	ALL	.48	.14	.46	.51	.55
Through	REA	.01	.34	.38	.61 1)	.83**1)
	LEF	.51*	.55*	.57**	.72*	.72
	ALL	.03	.35	.10	.61	.72
Left	REA	.65**	.55	.68**	.76**1)	.78**1)
	LEF	.55	.62**	.56*	.62* 1)	.69
	ALL	.51*	.57*	.56*	.60* 1)	.67

The different levels of severity of conflicts (K1 = slight, K2 = medium, K3 = serious) are generally recorded at a ratio of 80 to 19 to 1.

The relationship depends on the site and type of conflict. The best correlations between accidents and conflicts are generally found for the sum of all three levels of severity K1-3.

According to our results, traffic conflicts are valid predictors for different accident types at urban junctions. We assume, that the same valid relationship holds for other traffic locations, e.g. for low accident situations. Otherwise the numerical ratio of conflicts and accidents depends on the site and type of conflict. In order to forecast accidents from multiple regression functions, it is necessary to compute a different function for each type of conflict and for each type of traffic location.

5. Practical applications

Compared with other techniques, the TCT involves the advantage that practical aids for the evaluation of measures and the observation of traffic can be offered to the responsible bodies of communities and to the police.

A successful application of the method depends on the standardization and the facility of the technique, on available guidelines for the training of observation personnel and on statistical aids for the interpretation of the results.

The last topic includes the problem of conflict reliability measured over a couple of days and their theoretical distribution function. Hauer (1978) concludes that the expected conflict rate varies from day to day. He suggested a negative binomial distribution as appropriate for the representation of the distribution of conflict sample means. On this basis, confidence limits and error probabilities in testing hypotheses can be obtained, e.g. when treatment effectiveness in so called before and after studies is the main concern. Also the marginal increase in estimation accuracy in relationship to conflict counting time is of practical interest for field surveys. We are now studying the reliability problem to gain evidence for the distribution problems. One purpose of the current investigations is to examine the available empirical evidence in order to provide a general guideline for the standardized application of the TCT.

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3.16 BEHAVIOURAL STUDY BY THE INSTITUTE FOR PERCEPTION IZF-TNO

A.R.A. v.d. Horst, R.M.M. Symonsma, IZF-TNO, Soesterberg, Netherlands.

A measuring instrument is being developed for evaluating design elements as applied in the demonstration project on Cycle Routes in The Hague and Tilburg. Behaviour observations were made at four locations on the cycle routes with both film and video shots. It was examined to what extent observers were able to make simple, reliable records from the shots.

There was also a quantitative analysis of the film and video pictures in order to establish road users' behaviour in terms of course, course changes, speed, changes in speed and interaction with other road users. Both techniques, film and video, gave comparable results. The use of video is preferable, mainly in view of the cost.

In the meantime, equipment has been developed enabling direct selection from video pictures (see appendix). But the quantitative analysis continues to be expensive and time-consuming.

As there is no suitable measuring instrument yet for recording and assessing road users' behaviour characteristics, the Traffic Engineering Department of the Public Works Department requested the Institute for Perception IZF-TNO to make a preliminary instrumental-methodological study for development of a measuring instrument for behaviour observation. The behaviour observations will also have to fit in with the long-term research, the emphasis of which is more on establishing behaviour relevant to road-safety research (including the establishment of serious conflict behaviour between road users). One objective is that there must be a pronounced effort to develop objective techniques. Measurable behaviour characteristics of cycle traffic as related to road characteristics, and also as related to other road users, include course, course changes, speed, changes in speed, but also

rear orientation, indicating direction and the like. Attention is paid especially to interactions with other road users.

The video equipment consisted of a Sony camera Type VCK 2100 A and a Sony video recorder EV-320 CE. Use was also made of a video-timer, which gave the time accurate to whole seconds in the picture. Video pictures were taken for one hour per location. They were taken from a fixed camera position at a speed of 25 frames a second. The video-recorder was started manually the moment traffic (bicycle or car) arrived from one of the directions in question. Recording stopped when the vehicles had vanished from the picture.

Quantitative analysis consists of selecting positions of points of the vehicle on stills. Firstly, a black and white film was made of the video shot. At present, video-pictures can be selected direct. By means of transformation rules, the positions in the plane of the film can be translated into positions in the plane of the street. First of all, there is a transformation from film coordinates to street coordinates. The street coordinates are given relative to a more or less arbitrary system of axes. By differentiating successive positions in time, the speed of the vehicle can be obtained. One frame was selected from every six. The output is a plot of the successive positions per manoeuvre in a diagrammatic plan of the location and also graphs of speed and acceleration as related to time or to the road traversed (Figure 1 and 2).

A start was made with a description of bicycle/car interactions. It was examined whether the time-to-collision technique of Hayward (1972) and Hyden (1977) could be used for this descriptions.

As an example, the calculation of the TTC for the selected manoeuvre combinations was chosen. The method of calculation is as follows: In the street-plane, the positions of a given point of each of the two vehicles at successive times are known in the form of x and y coordinates. Four third-grade polynomes are estimated as a function of time, by means of the least squares method (Seifert & Steeg, 1960):

$$\begin{aligned} x &= x_1(t) \\ y &= y_1(t) \end{aligned} \quad \text{for vehicle 1}$$

$$\begin{aligned} x &= x_2(t) \\ y &= y_2(t) \end{aligned} \quad \text{for vehicle 2}$$

The general structure is: $f = a + bt + ct^2 + dt^3$. The courses travelled in the street-plane can be derived from this as continuous curves; see Figure 3 for example. With the aid of the approximation method of Newton - Raphson (Stoer, 1972), the point where both courses intersect (point S) is calculated together with the appropriate times t_1 and t_2 , the moment at which the given point of vehicle 1 or vehicle 2 passes S, the point of intersection.

On the assumption that, always as from the present time t , there will be no more changes in course or speed, a straight line is estimated at quarter-sec. intervals for every vehicle through the present point and the three preceding points. The intersection of these lines is again determined, and it is checked whether the vehicles are travelling on a collision course. They are doing so at time t if either of the following two conditions is satisfied (Figure 4):

$$t_{A1} < t_{A2} < t_{B1} \dots\dots\dots (2)$$

$$t_{A2} < t_{A1} < t_{B2} \dots\dots\dots (3),$$

in which, taking the vehicle's dimensions into account:

$$t_{A1} = t_{P1} - \frac{l_{a1} + b_{r2}}{v_1}$$

$$t_{B1} = t_{P1} + \frac{a_{b1} + b_{l2}}{v_1}$$

$$t_{A2} = t_{P2} - \frac{l_{a2} + b_{l1}}{v_2}$$

$$t_{B2} = t_{P2} + \frac{l_{b2} + b_{r1}}{v_2}$$

t_{P1} = moment at which point P1 passes intersection point S
 t_{P2} = moment at which point P2 passes intersection point S
 V_1 = speed of vehicle 1
 V_2 = speed of vehicle 2

The above applies to a 90° angle of intersection. Adjustments can be made for other angles. Special computations have to be done if one of the vehicles has a speed of zero. If (2) or (3) is satisfied, a collision will occur if the courses and speeds remain unchanged.

The time-to-collision, TTC, will then be

for (2): $TTC = t_{A2} - t$
 and for (3): $TTC = t_{A1} - t$

Determination of the TTC for successive times allows it to be plotted as a function of time, but only if (2) or (3) is satisfied. Examples of such curves are given in Figure 5, where these TTC curves are plotted for several combinations of manoeuvres at location 4.

The top limit for the calculating process has been taken at 5 sec.

In Figures 5a, b and d, the TTC falls below 1.5 sec. Such situations are described by Hayward and Hyden as serious conflict situations.

Without claiming that the problem has been dealt with exhaustively, it can be said that in view of the foregoing, the method of selection and analysis of video pictures, certainly seems a suitable means of arriving at descriptive criteria for conflict situations.

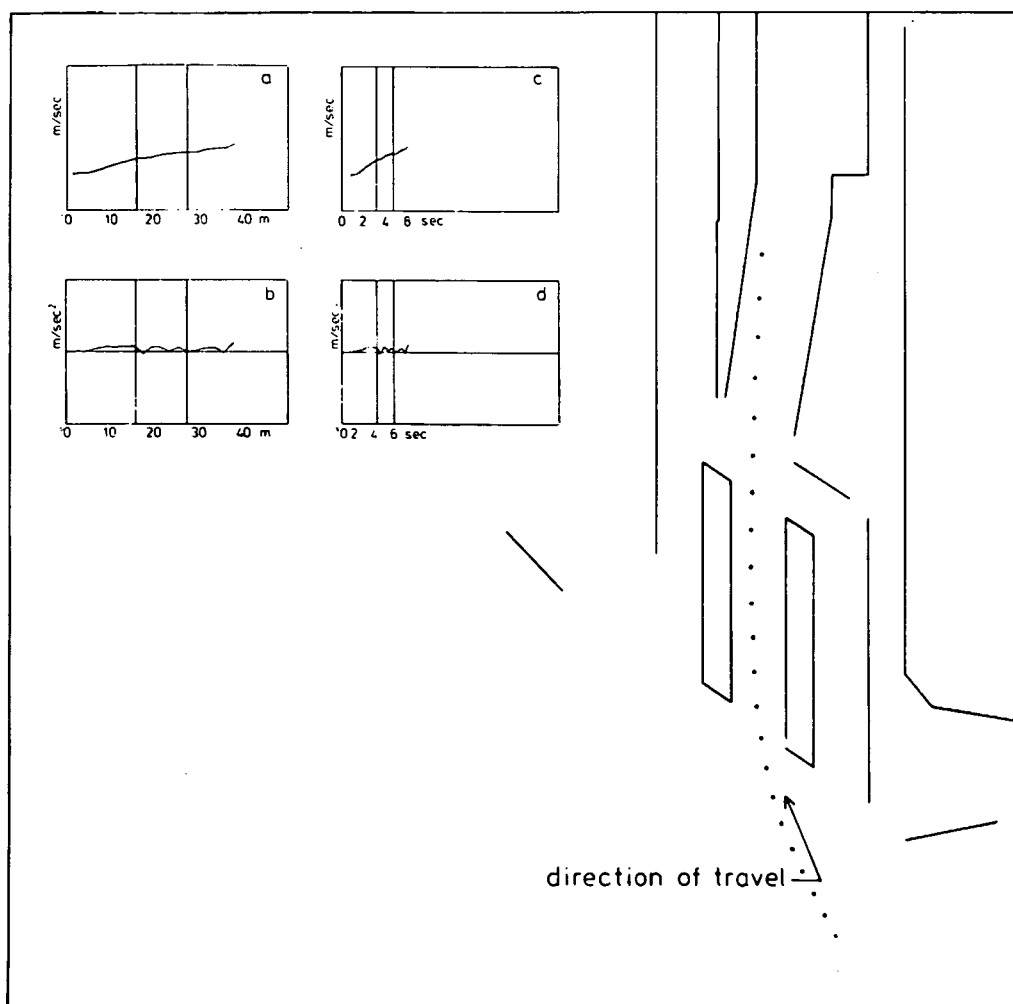


Fig.1: Example of position plot location 1
 Graph a: speed as a function of course travelled
 Graph b: acceleration as a function of course travelled
 Graph c: speed as a function of time
 Graph d: acceleration as a function of time

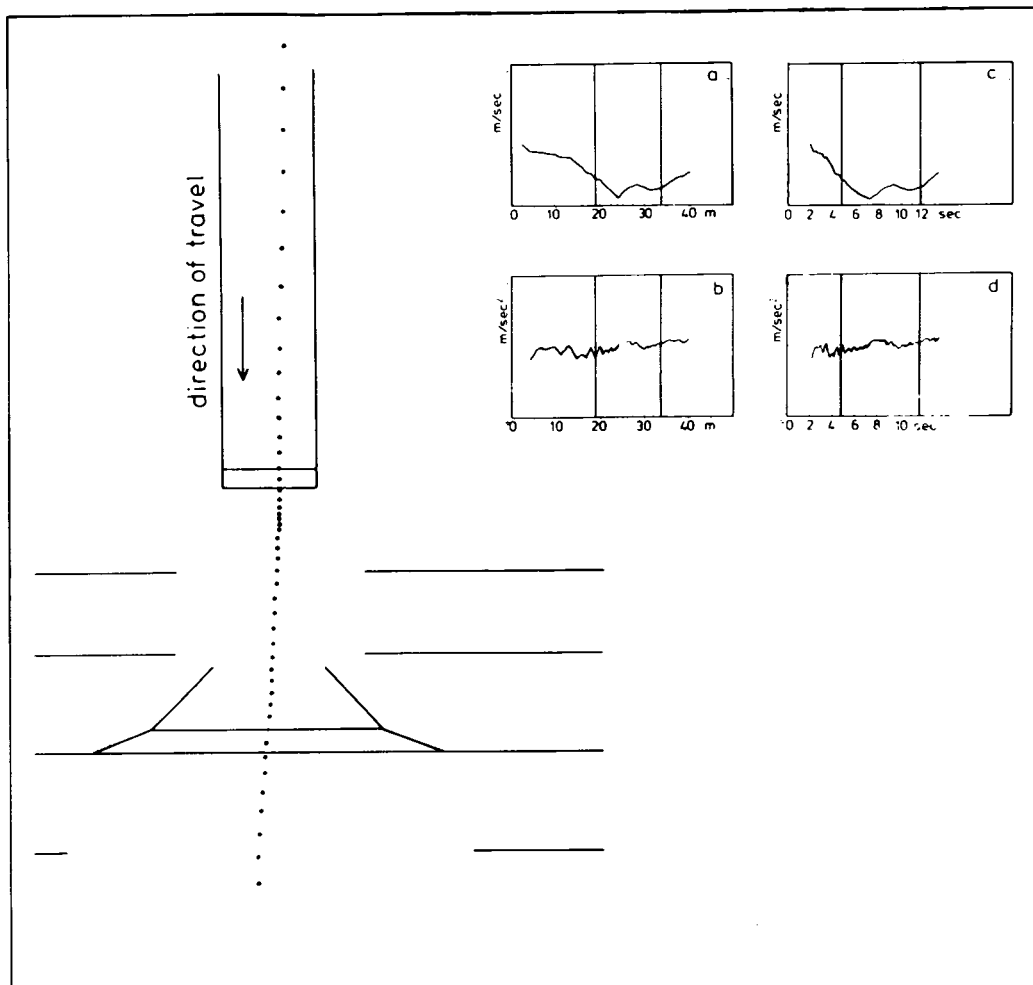


Fig.2: Example of position plot location 2

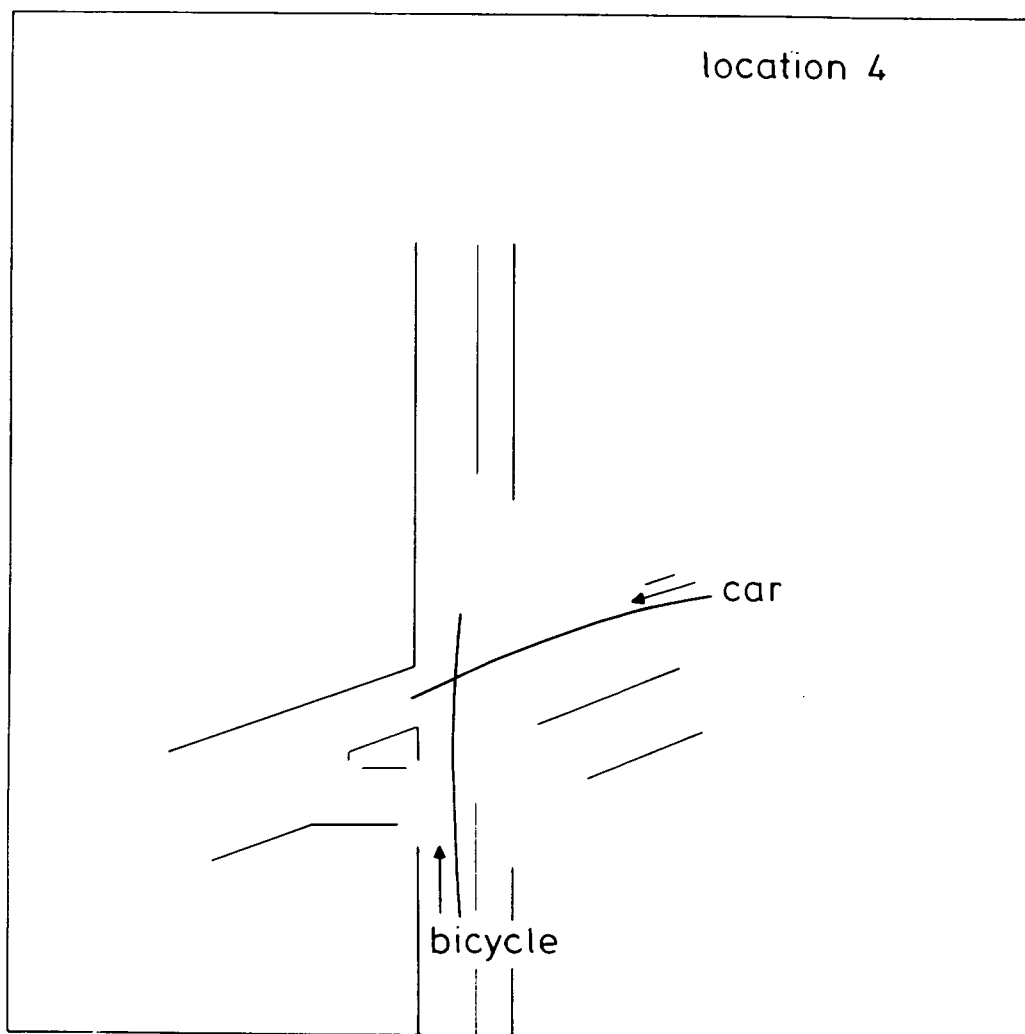


Fig.3: Estimated curves in street-plane for a combination of manoeuvres at location 4

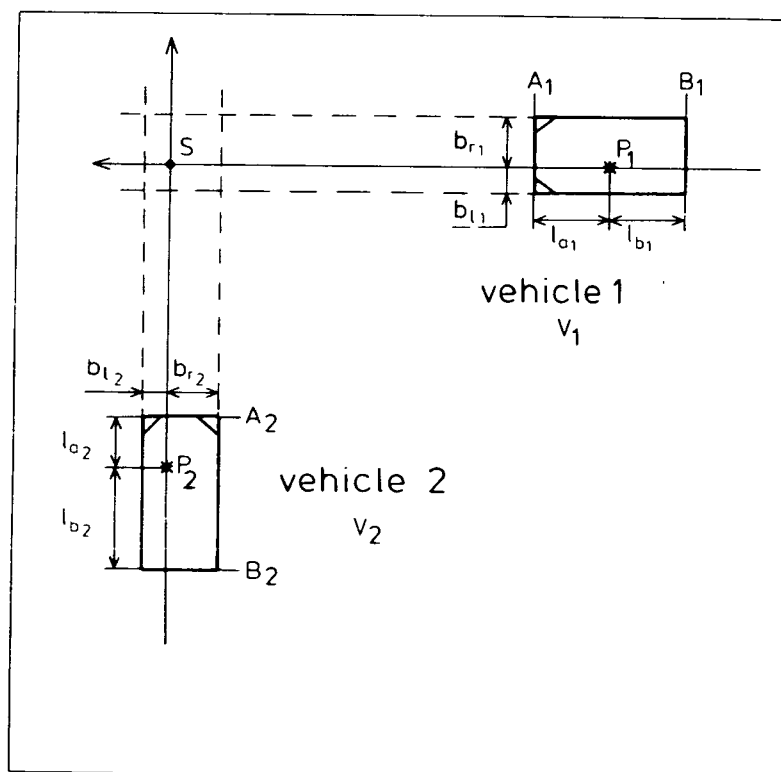


Fig.4: Characteristics of vehicles in question for determining TTC curves

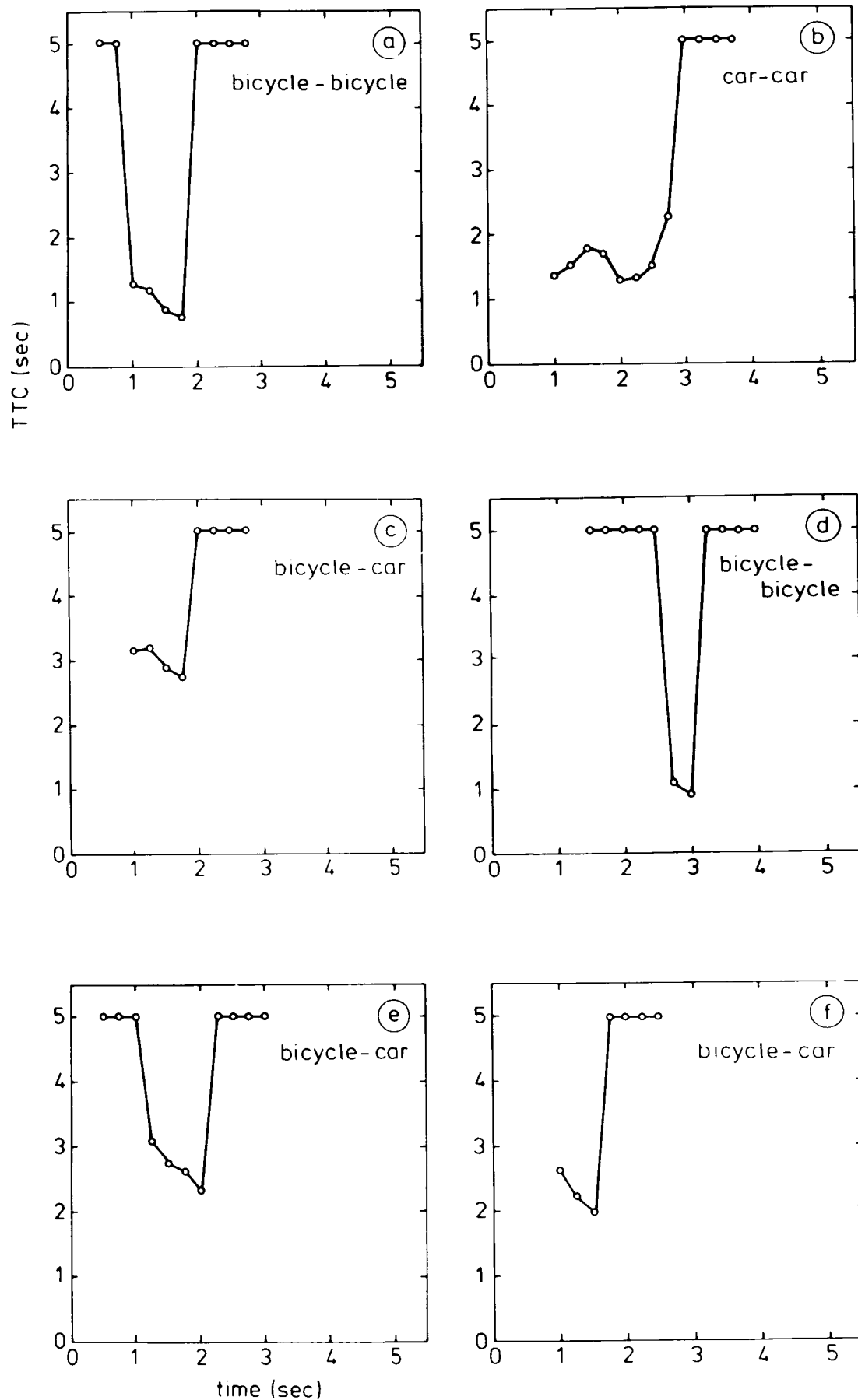


Fig.5: TTC curves for several combinations of manoeuvres at location 4

Appendix

A description of the video-equipment, used for behaviour observations at intersections of the Cycle Routes in The Hague and Tilburg.

A.R.A. v.d. Horst, Institute for Perception TNO, Soesterberg, The Netherlands.

Video-recording equipment

The recording equipment consists of the following elements (see Fig. 1):

Camera: black/white, Sony 3250

Timer: For- , VTG-33 (month, day, hour, minutes, seconds, 1/100 sec.)

Frame encoder: Own development

Video-recorder: Sony Umatic Video-cassette recorder VO 2850



video-recording equipment

Fig. 1.

The frame-encoder labels each frame separately. Digital information is stored at the start of each video-line. Within each frame the complete digital code (24 bits) is repeated four times. So, the decoder can always read the digital code at least twice, wherever the separation of two successive frames ('noise bar') is being (at stillstanding video-pictures), see photo on the next page.

Video-analysis equipment

This equipment is used for reading x- and y-positions of special points in a stillstanding video-picture. The operator indicates a point by positioning two crosshairs, continuously by a joy-stick (velocity control)



Photo

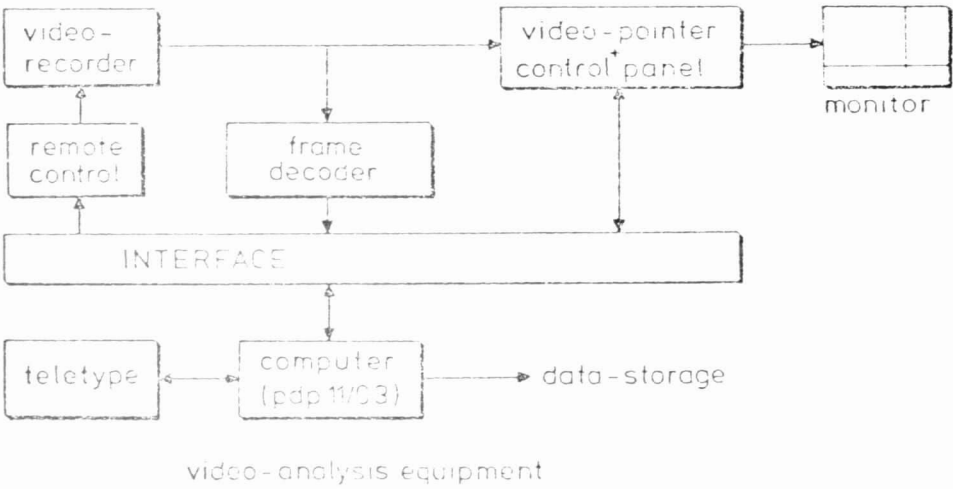


Fig. 2.

or step-by-step by four push-buttons.

A block-diagram is shown in Fig. 2.

A mini-computer (DEC, PDP 11/03, 28K memory) is used as a central supervisor. Many different functions can be realised easily in software. Communication between computer and other devices takes place by 8 digital channels of 24 bit each. By a special joy-stick search module (Sony SM-02) the video-tape can be winded or rewinded under computer control (with an adjustable speed between zero and three times the normal speed). By reading the special frame-code each desired video-picture can be searched automatically. Also the "noise bar" can be placed at the bottom of the monitor screen by the computer.

The operator has at his disposal a normal teletype and a special keyboard, consisting a.o. of 16 push-buttons, to which a function can be related in software. For example on a special command ("point ready") the computer reads the x- and y-positions of the cross-hairs, and positions the cross-hairs on predicted x- and y-coordinates of the next point. The operator has only to correct these coordinates with a few steps. The collected data are stored on disc of the central computer of the institute (PDP 11/40). The system offers the possibility for a quantitative analysis of stillstanding video-pictures.

3.17 Other Presentations

The following presentations were made at the workshop but no papers are available for publication in these proceedings:-

"Conflict Studies using post-encroachment time; and the methodology of data collection"; B Allen, McMaster University, Canada.

"Interview studies with road users involved in serious conflicts"; C Hydén, Lund Institute of Technology, Sweden.

"Further development of the conflict technique"; C Hydén, Lund Institute of Technology, Sweden.

"The traffic conflicts technique as an instrument to identify the level of service of traffic facilities: validation study with respect to the intersection area proper"; H Erke and B Zimolong, Technische Universität Braunschweig, W Germany.

"A validation study for the traffic conflicts technique"; H Erke and B Zimolong, Technische Universität Braunschweig, W Germany.

(The content of the last two of these is mostly covered by paper 3.15)

Information on these presentations may be obtained from their authors at the addresses given in Section 9 of these proceedings.

4.1 Observation and Recording Methods used in the Traffic Conflicts Technique

J. Shippey, TRRL, U.K.

1. INTRODUCTION

The first International Traffic Conflict Techniques Workshop was held in Oslo in September 1977.

As part of the programme of the Workshop, representatives of many of the participating organisations presented papers describing their work, or the work for which they were responsible, on the observation and detection of traffic conflicts or near accidents⁽¹⁾.

The purpose of this paper is to give a brief survey of the similarities and differences in the ways in which traffic conflict studies are made in different countries for use as a background for discussion at the 2nd International Workshop.

The paper summarises the main elements of each organisation's operational definition of a traffic conflict, and also categorises the observation techniques employed.

Throughout the text each organisation will be referred to by the country in which it is situated (see Appendix for list of organisations). Only Sweden has two groups working on the traffic conflict technique.

2. DEFINITIONS OF TRAFFIC CONFLICTS

The general definition of a traffic conflict agreed at the 1st International Workshop on Traffic Conflicts was as follows:-

"A traffic conflict is 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".

However the working definitions (ie the descriptions of events used by observers to identify a conflict) of the various group of research workers show considerable differences.

Most organisations have adopted at least one of the two elements of the original General Motors definition of traffic conflicts: '..... evasive action of drivers and traffic violations'⁽²⁾ as bases for their own operational definitions. (A violation is the breaking of some article of traffic law). The major addition to this definition is the use of a severity scale, first proposed by Spicer⁽³⁾.

Finland is the only country where evasive action and violation but not severity scaling are used.

Germany and USA use all three elements but the largest group, France, Great Britain (in their subjective technique), the Netherlands, Norway and Sweden (LTH) have adopted evasive action with a severity scaling but have dropped the use of violations.

Some organisations combine a more quantitative element with the qualitative 'evasive action' definition. These are: France, where the "risk" associated with a conflict is defined according to approach speed, the angle of collision and the types of road users involved; the Netherlands where the gap between conflicting road users must be 1 metre or less; and Norway, where conflicts are graded according to approach speeds.

Sweden (LTH) also uses evasive action as a criterion, but the main parameter which is used is 'time to accident', a variation of time measured to collision (TMTC), the complex quantitative measure first defined by Hayward⁽⁴⁾. Other users of TMTC are Canada, Great Britain (in the development of automatic detection of conflicts) and Sweden (VTI), although these three organisations do not rely solely on TMTC for their definitions, as they all use other quantitative measures as well.

The other organisations for which information is available are in Denmark, where measures of accepted gap, approach speed and acceleration are used, and Israel where vehicle presence is used in the definition of pedestrian conflicts and a measure of irregular vehicle manoeuvres is being developed. The elements of the operational definitions used by the different organisations are summarised in Table 1.

The 'Elements of Definition' referred to in Table 1 are as follows:

Evasive action: the avoidance of a collision by one or both of the conflicting vehicles by a change in direction or speed or both.

Violation: an infringement of a traffic law.

Severity scale: usually based on the severity of the evasive action required to avoid an accident; or the closeness that the vehicles came to having an

accident; or the estimated severity of the potential accident; or a combination of these.

TMTC: the time which it would take the vehicles to collide if no evasive action were to be taken. The minimum TMTC is suggested by Hayward as the critical value, but Sweden (LTH) uses TMTC at the moment when evasive action is taken.

Separation: either the time or distance between the vehicles at their closest point.

Angle of collision: whether the manoeuvre involved is crossing, merging or nose to tail.

Irregular vehicle behaviour: observation of unusual vehicle behaviour compared with that observed to be normal at given locations.

3. OBSERVATION TECHNIQUES

All the organisations, except Israel, in their pedestrian work use observers on site to record conflicts.

Most organisations use cine or video film records, often in conjunction with observers. Those which do not are France, Germany, Norway and the USA.

The only organisations using any form of automatic detection methods are Canada, Denmark and Great Britain.

The use of these different techniques is summarised in Table 2.

Country \ Element of Definition	Evasive action	Violations	Severity scale	TMTC	Acceleration	Speed	Separation	Angle of Collision	Road User Types	Vehicle Presence	Irregular vehicle behaviour	Other quantitative measures
Canada				✓			PC ₁					✓
Denmark					✓	✓	✓					
Finland	✓	✓										
France	✓		✓			✓		✓	✓			
Germany	✓		✓									
Great Britain (subjective technique)	✓		✓									
Great Britain (automatic)				✓	✓							✓
Israel (vehicle conflicts)						✓					✓	
Israel (pedestrian conflicts)			✓							✓		
The Netherlands	✓		✓				✓					
Norway	✓		✓			✓						
Sweden (LTH)	✓		✓	✓		✓			✓			
Sweden (VTI)				✓								✓
USA	✓		✓									

TABLE 1

Operational Definitions of Traffic Conflicts

<div> <div>Observation Technique</div> <div>Country of Organisation</div> </div>	On-site observers	Cine or video film	Automatic techniques
Canada	✓	✓	✓
Denmark	✓	✓	✓
Finland	✓	✓	
France	✓		
Germany	✓		
Great Britain (subjective technique)	✓	✓	
Great Britain (automatic)			✓
Israel (vehicle conflicts)	✓	✓	
Israel (pedestrian conflicts)		✓	
The Netherlands	✓	✓	
Norway	✓		
Sweden (LTH)	✓	✓	
Sweden (VTI)	✓	✓	
USA	✓		

TABLE 2

Observation Techniques

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5. ACKNOWLEDGEMENTS

This paper is contributed by permission of the Director, Transport and Road Research Laboratory.

6. APPENDIX

LIST OF ORGANISATIONS

CANADA	Road Safety Branch, Transport Canada, Floor 27c, Transport Canada Building, OTTAWA - ONTARIO KIA ON5
DENMARK	Danish Council for Road Safety Research, Akademivej Building 371, DK 2800 LYNGBY.
FINLAND	National Board of Public Roads and Waterways, P O Box 20, 00131 HELSINKI 13.
FRANCE	Organisation National de Securite Routiere (ONSER), BP 28, 2 av. du General Malleret Joinville, 94110, ARCUEIL.
GERMANY	Bundesanstalt fur Strassenwesen (BAST), Bruhler Strasse 1, Post fach 510530, 5000 KOLN 51, with Institut fur Psychologie, Universitat Braunschweig, 33 BRAUNSCHWEIG.
GREAT BRITAIN	Transport and Road Research Laboratory (TRRL), Old Wokingham Road, CROWTHORNE, Berkshire.
ISRAEL	Road Safety Centre, Technion City, HAIFA.
THE NETHERLANDS	Netherlands Institute for Preventative Medicine (TNO), Wassenaarseweg 56, LEIDEN.
NORWAY	Institute of Transport Economics (TØI), Grensevn 86 - OSLO 6.
SWEDEN (LTH)	University of Lund, Institute of Traffic Engineering, Lund Institute of Technology, Box 725, 220 07 LUND 7.
SWEDEN (VTI)	National Swedish Road and Traffic Research Institute, Fack, 58101 LINKOPING.-
USA	Federal Highway Administration, 400 7th Street SW, WASHINGTON DC 20590.

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Observation and Recording Methods

1. INTRODUCTION

The introductory paper (

- "Observation and recording methods used in the traffic conflict technique", J. Shippey), attempted to summarize the operational definitions and observation techniques used by those organisations actively involved in the use of the traffic conflicts technique as reported at the first TCT Workshop in Oslo, 1977.

It became obvious that nearly all the organisations had modified the techniques employed or wished to clarify the content of this summary, as well as giving additional information concerning new methods employed, as an evaluation or diagnostic-tool, and the use of the technique at locations other than intersections.

For simplicity this summary has been arranged by the country of origin of the organisations using the different methods of conflict analysis, and for each country the method employed and its current usage will be described.

The discussion of the different techniques led to the consideration of the fundamental point of definition of the terms used in describing them. This discussion is summarized later.

2. THE ORGANISATIONS AND THEIR METHODS

2.1 CANADA Transport Canada

After consideration of a number of semi-quantitative methods (e.g., late braking) post-encroachment time (PET) was found, after initial studies, to be the best measure of conflict occurrence. PET is the difference in time of two vehicles arriving at the same point. This is a separation for crossing vehicles, but for weaving and shunt situations it is more like the Swedish (LTH) time to accident (TO) as it is measured from the beginning of the evasive action. Repeatability and validity studies are currently being carried out, and, on their successful completion a user's manual will be prepared and tested. PET has only been used at urban signalised intersections. The effect of velocity

and PET has been investigated in the approaches to intersections but no improvement was observed on the use of the basic value. PET does not invariably rely on the presence of evasive action (i.e., in the case of a crossing incident) and, hence, it does not fall entirely within the definition of a conflict as decided at Oslo, however it is still thought to be a good indicator of the risk of a collision. Moving conflict studies are being carried out in the merging areas of some freeway access points.

.2 DENMARK Danish Council for Road Safety Research

The independent Danish researches into conflict have ceased in view of the impracticality of the use the hardware required. The Swedish (LTH) technique has been adopted, and used at rural intersections.

.3 FRANCE National Organisation for Road Safety (ONSER)

The French in fact use two measures. The first is a subjective analysis of evasive action and its severity, which it is thought, relates to collisions. The second measure is "risk". This is analysed after the observation, and combines measures of vehicles speed and type, angle of collision, type of junction and the severity of the incident for use in validation exercises with injury accidents.

The TCT was initially intended for use as an evaluation technique, but was found to be ineffective. It was then used as a diagnostic technique by various Départments, but injury accidents was found to be a more useful measure. It was also prohibitively expensive in view of the number of observers required to make a comprehensive study at a black spot. However, it appears that accident data will become more difficult to obtain, so the TCT may come into its own.

It is intended to investigate the subjective feeling of safety of residents related to the actual safety in terms of conflicts or accidents, but operational tests have, so far proved negative.

2.4 GERMANY Bundesanstalt für Strassenwesen with Universität Braunschweig

The presence of evasive action is the basic element of the conflict definition. A severity scale with three levels is used. The use of violations has ceased.

Accident - conflict relationships have been found to vary between different types of conflicts and accidents as well as between classes of junctions. Moreover, the data indicate linear relationships for most accident/conflict types.

The Conflict Technique is in use on the approaches to intersections as well as in the intersection proper.

A new recording procedure has been developed for the observation of pedestrian conflicts.

2.5 GREAT BRITAIN Transport and Road Research Laboratory (TRRL) - (Subjective techniques)

The original severity scaling has been modified to exclude severity 1, which consisted of precautionary evasive action where there was no probability of collision, and technically, therefore, no conflict. However a new grading 2+ has been included, which covers serious conflicts whose severity is not such that they could correctly be classified with the originally defined grade events. These changes underlined the problems of subjective verbal definitions and so an examination was made of factors considered by observers when grading conflict severities. The findings of this examination may be found in Paper No 30 ("Notes on revision of conflict severity classification") but the factors, in short, are:

- 1) Time before collision - 3 levels
- 2) Severity of evasive action - 4 levels
- 3) Complexity of evasive action - 2 levels
- 4) Minimum ultimate proximity - 5 levels

A very brief study showed good agreement between gradings using these factors and analysis based on the original definitions.

There is a definite indication of the importance of a combination of measures rather than one simple measure, but in order that further development can take place, it would be desirable to put quantitative values on the levels in each factor.

The technique has been used at both urban and rural intersections, and one county authority is intending to use it as a diagnostic tool at a contra-flow site (traffic flow in both directions in one carriageway) at road works on the M5 motorway.

Many other County authorities use the TCT as a diagnostic tool at accident black spots but we have little indication of its effectiveness because of lack of feedback.

2.6 GREAT BRITAIN Transport and Road Research Laboratory (TRRL) - (Automatic detection)

The analysis programs have been up-dated, and now determine a TMTC and time gap for each conflict type.

2.7 ISRAEL Road Safety Centre

The complex analysis of vehicle movement in order to determine the occurrence of irregular vehicle behaviour, continues.

There are certain parallels between the measurements made in this technique and the factors mentioned in the Great Britain subjective techniques:-

- 1) Reaction time
- 2) Grading of deceleration
- 3) Observation of both braking and direction change, although direction change was found to have little effect compared with braking. However, its existence is important.
- 4) No equivalent to minimum ultimate proximity.

2.8 THE NETHERLANDS Institute of Preventative Health Care (TNO)

The validation of conflicts observed between child pedestrians and vehicles in residential areas continues. Observers follow the children and observe conflict. A measure of risk throughout the whole of residential areas is found, rather than specifically at junctions.

An interview study attempting to relate subjective assessment of safety to observed safety in terms of conflict has shown no correlation at all.

Video recordings are used solely for training observers.

A second Dutch group, Institute of Perception (TNO), is investigating the use of analysis of video tape which could be used to produce TMTC's. The result of the semi-automatic analysis are analysed by computer to produce vehicle speeds and accelerations which could be converted to TMTC's. Initial work is not yet complete.

2.9 NORWAY - Institute of Transport Economics (TØI)

The technique employed has changed little. However the accident data base has been modified by the addition of a sample of insurance company claims which now have to be reported to the central data bank.

2.10 SWEDEN - Lund Institute of Technology (LTH)

The occurrence of a conflict is determined only using evasive action and a value of T_0 less than 1.5 secs. Examination of other criteria regarding road user type, angle of collision etc., is then used for accident prediction. For rural sites now being studied, speed may also be used in the initial determination of conflict presence. It has not been used in the urban situation because speed range has been found to be small.

Video recordings are not generally used, but have been in a recent interview study in which road users included in conflicts have been questioned and then confronted with a recording of the incident in which they were involved. Video recordings are also used in observer training.

Some problems have been found in relating the location of vehicle/vehicle conflicts with accidents within junctions although these problems were not encountered when cyclists or pedestrians were involved. Some local authorities use TCT for both evaluation and diagnostic work.

In addition to intersections, conflict studies have been carried out outside schools and at pedestrian crossing on tramways.

2.11 SWEDEN (National Swedish Road & Traffic Research Institute (VTI))

The system employs the automatic detection of speed and acceleration using video and vehicle sensors. TMTC is being studies where possible, although there are few incidents involving evasive actions. The system is being developed at the moment, hence there is only instrumentation at a few sites.

2.12 USA Federal Highway Authority

The basic General Motors technique is still being used in some States, although the recording of violations has now ceased.

A definition, broadly based on the GM definition has been developed and is being checked for repeatability and reliability. These tests are expected to be successful, and if they are a training manual will be produced. Future work will attempt to correlate conflicts with accidents, but until successful completion of that phase, conflict detection will not generally be used for diagnostic or evaluative work; although some States are currently using it for diagnosis.

Areas other than intersections where conflict studied have been used are: moving conflicts when overtaking wide loads, and the assessment of operational deficiencies in traffic control at construction sites.

3. SUMMARY OF DISCUSSION

Although this session provided a useful forum for the up-dating of information on operational definitions and observation techniques, perhaps the most important contribution was the consideration of definitions of terminology.

It became obvious in the course of discussion that the same words were being used by different organisations to mean different things. The most significant of these differences seemed to be in the main measure of safety: accidents. "Accidents" were taken, by different organisations to be:-

- 1) Injury accidents
- 2) Injury accidents, plus collisions with damage over a certain amount.
- 3) All collisions for which information was available, and
- 4) Injury accidents, plus a sample of collisions reported by insurance companies.

It is obvious, from this wide range of definitions, that no one measure of "conflict" is likely to correlate significantly with "accidents" in all countries - hence the wide range of definitions of conflict.

Similarly there was a difference of opinion of the interpretation of severity scales. Should these refer only to the severity of the evasive action, or to the severity of the end result if evasive action were not to be taken, or to a combination of these?

It appears that:

- 1) The ultimate safety measure must be defined. This is usually some measure of "accident" (expected or observed)
- 2) An "accident surrogate" must be defined. This definition may include a severity scaling, but the measure should relate well with the ultimate safety measure.

It is likely that 1) will be dependent upon the type of accident data available in the country of origin. Hence, 2), will also be country dependent. Is it, then, likely that common ground will be found in operational definitions of conflict and hence the observation techniques of different organisations?

TABLE 1
Operational use and definitions of 'conflict'

Country	Type of Location		Evasive Action	Severity Scale	TMTC or TO	Acceleration/ deceleration	Speed	Separation	Angle of Collision	Road User Types	Manoeuvre Type	Irregular Behaviour	Type of Junction	Complexity of evasive action
	Urban	Rural												
Austria	✓		✓	✓										
Canada	✓	✓			✓			✓						
Finland	No up to date information available													
France	✓		✓				R		R	R	R		R	
Germany	✓		✓	✓	I	I	I			✓			R	
Germany (pedestrian work)	✓		✓	✓	I	I							R	
Great Britain (subjective analysis)	✓	✓	✓	✓	I	I		I						I
Great Britain (Automatic detection)		✓			✓	I	I	✓						
Israel	✓		✓	✓		I	I		I			✓		✓
Netherlands (Child pedestrian)	✓		✓	✓				✓						
Netherlands (Semi-automatic)	✓				✓	✓	✓			✓				
Norway	✓		✓	✓			✓							
Sweden (LTH)	✓	✓	✓		✓		R			R			R	
Sweden (VTI)		✓			✓	I	I							
USA	✓	✓	✓	✓										

Notes:

Urban and Rural indicate the types of location where TCT is used.

- : Indicates a basic element of the TCT definition.
- I: Indicates that a measure is determined, either subjectively or objectively, but it is not used as an independent element of the definition.
- R: Indicates a measure has been used to determine the 'Risk' associated with a conflict, not to determine whether a conflict has occurred.

TABLE 2
Data collection methods

Country	Observation technique	Observers on site	Automatic detection	Cine or video film		
				Operational	Training	Research
Austria		✓				✓
Canada		✓			✓	✓
Finland	No up to date information available					
France		✓				
Germany		✓				
Germany (pedestrian work)		✓				✓
Great Britain (subjective analysis)		✓			✓	✓
Great Britain (automatic detection)			✓			
Israel		✓				✓
Netherlands (child pedestrian)		✓			✓	✓
Netherlands (semi-automatic)			✓			✓
Norway		✓				
Sweden (LTH)		✓			✓	✓
Sweden (VTI)			✓			✓
USA		✓				

5.1 Session 4. METHODOLOGICAL ASSESSMENT OF THE TECHNIQUES

Opening Remarks

E. Hauer^{*}

1. The purpose of these remarks is to set the stage for the discussion in this session. The proposed program for the Workshop identifies the following four topics:

- a. Validity
- b. Variability and Repeatability
- c. Reliability of Observers
- d. Study Design Considerations

For each of these four topics I will attempt to identify issues deserving discussion. I hope that my omissions and biases will be rectified during the subsequent debate.

VALIDITY

2. Whether there is validity to the Traffic Conflicts Techniques is common concern. It is also a confounded and confusing issue. Some believe that conflicts can be used to measure safety. Others think of conflicts as a valid measure of performance in its own right. Many believe in some mixture of both. The sceptics do not believe either.
3. Some of the confusion stems from contemplations of validity without reference to the specific task which the TCT is supposed to perform. It is clear that various variants of the TCT are being used for a variety of purposes.

^{*}Department of Civil Engineering, University of Toronto, Toronto, Ontario, M5S 1A4, Canada.

The TCT is considered, e.g.,

- a. For the identification of operational deficiencies on systems;
- b. To serve in warrants for control devices etc;
- c. To identify safety deficiencies on systems;
- d. To examine safety effects of rules, procedures, devices designs or countermeasures.

4. The validity of the TCT must be judged in relation to the task at hand. In some cases (a, and possibly b) the relationship between conflicts and safety is not of primary interest. Conflict occurrence is perceived as an aspect of level of service similar to delay, congestion or noise. This is so because the occurrence of events which cause the road user to take sudden evasive action is a source of irritation (just like delay or noise). It must be clear that in this case, the rate of conflict occurrence does not attempt to be an indicator of safety. It only reflects the unpleasantness to the road user of sudden evasive manoeuvres to which he is subjected. In this context therefore, the question of validity must be asked about the relationship between the conflict event and road user irritation.

In other cases, the occurrence of conflicts is regarded as an indication of some operational deficiency as well as of hazard. However, one is satisfied with the intuitive knowledge that a reduction in the rate of conflict occurrence is very likely to be a safety improvement. To know just how large the improvement is may not be of crucial importance. (Consider, e.g., better directional signing which leads to fewer erratic manoeuvres at a certain freeway off-ramp. Operational efficiency is improved and safety most likely enhanced.)

5. The problem of validity is of grave concern when conflicts are used to measure safety. To measure safety means to express the change in the safety

of a system (either relative or absolute) in numbers. This, e.g., is the case when tasks akin to those described under c and particularly d in paragraph 3 are to be undertaken. Whether the TCT is a valid tool to measure safety should be the central point of discussion here.

6. Some of the persistent fog hovering over this issue stems from carelessness in defining what (un)safety is. I have dealt with this question at some length in my contribution to the previous workshop. Only the bare bones of the argument bear repetition.

7. I know only one defensible definition of the safety of a system:

Safety is the expected number of accidents and severity of accidents occurring on a system per unit of time.

Emphasis is on the word expected. The "signals" we receive from the real world (in the form of actual accidents and/or conflicts) are merely reflections of this underlying expected value. These signals enable us to estimate what the expected value might be; its exact magnitude will never be known. It follows, that the task of measuring safety is the task of obtaining estimates of the expected number and severity of accidents.

8. Within this framework, the question of validity can be dealt with simply. System safety can be estimated directly from the history of accident occurrence. The accuracy of estimates so produced is well known. System safety (or changes therein) can also be estimated indirectly by the TCT. The accuracy of estimates so produced is less well explored. Nevertheless, in those circumstances in which the TCT can produce estimates of safety which are more accurate than those obtained by reliance on the accident history, the TCT should be regarded as valid.

9. It follows that the debate about the abstract term "validity" could profit by

focusing our attention on the more tangible and measurable problem of estimation accuracy. The issue of TCT validity will be resolved by determining:

how accurate are the estimates of system safety or changes therein when produced by the TCT; how do they measure up to the accuracy of estimates derived from the accident history of the system.

10. This approach steers debate away from some common pitfalls. The validity of the TCT is often questioned because of its inability to "predict" the number of accidents. The number of accidents to occur on some system can no more be predicted than one can predict the roll of a die. Such predictions are the domain of prophets. The role of the TCT is to estimate the expected number and severity of accidents. Its validity and usefulness must be judged according to its success to perform the task it is intended for.

The same misgivings about the validity of the TCT are often coached in terms of disappointing coefficients of correlation between conflicts and accidents. Somehow we have been conditioned to expect correlations close to 1. However, even if we had a perfect definition of the conflict event, and hired infallible observers to count conflicts during periods which correctly represent the time for which the accident history is used and if all accidents were in fact reported and also correctly recorded, even in this case the expected sample coefficient of correlation would be substantially below unity. This is due to the inevitable difference between the sample means and expected values for both conflicts and accidents. Thus, a sample coefficient of correlation which is substantially below 1 may be in some cases a confirmation of validity rather than indication of its absence!

Estimation accuracy is the key to our deliberations. Thus, instead of dwelling on the correlation between accidents and conflicts, we should look

at the two main factors which determine the accuracy of safety estimation by the TCT:

- a. The accuracy with which the accident-to-conflict ratio is known;
- b. The accuracy with which an estimate of the rate at which conflicts occur can be obtained.

11. If the distribution of accident-to-conflict ratios obtained through experimental research is very wide, the value which applies in a specific case is known with little certainty and estimates of system safety are inaccurate. If the distribution of accident-to-conflict ratios is narrow, safety can be measured accurately. Thus, the narrower the distribution of the accident-to-conflict ratio, the more validity to the TCT. The accuracy with which estimates of the rate of conflict occurrence can be obtained depends on the inherent variability of the conflict count, the reliability of observers and the resources devoted to the study. These topics are discussed next. I will lump them together under one heading.

ESTIMATION OF THE RATE OF CONFLICT OCCURRENCE

12. The essential element of the TCT is the estimation of the EXPECTED NUMBER OF CONFLICTS (by type) OCCURRING PER UNIT OF TIME. This estimate is derived from a count of conflicts. The accuracy with which this expected conflict rate is estimated from the count depends on:

- a. The variability inherent in the occurrence of conflicts;
- b. The "noise introduced into the count by the process of conflict identification;
- c. The "size" of the count.

13. Early investigations indicated that the process of conflict occurrence is characterized by large variability. In that study, variability included both that inherent in the process and that contributed by human observers. In the

intervening period more research has been conducted. It is hoped that some results will be reported in this session and that by now the contribution of the two sources of count variability can be separated.

14. The problem of observer reliability has been relatively widely investigated. It appears that the time has come to compare notes, identify elements of consensus as well as disagreement and to assemble all this information for the guidance of researchers and practitioners.

15. The third element determining the accuracy of conflict rate estimates is the "size" of the count. Large scale research on this issue has been conducted in the U.S. and it is hoped that the results will be reported here.

Deliberations about the amount of effort and resources to be devoted to the count of conflicts are far from simple. At least two issues deserve discussion. First, the trade-off between count accuracy and conflict definition. Second, the relationship between count accuracy and the task at hand.

16. There is some indication that the more serious the conflict counted, the stronger its relationship with the expected accident rate. However, serious conflicts are rare occurrences. Finding enough serious conflicts to allow accurate estimation of the expected rate of conflict occurrence may be tedious and therefore costly. Conversely, if even minor conflicts are counted in the field, the survey is likely to be brief and cheap. However, the magnitude of the accident-to-conflicts ratio will be uncertain and therefore the overall safety measurement inaccurate.

17. It is also not quite clear what levels of estimation accuracy should be considered satisfactory. Traditionally, the issue has been skirted by use of "accepted" levels of significance or power. In my view, this position is seldom tenable. The problem of estimation accuracy can not be divorced from

the reality of the cost associated with the field survey. Nor can it be judged without regard to the importance of the specific task at hand. To illustrate, a conflict rate estimate aimed at the safety analysis of a specific intersection need not be of the same accuracy as an estimate used to evaluate the effectiveness of a countermeasure to be implemented on a nationwide basis.

18. Finally, the oft-neglected issue of representative sampling deserves mention. Conflict surveys are conducted during certain hours of the day (usually during daylight) and specific times of the year (dictated by weather conditions and manpower availability). The practitioner and researcher must keep in mind the degree to which these sampling periods are representative. Many accidents occur at night and when roads are slippery. One can hardly expect a conflict survey conducted during the day when the sun is shining, to measure night-time safety or wet-road safety.

SUMMARY

- * Validity must be judged in light of the task for which the TCT is intended.
For many tasks validity is not an issue.
- * The question of validity arises when the TCT is used to measure safety in quantitative terms.
- * The measurement of safety is the task of estimating the expected number of accidents and their severity.
- * The validity of the TCT depends on the accuracy of estimates which it generates.
- * The TCT is not a tool for the prediction of accidents.
The sample coefficient of correlation is not the right measure of validity.
- * The accuracy of safety measurement depends on:
 1. How well do we know what the applicable A/C ratio is.
 2. How good is our estimate of the rate at which conflicts occur.
- * The central role of research is to generate ever better estimates of the A/C ratios.
- * The accuracy of the estimates for the conflict rate depends on:
 1. Inherent variability
 2. Uncertainty in conflict event identification
 3. Size of count
- * Knowledge accumulated about 1 and 2 seems ripe for summarizing.
- * Two unanswered questions about the size of count:
 1. Find balance between the accuracy of the conflict count and the reliability of the A/C ratio.
 2. How accurate is accurate enough.
- * The periods during which conflict surveys are often conducted may not be representative of the period for which the safety of a system is to be measured.

5.2 SUMMARY CONCLUSIONS OF SESSION 4

METHODOLOGICAL ASSESSMENT OF TECHNIQUES

1. The task of the TCT

Mr Hauer stated in his introduction that if we can agree that the subject of discussion in this meeting is the use of the TCT in measuring safety and not operational deficiency, only then the problem of validity is relevant. The American delegates stated that in their country the traffic engineers are only interested in using conflicts as an operational measure and are indeed not interested in validity problems. It was argued by other delegates that even if you use it only in this way that there is a problem of validity; the validity of conflicts with regard to 'inconvenience'. Furthermore, the concept of 'inconvenience' or 'operational deficiency' is not well defined like safety.

2. The definition of safety

Mr Hauer proposed: "Safety is the expected number of accidents and severity of accidents occurring on a system per unit of time". It was argued that the role of severity is not clear in this definition. A weighting of the severity classes is needed to relate one safety measure, to conflicts. This need is for practical and mathematical reasons. Cost/benefit weighting was suggested.

It was proposed to change the definition into: "safety is the expected number of accidents of defined severity....."

It was mentioned that this definition only refers to objective safety and not to feelings of safety. The latter may be based on conflicts and so influence the objective safety.

3. Validity, reliability(of observers) and repeatability (over time)

It was a feeling that the use of the word 'accuracy' in Mr Hauer's introduction is used first for problems regarding validity and second for reliability. The meaning however was clear so it seemed to be only a question of semantics.

The reliability and repeatability problems seem to be solved for most of the techniques but not the problem of validity.

What is needed is a summary of all this

4. Field disturbing influences by observers

The possibility of observers influencing conflict behaviour is present in most of the situations. It is not known what the influence is on the observations (at least one accident was caused by it in Canada). The effects however become smaller in time. The problems seem to be smaller at urban intersections with many pedestrians. Detectors on the road may also disturb the situation although one study has been made which showed no response to an array of cable detectors at an intersection.

Training conflict observers.

A. Lightburn and C. I. Howarth.

Department of Psychology
University of Nottingham
England.

In the previous session we heard a discussion of studies on the reliability and variability of observers and the implications for study design considerations. In this session we are taking one step further back and looking at the manner in which these observers are trained for conflict study work, and the effects of different methods of training on their assessments of traffic conflict situations.

There is a saying in Britain, which I am sure has equivalents throughout the world, that " a chain is only as strong as its weakest link ". If we think of conflict studies --- their instigation, application, planning, implementation and analysis --- as that chain, then it is possible to imagine that the observers could be one of the weakest links in that chain. If the observers are the weak link, then this immediately casts doubt on the results of validity and repeatability studies.

The main problem is that of subjectivity. No matter how mutually exclusive and well-defined the severity classifications are, the traffic conflicts technique is based on people using their subjective judgement to quantify what is often a complex traffic situation, and one which is over within a very few seconds. People bring to these observations not only all your careful instructions on what to record and how to record it, but also that intangible variable -- personal bias. Personal bias based on their expectations of what will happen and past experiences of similar locations or events. For example, someone who is biased against lorries because of a near or actual accident in the past may be unnaturally pre-disposed to include them as the main antagonist in an incident which they observe during a study. They may also be more inclined to

grade it more severely due again to personal bias. And we, who probably consider ourselves as "expert" judges, are not excluded from the effects of bias. Bias is by no means the prerogative of our observers. Each and every one of us should be aware of the possibility of bias not only within our observers, but also within ourselves.

So how do we deal with the problem of bias in our observers? Can we estimate it for each individual? Or can we find ways and methods of training which effectively eliminate it? What are the experiences which may predispose some people, in terms of Signal Detection Theory, to "false alarm" or to grade up? At Nottingham we have looked at differences in detection rates and allocation of grades by drivers and non-drivers. We had no prior expectations of which group would be the more accurate. (Thereby hopefully eliminating the well-documented experimenter bias!). It is possible that drivers who have some weight of experience of conflict situations may dismiss incidents that we want them to classify as conflicts, as "normal" driving. Non-drivers may be freer of pre-conceived ideas of what constitutes a hazardous situation and may be more likely to agree with expert judgement on events classified as conflicts. On the other hand, drivers may be better at anticipating potential hazards, may see a situation building, and therefore recognise and record the event with more insight.

And then, does the method of recording have an effect? So often an observer will complain that a particular incident falls between two categories, almost no matter how fine the classifications! Our own studies with two different recording methods suggest that this can alter both the consistency and the accuracy of grading. The traditional forced choice method asks the observer to choose from four or five categories. When all factors affecting the judgement of the severity of an event were reconsidered by John Older at the Transport and Road Research Laboratory, Crowthorne it was found that four factors, each with up to five levels of severity were sufficient to classify a given event. The four factors were a) time before collision --- long, moderate, short.

b) severity of evasive action --- light, medium, heavy, emergency.

c) complexity of evasive action --- simple, complex.

d) minimum ultimate proximity --- near, near miss, very near miss,
minor collision, major collision.

Preliminary analysis of a study in which a slightly modified version of these four factors was put into practice indicates that this method correlates very highly with the traditional method. Further, this factor method gives better consistency (intra-observer reliability up to 0.96) and a higher observer-expert correlation (highest found was 0.96). This study was conducted at Nottingham and was concluded only three weeks ago. There are further analyses still to be done on these data, but the preliminary results so far are very promising.

This latest study has confirmed the finding of the previously reported study that training can create skilled observers capable of evaluating traffic manoeuvres by recording conflict situations, but that a selection procedure must be applied to eliminate the poorer quality observers. We have already demonstrated a fairly effective way of pinpointing at an early stage those observers who are most likely to be unreliable and inconsistent. This method of selection seems equally applicable in this latest study.

As well as correlations within and between observers, and correlation of observers with expert judgement, we have used the Theory of Signal Detection. This method provides a very useful and illustrative means of describing the data in terms of hits, misses, false alarms and correct rejections. But where Signal Detection Theory is even more valuable is in separating the elements embodied in the observer-expert correlation coefficients. By plotting the Receiver Operating Characteristics (ROC) curves, it is possible to see whether improved agreement with the expert is due to i) improved discrimination of conflicts from non-conflicts by looking at changes in d' , and

ii) any changes in the criterion adopted by the individual towards that of the expert by looking at β .

Correlation coefficients alone will not give this important information on how each observer is operating.

My last point which I hope will be taken up in the discussion to follow concerns the question of just what is a "satisfactory" level of performance by observers after training? It would be ideological and unrealistic of us to say 100% or even 95%. And how does laboratory training transfer to real life conflict observation? I had hoped to have an answer to this last question, but the preliminary analysis of our current data investigating just this

problem has not shown the answer to be a simple one and further analysis of the data is required.

To sum up --- the purpose of this session is to examine methods of training observers. Yet in so doing I hope we will not forget to examine very critically the effects of different forms of training on the individual observer. It is not enough to say whether a method is successful. We must be able to say which methods are more successful than others, in what ways and why. We must find ways of estimating and/or eliminating observer bias and examine the ways in which it can affect our results. We must discover ways of predicting which observers are the most consistent, accurate and reliable. In short we must pinpoint the weaknesses in our chain and find ways of strengthening them.

6.2 REPORT ON SESSION 5: OBSERVER TRAINING

Mme Mulhrad(France) opened the discussion by commenting that long-term observers may "wear out". Although observers continue to improve after training, it is possible that if kept on observation work for a long time they may ultimately need to be replaced. It was suggested that observers may improve up to a certain stage but then their performance drops off.

Recording conflicts can be a monotonous occupation and lead to boredom.

Mr Older(UK) reported on increased work rate when their observers recorded all, including minor, conflicts. Mr Zimolong(Germany) agreed that recording only serious conflicts is very monotonous because they are such rare events. Their observers therefore also recorded traffic violations, although no further use was made of this data.

The point concerning observer bias which Mrs Lightburn(UK) brought up in the introduction was taken up by Mr Hyden(Sweden) and Mr Baker(USA). Both agreed with Mrs Lightburn that some observers have difficulty in detecting some conflicts, are unreliable and have to be eliminated. Mme Muhlrads(France) suggested that some observers can observe the whole of the junction, while others perform better if they are only given one direction or manoeuvre to observe. Mr Allen(Canada) agreed that when observers focus on one or two specific manoeuvres and have clearly defined responsibilities that they seem to concentrate more.

There was some discussion on the type of observer to use. Prof. McDowell(UK) and Prof. Hauer(Canada) considered that it might be alright to use students as long as they were used to look at very specific manoeuvres. But when recording complex situations at sites where possible changes in layout are anticipated, then the traffic engineer might be better. Mr Baker(USA) pointed out that there was some evidence to suggest that the "right" individual, who is a permanent conflict observer, will get very proficient and may well be better than the engineer. Mrs Lightburn(UK) pointed out that traffic engineers may have preconceived ideas about the situation and biased expectations.

The question of automatic detection methods was raised by Prof. Hauer(Canada). Both he, Mr Older(UK) and Mrs Lightburn(UK) agreed that automatic techniques would eliminate all the problems of using human observers with all their attendant failings and biases. However, until these methods could be considerably improved observers will continue to be used. Prof. Hauer (Canada) commented that at least someone actually

LOOKS at the situation instead of trying to analyse what is wrong from an armchair!

There was some feeling by Mr Hyden(Sweden) and Prof. McDowell(UK) that semi-automatic techniques, while still operated by observers and therefore still open to subjectivity, may at least avoid observers missing conflicts while they are busy recording a previous one.

As far as training manuals for conflict observers are concerned Mr Zimolong (Germany) already has one in use. He is going to give a copy to Mrs Lightburn(UK) which, when translated, will be circulated to everyone here. Mrs Lightburn(UK) is completing a manual shortly and this(with the permission of TRRL) will also be circulated. Mr Glauz(USA) is presently working on a manual which is due for completion in September. Perhaps they could make it available to us all then.

INTERNATIONAL COMPARATIVE STUDY ON TRAFFIC CONFLICT TECHNIQUES

ROUEN 19-23 March 1979

G. Malaterre & N. Muhlrad, ONSER, France *

1. Introduction

Four teams have participated in this joint comparative study, coming from Germany (University of Braunschweig), Great-Britain (TRRL), Sweden (Lund Institute of Technology), and France (ONSER). A fifth team from U.S.A. may be able to join in later, by performing observations in Rouen in May 1979, on the same locations that have been studied by the other teams in March.

France was chosen as the best place for this study, as it is the most Southern country of the four European ones involved, and therefore the most likely to display reasonable weather at the end of winter ... Rouen seemed to be a good choice of urban area, because of medium size, easy access, good representativity of usual urban traffic problems, availability of accident data.

Two possible intersections were selected prior to the experiment, corresponding to very different traffic situations and types of urban environment as well as accident situations. The amount of observation and common work to perform on each one of these locations was decided during the experiment by all the participating teams. First global results and comparisons were drawn at the end of the week, but each team has agreed to do further analysis on the detailed data collected during the Rouen session, prior to the conflict workshop to be held in Paris in May.

2. The city of Rouen

The urban area of Rouen counts 400 000 inhabitants, half of them being located on the North side of the river Seine, and the other half on the South side. Four bridges join the two banks of the river near the city center. The oldest part of the urban area is the North bank commercial and business center, built mostly with very narrow medieval streets.

The urban area is growing at the rate of 1 % a year, but mobility of the residents increases faster (4 to 6 % a year). Traffic problems became acute in 1968, with serious traffic jams in the city center and on the North-South and East-West arterials. Car traffic reorganisation was then planned, starting with the building of the fourth (now existing) bridge. Together with traffic improvement, the aim of the new plan was to increase activity in the city-center, and extend it on the left bank of the river.

assisted by B. Spicer, H. Gstalter, C. Hydén, P. Garder, L. Linderholm

Action took place with the building of a new business and shopping area on the South side (St Sever), creation of an extensive pedestrian network both in the old center and in the new one, on-street parking regulations, creation of car-parks around the central district, and a system of one-way streets.

This plan has been very successful at improving traffic, and also at increasing attractiveness of the city-center... so much so that new traffic problems are now appearing. Evening peak hour, which was situated between 6 p.m. and 7 p.m. in 1968, is now twice as long (5 p.m. to 7 p.m.) and just as intensive ... No solution to the problem can be found any more with priority given to cars as the main means of conveyance : the local authorities of Rouen are therefore now considering solutions based on a priority to public transports.

Short term action will be to create a system of bus corridors in the city center and on the main arterials. In the long term, a tram network is considered, with an underground part in the central area. At the moment, the modal split in Rouen is 60 % of all journeys performed by car, 15 % by two-wheeled vehicles, and 15 % by public transport ; the local authorities hope that future increase of mobility will be absorbed mostly by public transport, which would lead to a more balanced modal split (40 % cars, 20 % bicycles and mopeds, 40 % public transports).

3. Traffic safety in Rouen.

As an average, 900 injury accidents occur every year in the city of Rouen (not including the outer part of the urban area). Accidents are mostly to be found on the main arterials, but do not really concentrate in particular locations, and serious accident black-spots are few.

Specific action to improve safety has been undertaken by the Technical Services of the city in the last four years. Accident spots were selected on the basis of the local police accident file (which was put on computer two years ago). Each spot and corresponding accident situation were then analysed by a safety group including members of the Police, the Technical Services, and the CETE of Rouen (Ministry of Transports) ; improvements were designed as a consequence of the analysis. Overall, 30 accident-spots were studied in the last four years, 20 solutions were proposed, and about 15 spots were accordingly transformed, with a good efficiency.

Only six or seven intersections are now left in Rouen with more than 4 accidents a year. Quite a few more average 2 to 3 accidents a year. The safety problem is now getting very complex to solve... Future safety action of the Technical Services is to include information to the public and to the local representatives concerned by the problem.

Overall, due to local action as well as to more general measures (mandatory safety belts for instance), injury accidents in Rouen have been decreasing over the last few years. It is to be noted, that in 1978 most of the accidents involved a two-wheeler (44 %) ; while only 15 % of all accidents involved a pedestrian, half the fatalities were pedestrians.

4. The locations chosen for the experiment

The first location, BELGES, is a large size intersection (see diagram) with fairly heavy traffic : 12 000 vehicles per hour at peak-time, all legs included. It is situated at the head of one of the four bridges ; of the overall traffic at this intersection, about 55 % are journeys done inside the urban area, 35 % journeys between the urban area and the outside, and 10 % through traffic. Heavy-weight vehicles represent about 8 % of all vehicles circulating on the intersection.

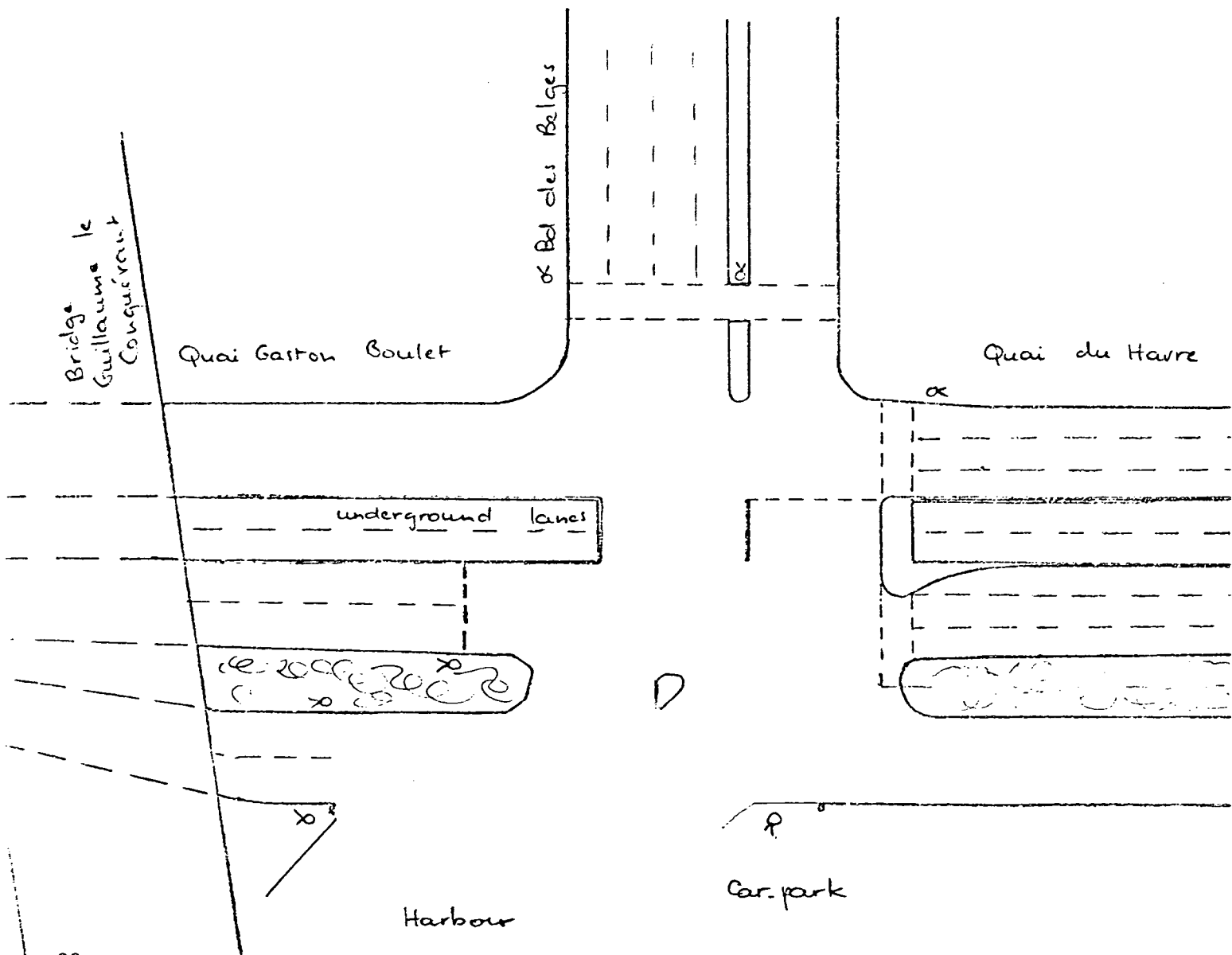
BELGES is a major accident black-spot, with an average of 15 accidents a year ; it is in fact the only location in Rouen where more than 10 accidents occur par year...

The physical lay-out of the intersection is quite complex : Boulevard des Belges is a large size arterial with a central reservation, taking traffic coming from the North as well as from the bridge Guillaume le Conquérant, which goes over the intersection ; the South leg of the junction is much narrower and leads only to a car-park and to the Harbour ; the two other legs of the junction include one stream of traffic from East to West (3 lanes), another one which is underground (2 lanes), and two streams of traffic from West to East, separated by a central reservation (2 lanes each). The intersection is signal-controlled.

The second location, JEANNE D'ARC, is of a more common urban type (see diagram) ; the North-South branch of the intersection is a relatively important artery of the city-center, while the other legs are small access streets. The location is situated in a part of the center which is partly occupied by residences and partly by offices or services.

Accidents on the intersection average two to three a year. Their occurrence seems to be related with the fact, that this junction is used as part of a rat-run to avoid some longer car-routes. (This situation has appeared after implementation of the local part of the traffic-plan, a year and a half ago...). The intersection is not dimensionned so as to absorb easily the resulting extra-traffic.

FIRST LOCATION
BELGES



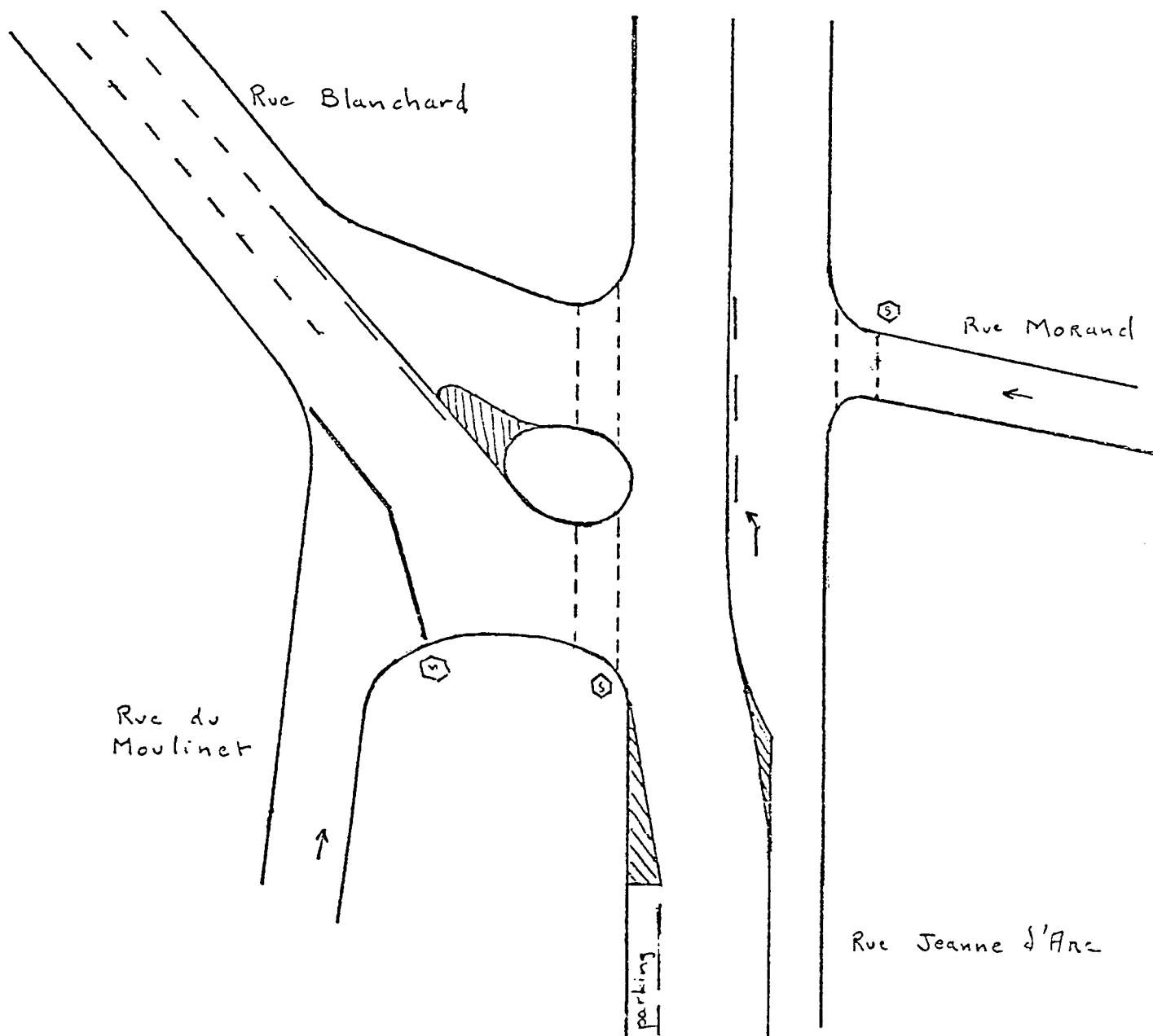
The main legs of the junction are the two sections of rue Jeanne d'Arc, which runs from North (the station) to South (the river) ; traffic from the North use two lanes, while one only is left for traffic from the South. The East leg of the junction is a very narrow and very short access street ; it is one-way, with exit on the intersection and a STOP sign. On the West side, two streets meet at the junction, where the two streams of traffic are separated by an island ; two STOP signs give priority to Rue Jeanne d'Arc. Pedestrian zebra crossings are marked on the East, North and West legs of the intersection.

5. Experimental conditions

The observation means of the different teams were the following :

- Great Britain : two observers on the ground, and a third person in charge of a 16 mm time-lapse camera (two frames per second) ; the camera was equipped to be either set on the roof of a car, or fixed to a lamp-post, or placed on a balcony above the street ; the film-cartridge had to be changed once every hour.
- Germany : five persons were available as observers, but only four of them had to be on the ground at the same time ; each observer was in charge of watching traffic from one leg of the intersection and going one direction ; two periods were therefore necessary to observe the whole location.
- Sweden : four persons were available ; two of them were observing on the ground at the same time, while a third one was in charge of a video-camera ; the camera had to be placed high up (3rd or 4th floor) on a balcony or at a window, at a distance of about 50 metres from the intersection ; tapes had to be changed every half-hour.
- France : two teams of two observers on the ground at the same time, placed at opposite angles of the intersection, so as to be able to watch the whole traffic situation.

Of the two locations, the first one (BELGES) was preferred by the German and the French team, while the Swedish and English ones felt that Jeanne d'Arc was more interesting and more comparable to home situations. Because of problems arising for the location of cameras on the second intersection (in particular, there are no lamp-posts in the center of Rouen ...), it was decided that observations would be performed on BELGES on the first day, giving time to get the necessary authorizations on JEANNE D'ARC, where observations would be carried out the second day.



SECOND LOCATION
JEANNE D'ARC

After the second day, it appeared clearly that :

- BELGES was too big a junction to do justice to the English technique, as the TRRL had only Rouen, thus making large-scale observation difficult.
- JEANNE D'ARC was considered a better location by the Swedish team, as the types of conflicts occurring there were more varied (in particular, a fair number of pedestrian conflicts).
- BELGES was considered more interesting by the German team, who wanted also to carry out a second period of observation on the junction, to take into account traffic on the two legs that had not been observed on the first day.
- BELGES was also preferred by the French team, as it could provide interesting comparisons between accident situations and conflict situations.

In the end, it was decided that three of the four teams (Sweden, Great-Britain and France) would operate on JEANNE D'ARC on the third day of observation, while the German team would go on with their work on BELGES. The French team also carried out additional observations on BELGES, outside the periods used in common by all the teams.

The final common observation scheme was the following :

- Tuesday, March 20th, 11.00 to 14.00)
15.45 to 18.00) BELGES
- Wednesday, March 21st, 9.00 to 11.15)
11.45 to 14.10) JEANNE D'ARC
- Thursday, March 22nd, 12.20 to 14.15) JEANNE D'ARC (France, England,
15.00 to 17.15) Sweden), BELGES (Germany)

The French team also observed on BELGES from 18. to 21.
21. to 23.
and from 7. to 9.30

On BELGES, the time-lapse camera was fixed to a lamp-post on the bridge Guillaume le Conquérant which runs nearly above the intersection ; the video-camera was placed on the sixth-floor balcony of a bank, situated on Boulevard des Belges. On JEANNE D'ARC, the time-lapse camera operated from the roof a car parked at about 30 metres from the junction on Wednesday, and from a first floor balcony on Thursday ; the video-camera was fixed to a third-floor window at about fifty metres from the intersection.

During the whole exercise, weather conditions were mostly grey or rainy, windy and rather cold...

6. Availability of observation data

For the Swedish team, whole observation data was available immediately, whether directly collected on the ground or shown on the tapes. English data provided by the ground observers was also available on the spot, but the film itself is not likely to be processed and analysed before several months. German data was immediately ready, but prediction of accidents from conflicts could not be carried out, because the necessary coefficient are missing for the kind of intersection treated (BELGES). The French team could also produce conflict data on the spot, but prediction of danger from this data requires computer processing, and can be done quickly, but only at the office.

7. Comparison between the conflicts observed

The four teams classified the conflicts with different severity scales :

- Great-Britain : five levels (2, 2+, 3, 4, 5). Only the levels 2+ to 5 were considered serious. In the final comparison, conflicts rated 2 were taken into account only if they had been detected and considered serious by some of the other teams.
- Germany : three levels (slight, medium and serious). Only the two top-levels conflicts were taken into account systematically in the final comparison ; slight conflicts were treated in the same way as the English conflicts 2.
- Sweden : conflicts were not classified ; only serious ones were noted by the observers.
- France : five levels (noted 1, 2, 3, 4, 5), all considered serious ; slight conflicts are rated 0,5 and are not usually noted by the observers ; as an exception, they were actually noted on the third observation day (Jeanne d'Arc) so as to facilitate comparisons between the four techniques, and they were used in the same way as the English conflicts 2 or the German slight conflicts.

The following tables give the list of serious conflicts detected by at least one team on the first two days of observation. Some symbols have been used in these tables :

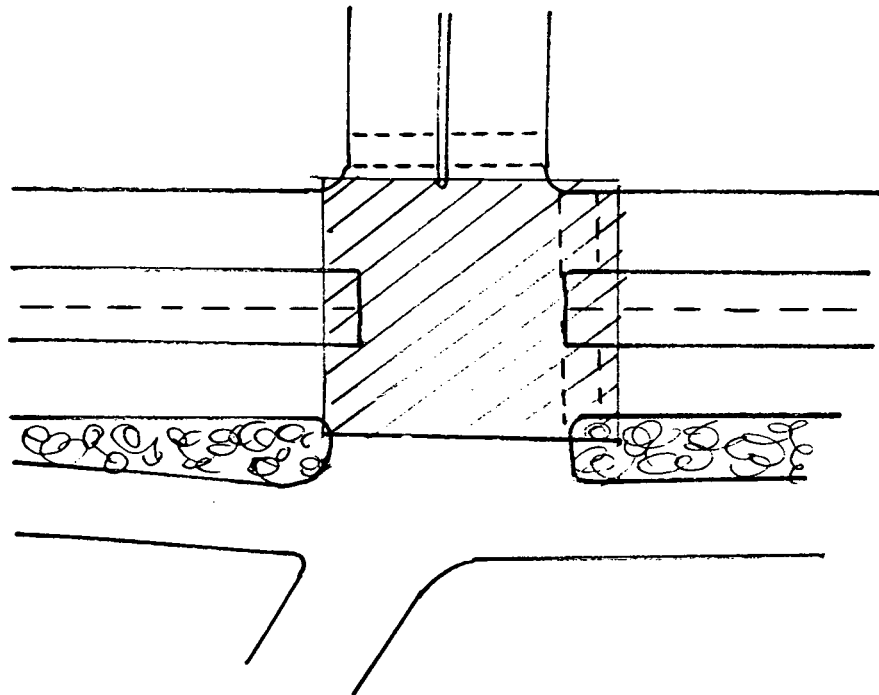
D	for Germany
S	for Sweden
GB	for Great-Britain
F	for France
sl	for slight
M	for medium
S	for serious

TABLE 1. FIRST LOCATION (BELGES)

Date : Tuesday, March 20th


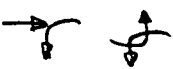

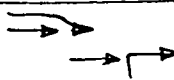
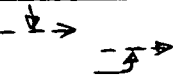
Periods of observation : 11.30 - 14.00
15.45 - 18.15



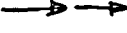

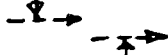
Area of observation :


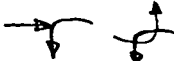

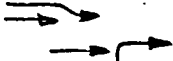



Conflicts recorded :

Types Time --> ↓	right angle ↕	one vehicle turning left ↩ ↪	rear-end → →	right turn or weave ↘ ↗	pedestrian ↔ ↗	teams not on observation on the conflict location
11.35				F 1		S, GB, D
11.50		D M				GB
11.53				F 1		
11.53		S GB 2+				D
11.53		S GB 3 F 1				D
12.01					S	
12.02		S GB 2 D sl				
194						

Types Time ↓	→						teams not on observation on the conflict location
12.07				S			D
12.10			S D sl				
12.08			D S				
12.44			S D sl GB 3				
12.45				D 5			
13.07			S				GB
13.19 collision			GB 4 F 3 D 5 S				
13.25			D M				
13.29			F 1 D M GB 2+ S				
13.29				S D sl			
13.46			D M GB 2				
13.42			S GB 2				
15.53						GB 2+	
15.53						S	
16.00			S				
16.05			D M S				GB
16.18			D M				
16.20			F 1				GB
16.21				D M			
16.26					F 1		D

Types Time	 right angle	 one vehicle turning left	 rear-end	 right turn or weave	 pedestrian	teams not or observation on the conflict location
16.31				D M		
16.44				GB 2+ S D sl		
16.52		S D M GB 2+				
16.55					D M	
16.57		GB 2+ D sl S				
16.59		GB 2+ D sl S				
17.00		F 1				
17.03		S GB 2 D sl				
17.03		D M				GB
17.09			S			GB
17.10				D M		GB
17.11		F 1				D
17.17		F 1				GB
17.18				F 1		GB
17.25			S			
17.27					S	
17.30				F 1 D sl		GB
17.34					D M	GB
17.35	S GB 2+ F 2					
17.37				S GB 2+ D sl		
196						

Types Time	 right angle	 one vehicle turning left	 rear-end	 right turn or weave	 pedestrian	teams not on observation on the conflict location
17.37					S	
17.39				GB 2+ D sl		
17.40				S F 1 D M		GB
Total number of conflicts	1	25	6	11	7	

Raw results are the following :

- . total number of conflicts on the first location : 50
- . total number of conflicts in common observation period : 48
- . conflicts observed - by the four teams 2
 - by three teams 11
 - by two teams 8
 - by only one team 27
- . percentage of conflicts observed by 3 teams or more : 27 %
- . percentage of conflicts observed by more than one team : 44 %

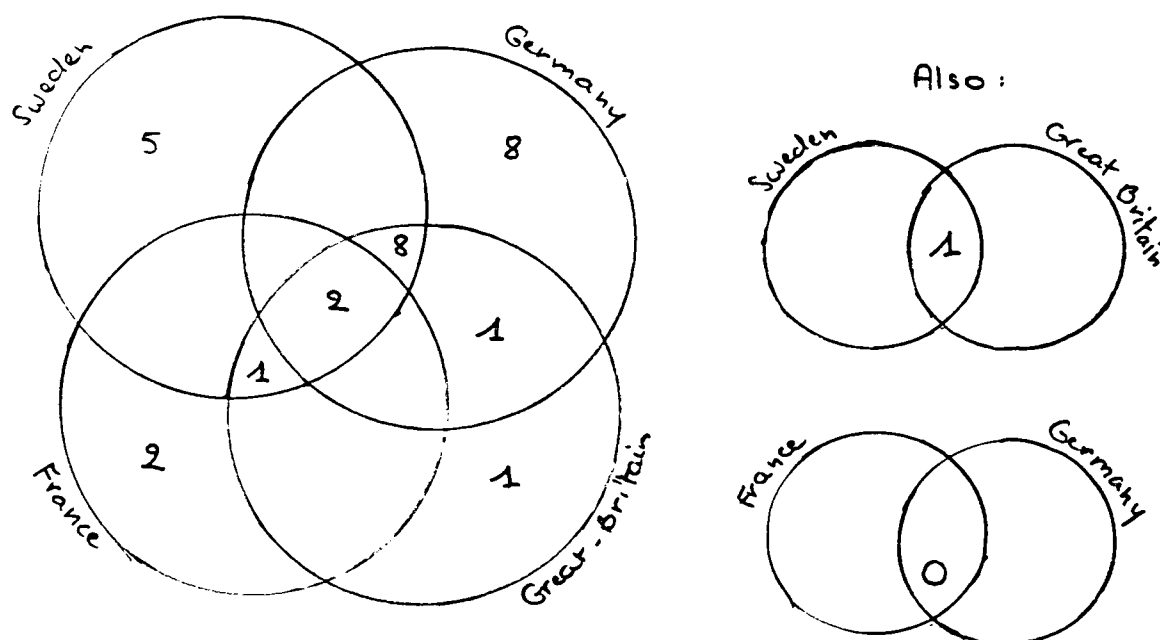
If only the conflicts detected while all the teams were actually observing are considered, we come to the following figures :

	S	D	GB	F	Total
number of conflicts observed	19	21	14	5	31
detection rate	61 %	68 %	45 %	16 %	100 %

number of conflicts detected	by the 4 teams	by 3 teams	by 2 teams	by 1 team	Total
	2	9	4	16	31
	6 %	29 %	13 %	52 %	100 %

It appears from these figures that agreement between the four series of results is not very high. It is the highest between Sweden, Germany and Great-Britain, while the French detection rate was very low.

Number of serious conflicts detected



As far as severity scales are concerned, it is only worth while comparing the English and the German ones from results on the first location :

D \ GB	slight	medium	serious	total
2	2	1		3
2+	5	2		7
3	1			1
4			1	1
Total	8	3	1	12

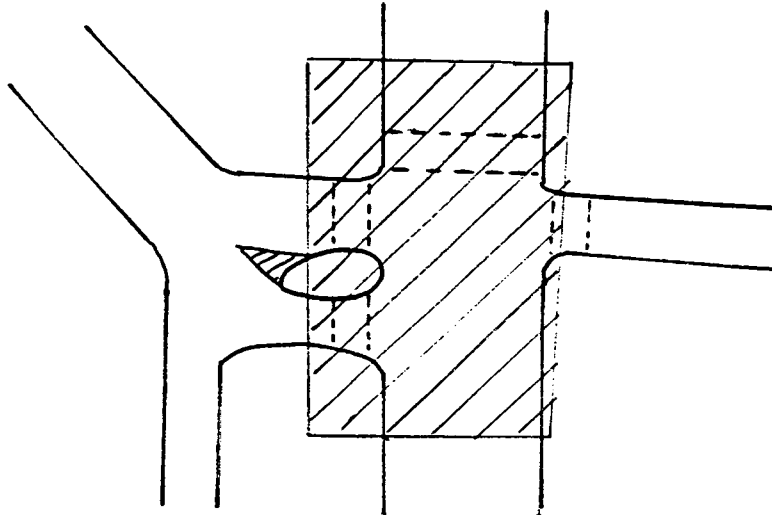
The English level 2+ seems to coincide with the German level "slight", but the two scales do not agree very well.


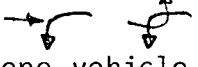

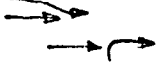
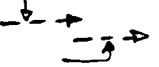
TABLE 2 : SECOND LOCATION (JEANNE D'ARC)


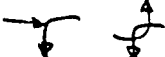
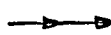
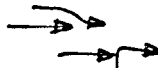
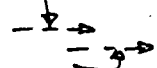
Date : Wednesday, March 21st

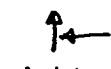
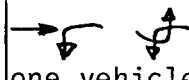
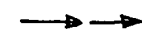
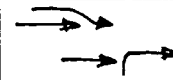

Periods of observation : 9. - 11.15
11.45 - 14.10


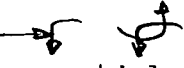
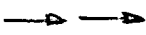
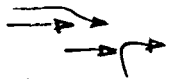
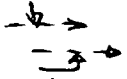
Area of observation :



Types Time	 right angle	 one vehicle (at least) turning left	 rear-end	 right turn or weave	 pedestrian	teams not on observation on the conflict location
9.22					S GB 2+ D sl	
9.43					S D M	
10.00		S GB 2+ D M				
10.08				F 1 D sl		
10.10	S GB 2+ D M F 1					
10.16		F 1 D M				
10.30					F 1	
10.31					S	
10.35					F 1 GB 2+	
10.41 200				S		

Types Time	 right angle	 one vehicle turning left	 rear-end	 right turn or weave	 pedestrian	teams not on observation on the conflict location
10.42				GB 2+ D sl		
10.59				D M GB 2		
11.01				S GB 2		D
11.48				F 1		GB, D
11.49					S	GB, D
11.52					S D sl	
11.55		GB 2+				
11.56		S				
12.02				F 1		
12.11				F 1 GB 2		
12.14		D sl S				
12.16		GB 2+ F 1 S D sl				
12.20		D M GB 2				
12.20				GB 2+		
12.21					GB 2+ S	
12.24		D M GB 2				
12.26		D sl S GB 2				
12.26				GB 2+ S		
12.34			D M S			
12.42					S	201

Types Time	 right angle	 one vehicle (at least) turning left	 rear-end	 right turn or weave	 pedestrian	teams not on observation on the conflict location
12.42				D M		
12.44				F S 1 GB 2+ D M		
12.56		D M				
12.03				S		
13.12					F 1 GB 2	
13.12	S D sl					
13.17		GB 3 D M				
13.17		S D sl				
13.22					S	
13.30					GB 2+	
13.31					GB 2+ S	
13.31				S		
13.34					S GB 2+	
13.34					S	
13.38			S GB 2+			
13.41		S GB 2+				
13.48	GB 2+ D sl					
13.50				F 1		D
13.52				S D sl		
13.52	GB 2+ D sl					
13.57 202		GB 2+ D M				

Types Time	 right angle	 one vehicle (at least) turning left	 rear-end	 right turn or weave	 pedestrian	teams not on observation on the conflict location
13.58 collision			F 3 GB 4 D S S			
13.58		GB 2+ D sl				
14.00			S			D, F
14.02					GB 2+	D, F
14.04				GB 2+ S		D, F
14.07		GB 2+ S				D, F
14.07					S	D, F
14.10				S		D, F
Total number of conflicts	4	16	4	18	17	

Raw results are the following :

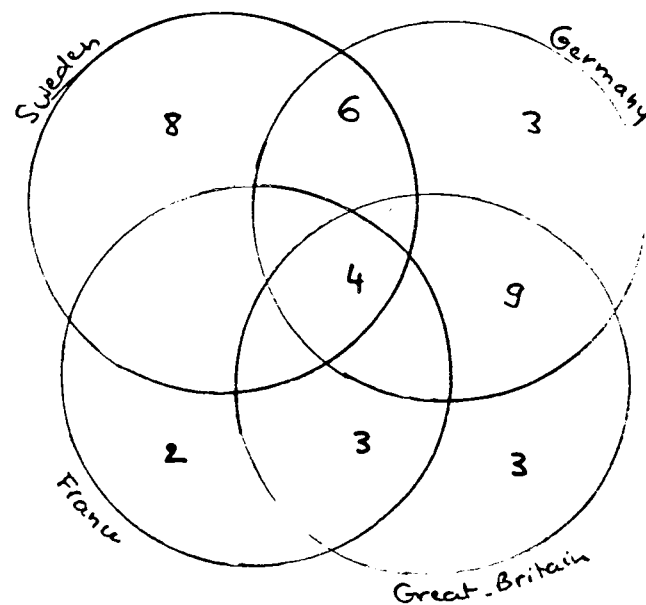
- . total number of conflicts on the 2nd intersection : 59
- . total number of conflicts during the common observation period : 50
- . conflicts observed :
 - by the four teams 4
 - by three teams 3
 - by two teams 28
 - by only one team 15
- . percentage of conflicts observed by three teams or more : 14 %
- . percentage of conflicts observed by more than one team : 70 %

If we consider only the conflicts collected while all teams were actually observing, we come to the following figures :

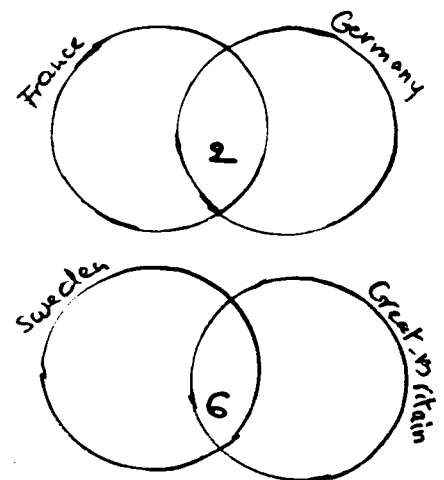
	S	D	GB	F	Total
number of conflicts observed	29	27	28	12	50
detection rate	58 %	54 %	56 %	24 %	100 %

number of conflicts detected	by the 4 teams	by 3 teams	by 2 teams	by 1 team	Total
	4	3	28	15	50
	8 %	6 %	56 %	30 %	100 %

Conflicts detected by only one team were less numerous than on the first location.



Also :



Again, it is possible here to compare severity scales only between British and German results :

D \ GB	slight	medium	serious	total
2	1	3		4
2+	6	4		10
3		1		1
4			1	1
Total	7	8	1	16

Agreement between the two scales is low, except for the most serious conflicts (collisions).


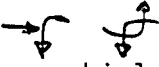


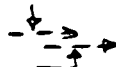
These comparative results obtained from the first two days of observation showed, that the French team was currently detecting far less conflicts than the other three. To check whether this was due to a difference in severity rating, French observers were asked on the third day to note the conflicts rated as slight (0.5). These were ignored in the following comparison when they had been seen only by the French team.



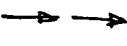
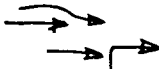
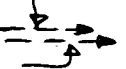
Table 3 gives the common results of the third day of observation, on JEANNE D'ARC, for three teams : Great-Britain, Sweden and France.


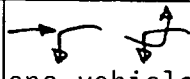
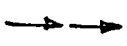
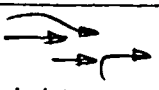
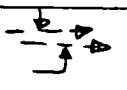
TABLE 3. SECOND LOCATION (JEANNE D'ARC)

Date : Thursday, March 22nd

Periods of observation : 12.20 - 14.15
15.00 - 17.15

Types Time	 right angle	 one vehicle (at least) turning left	 rear-end	 right turn or weave	 pedestrian	teams not on observation on the conflict location
12.20	GB 2+					
12.21				F 1 GB 2		
12.28				S F 0.5		
12.38				S F 0.5		
12.47		S GB 2+ F 1				
12.54					S GB 2+ F 0.5	
12.57	F 1 GB 2					
13.12				GB 3 F 0.5		
13.13			F 1			
13.15					S F 3	GB
206						

Types Time	 right angle	 one vehicle (at least) turning left	 rear-end	 right turn or weave	 pedestrian	teams not on observation on the conflict location
13.40					S GB 2 F 0.5	
13.42					S F 0.5 GB 2	
13.44					S GB 2	
13.44		S F 1 GB 2				
13.46			S GB 2+			
13.48				S GB 2+ F 0.5		
13.53		F 1				
13.54		S GB 2+ F 0.5				
14.09	S F 0.5					
14.09		GB 3				
14.13	S GB 2					
15.07					S F 1	
15.16			S			
15.22				GB 2+ F 1		
15.58		S F 2 GB 3				
16.15					F 1	
16.20		S GB 2 F 0.5				
16.20		S GB 2				
16.20				F 1		
16.22		F 1				

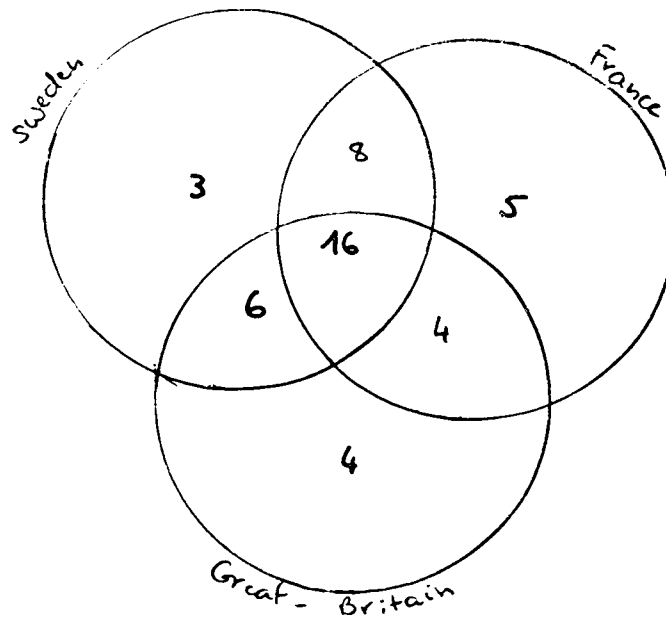
Types Time	 right angle	 one vehicle (at least) turning left	 rear-end	 right turn or weave	 pedestrian	teams not or observation on the conflic location
16.22		F 1/F 2 GB 3 S				
16.30		GB 2+ F 1 S				
16.38		GB 2+ S				
16.38		F 0.5				
16.41		S F 0.5				
16.41				F 1 S		
16.45					S	
16.46		S GB 2+ F 1				
16.47	GB 3 F 2 S					
16.56		S GB 2				
16.53				S		
17.01		GB 2+ S F 0.5				
17.06		S GB 3 F 3				
17.08		S GB 3 F 1				
17.13					S F 0.5	
17.13		GB 2+				
Total	5	20	3	9	9	

Results are the following :

- Conflicts detection :

	GB	S	F	Total
number of conflicts observed	30	33	33	46
detection rate	65 % -	72 %	72 %	100 %

number of conflicts detected	by the 3 teams	by 2 teams	by 1 team	Total
	16	18	12	46
	35 %	39 %	26 %	100 %



The number of conflicts observed by all teams is here quite high.

- Comparison between severity scales.

Only the French and British results could be compared :

GB \ F	0.5	1	2	3	4	Total
2	3	3				6
2+	4	4				8
3	1	1	3	1		6
4						
Total	8	8	3	1		20

The two scales do not agree very well. Conflicts rated 2 and 3 by the French team are all rated three by the English one, but there is no coincidence at a lower level.

8. Diagnosis of the two locations.

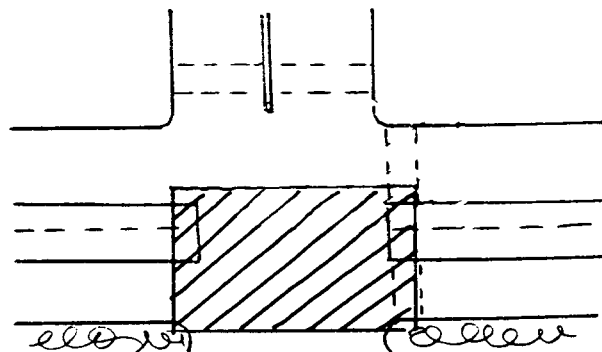
From conflict data, the four teams tried to diagnose the safety problems on the two intersections studied. Further work on the subject has been performed later, but the following results were the ones drawn immediately at the end of the Rouen week.



1. BELGES

a) Great-Britain

Data collected by only two observers on the ground and during a limited length of time was not sufficient to draw a complete diagnostic on the location ; full processing of the film would have been necessary.

As it is, observation was concentrated on one part of the intersection :



The main problem seems to be related to left-turning vehicles : either  or . This is apparently due to the way traffic lights are phased ; some cars coming from Le Havre go against red ; also, visibility is bad.




A secondary problem is rear-end conflicts between vehicles coming from Le Havre, one of them having to weave to avoid a car stopped in the middle of the junction :



In fact, the middle of the intersection appears a very confused situation, and gets blocked very often ; conflicts occur because of bad understanding of the situation by the drivers.

b) Sweden

Accidents were predicted from conflict data for the following period : 11.40 to 17.45, from Monday to Friday. The average number of accidents to be expected is 1.1 per year, half of it being car-to-car collisions.

The main safety problem involves left-turning vehicles : either  or  (car-to-car). A secondary problem concerns two-wheelers :  Half of the total number of conflicts occurred in the South-West quadrant.

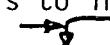
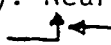
The Swedish team also stresses the mess in the center of the intersection as one major source of conflicts. As it was, conflict data appeared rather limited and it would have been preferable to perform a second day of observation on this junction.

c) Germany

BELGES is a junction of the same type as some studied in Germany ; however the phasing of the traffic-lights is very different of what could be found in Germany, and the data-sheets corresponding to signal-controlled intersections could not be used here ; conflict data had to be collected as on a non-signalised intersection.


Two opposite approaches of the junction were observed at the same time : the East and West one (\rightarrow and \leftarrow) on the Tuesday, and the North and South one (\downarrow and \uparrow) on the Thursday ; however road-works started on the location during the second day of observation and the amount of data collected on the North and South approaches was therefore limited.

It was impossible to predict injury-accidents from conflict data, as the function used in Germany relates conflicts to injury and also damage-only accidents, all reported by the police. On a junction of this type, about 80 collisions would be expected to occur.

The main safety problem appears to involve left-turning vehicles coming from the city-center :  (9 serious conflicts of this type). Nearly as dangerous is the left-turn from the opposite direction :  (8 serious conflicts, more serious conflicts than light ones). Bad visibility in the middle of the junction seems to be a major cause for these conflicts.

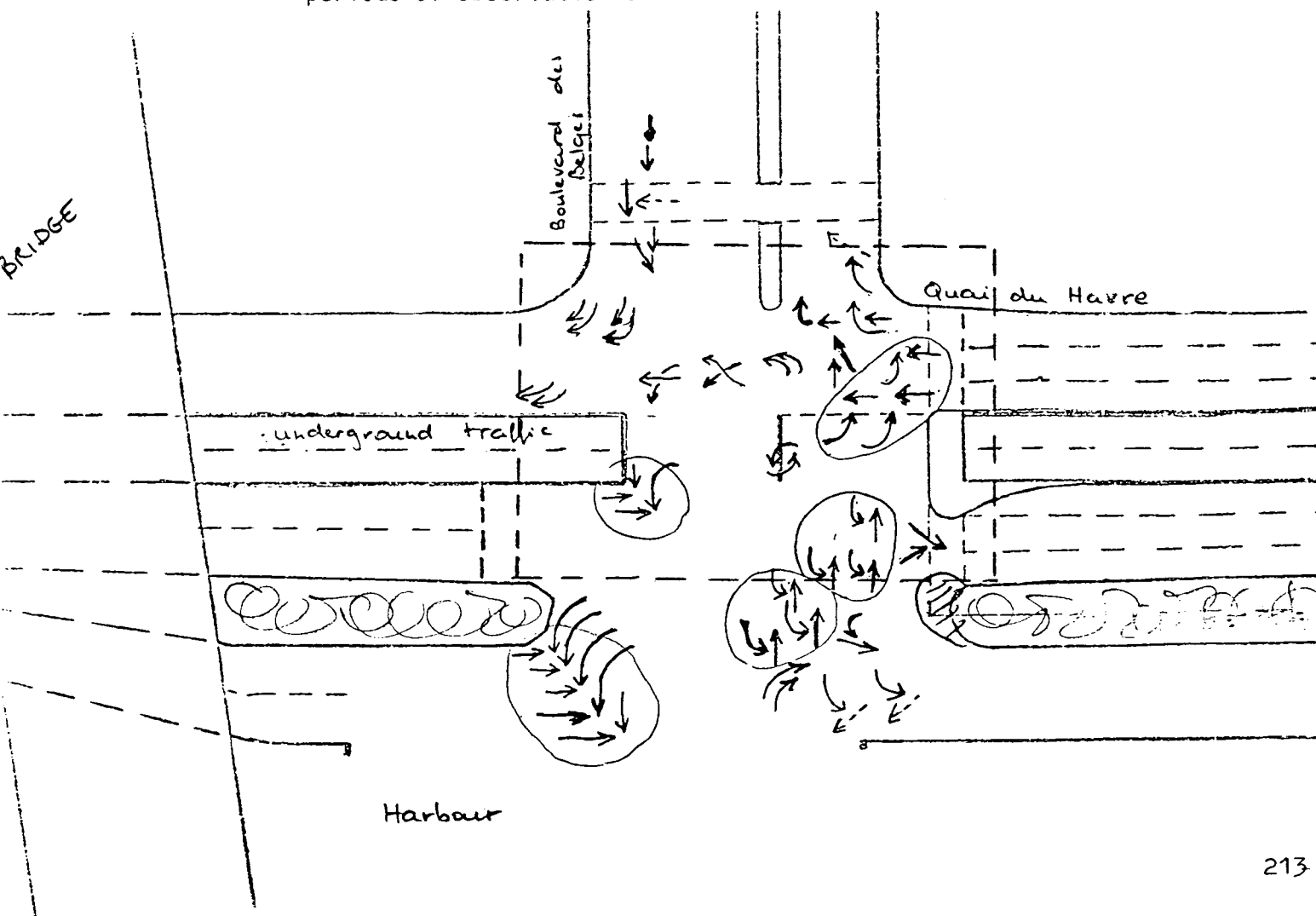
Lots of conflicts occur in the central area of the junction, but they are generally slight as speed is very low. Also, weaving conflicts involving vehicles from the East or the West are numerous, but not serious.




On the whole, traffic volumes are too heavy for the junction as it is designed ; this creates a psychological problem as car drivers are under pressure to get off the central area as quickly as possible. Also, visibility is too bad in the middle.

Further segregation of traffic streams would be a solution, with a bridge for vehicles turning left towards the North :  . But this seems hardly feasible...

d) France

Immediate diagnostic based on conflict data could only be approximative, as risk calculation requires computer processing. Also, the French team had a prior knowledge of the accident situation at the intersection, which would have influenced their conclusions. All that was done was therefore to locate the main safety problems as they appeared from the conflict data collected during the common periods of observation and the additional ones.



The major problem was right-angle conflicts :  .
Left-turning vehicles from the North were also involved in a lot of serious conflicts :  ; these one occurred equally in the two streams of traffic going East. Finally, left-turning vehicles from the West created also a serious problem :  .
The other conflicts recorded are a lot slighter.

2. JEANNE D'ARC

a) Great-Britain

It appears from conflict data, that car-to-car accidents should not be very numerous on this location : if countermeasures are proposed to avoid them, they shouldn't therefore be too heavy.

Most conflicts occur with vehicles emerging from rue Morand on the East side of the junction (half the serious conflicts). A solution to this problem would be to close the exit of rue Morand, and only leave access to it for cars coming from the other side ; this should be easily feasible.

Another major problem is conflicts involving two-wheeled vehicles ; car drivers either do not see them, or ignore them... No engineering solution can be proposed here ; appropriate measures could be campaigns for an improvement of two-wheeler conspicuity.

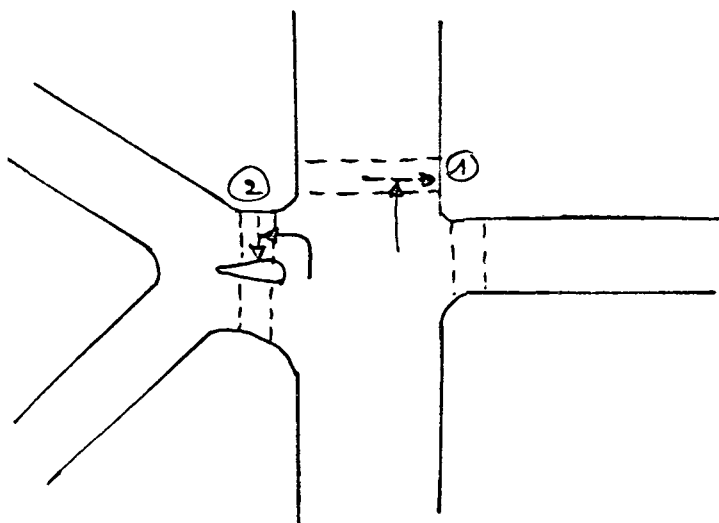
Pedestrian movement at this location appears very dangerous when compared to conditions in an English town... However, pedestrians seem unaware of the problem. Nothing much can be done with the pedestrians except warn them of the danger.

Finally, vehicles going down rue Jeanne d'Arc from the North are doing so at very high speed ; measures should be taken to slow them down. This should reduce some of the pedestrian/vehicle accidents.


b) Sweden

The model developed in Sweden was here again used to predict injury accidents ; from Monday to Friday, 9 o'clock to 17.30, 4.1 accidents per year are expected to occur ; among these, 1.5 should be car-pedestrian ; 1.5 should be car against two-wheeler, and the remaining 1.1 car-to-car.

Two main pedestrian-problems emerge from conflict data :





Problem 1 corresponds to the most common pedestrian accident situation (80 % of all pedestrian accidents in Sweden). It is related here to the high speed of the vehicles on rue Jeanne d'Arc, and also to traffic congestion, during which the sight of the pedestrians is obstructed for car drivers.

Problem 2 often results in a secondary type of conflicts : cars stopped to let the pedestrian go are in the way of vehicles going down rue Jeanne d'Arc : . Vehicles turning left towards the West appear unusually numerous.

A solution for problem 2 would be to remove the pedestrian crossing away from the junction. A measure for problem 1 would be to put in a central island, in order to help pedestrians cross rue Jeanne d'Arc in two parts, and also avoid vehicle overtaking.




There is also a serious two-wheeler problem on this junction : two-wheelers riding down rue Jeanne d'Arc are involved in conflicts with left-turning vehicles. Speed on rue Jeanne d'Arc is too high, especially as the road-surface becomes very slippery with rain. No measure can be proposed here.

As far as car-to-car conflicts are concerned, the bigger problem involves left-turns from the West : . Flows of vehicles are small, but conflicts of this type are numerous. Conflicts with right-turning cars () are also numerous, but not very serious.

The general conclusion for this location is that speed on rue Jeanne d'Arc is too high ; speed reduction countermeasures are most needed here.

c) Germany

The German team had only one day of observation to draw a diagnostic on this location.

The main problem is related to through traffic from the North, and the corresponding high velocity ; turning vehicles have to accept small gaps. Main conflict types are  or  or 

The pedestrian conflicts are not very serious and there should not be a pedestrian accident problem on this junction.

d) France

Again, the French team only drew basic conclusions from their conflict data, as they had prior knowledge of the accident situation, and could not perform risk calculation on the spot.

The most dangerous problem seems to be related to vehicles emerging from the East leg of the intersection (8 serious conflicts). Conflicts involving vehicles from the West and turning right or left on rue Jeanne d'Arc are the most numerous (14).

There does not seem to be any major pedestrian safety problem. If any, it involved left-turning vehicles from rue Jeanne d'Arc on the West side pedestrian crossing :



9. Accident situation and accident factors on the two locations.




Police accident reports were analysed in details, and assumptions on possible accident causes were checked on the ground by the French team.

1. BELGES

a) Accident data

In 1978, 15 accidents occurred at this junction (9 in the common observation area). Only five of them corresponded to conditions similar to our period of observation (11.40 to 17.45, Monday to Friday) (1 only in the observed area), three more occurred during the same hours, but on a Saturday or a Sunday.

Overall, six accidents were week-end ones, and six occurred at night. Also, six accidents happened on a wet road surface (half of them at night).

Main types of accidents are right-angle ones  (7 of them) and left-turn ones, either  or  (the remaining 8). Two accidents involve a two-wheeler and two others a lorry ; there are no pedestrian accidents.

As far as right-angle collisions are concerned, the two drivers involved are often both convinced they had a green light ; the vehicle coming from boulevard des Belges was just starting. In some cases, drivers coming from the West acknowledge having gone through on orange light. There seem to be a problem of phasing of traffic lights, as well as of speed, attitude of the drivers when the lights turn orange or red, and visibility.

Of all the left-turn accidents, 5 involved turning movements towards the harbour, and 3 towards boulevard des Belges. In the first situation, the turning vehicle was often just starting after a waiting period in the middle of the junction ; the straight-going vehicle was either not seen or going through a red or an orange light. In the second situation, accidents seem to be due mainly to high speed of straight-going vehicles on Quai du Havre, and to a visibility problem ; in one case, a driver didn't see a red light.

b) Summary of possible accident causes

Several factors have to be considered :

- traffic lights on quai Gaston Boulet (West leg of the intersection) are badly respected by drivers. Visibility of these traffic lights, their phasing and the speeds of on-coming vehicles at different times of the day have to be checked.
- vehicles stopped at the lights on boulevard des Belges seem to start again too early. Where do the drivers take their information ? Is the duration of the all-round red period long enough ?
- drivers of the left-turning vehicles seem to have difficulties when stopped in the middle of the junction. Some more points should be checked : where do the vehicles stop prior to turning ? Where do they take their information before starting again ? What is the mutual visibility between road-users in the central part of the intersection ?

c) Characteristics of the location that may be related to accidents

The junction is badly designed ; trajectories of vehicles are not properly guided, and the waiting-space for left-turners is not defined. The junction is partly paved and partly covered in asphalt and its surface is in a poor state. Traffic lights are not numerous and quite small. Pedestrian facilities are very limited, and access to the neighbouring car-parks is difficult .

Traffic-lights on the East leg of the intersection (quai du Havre) turn red 10 seconds before the ones on the opposite direction (quai Gaston Boulet) ; a filter for right-turning vehicles comes up on boulevard des Belges 8 seconds before the main lights turn green ; all-round red lasts 6 seconds .

d) Field observations based on accident data

On the West leg of the junction (quai Gaston Boulet), vehicles arrive at the intersection with a very high speed, especially during off-peak hours ; for these vehicles, the intersection is not clearly visible as the Bridge Guillaume le Conquérant hides part of it ; the general feeling is that of an expressway ; only one traffic light can be seen at more than fifty metres, and only by cars on the very left-hand lane ; other lights are either hidden behind a traffic-sign or badly oriented ; bushes planted on the central reservation also obstruct visibility for the cars using the two right-hand lanes. On both sides of the central reservation, cars going through an orange or a red traffic light have actually been observed, particularly at night.

On the opposite leg of the junction, quai du Havre, vehicles also reach high speeds ; the only traffic-light is small, and is frequently masked by lorries parked on the pavement ; road-surfacing is very poor, and visibility from the left is partly obstructed by the guard-rails along the underground car-lanes.

On boulevard des Belges, on-coming vehicles use four lanes, two of them for turning right and two of them for going straight on ; when the filter comes up, the two right-hand lines of vehicles start again, which creates an illusion of green light for the other waiting lines of cars ; straight-going cars that go through the junction under these conditions reach the stream of traffic coming from the West with a light that is still green ; mutual visibility is very poor there because of the guard-rails along the underground car-lanes and of the planted central reservation. Straight-going cars starting with the right-turn filter have actually been observed a number of times.

In the central part of the intersection, waiting cars stop in a variety of places. The intersection is very quickly jammed at peak-hour.

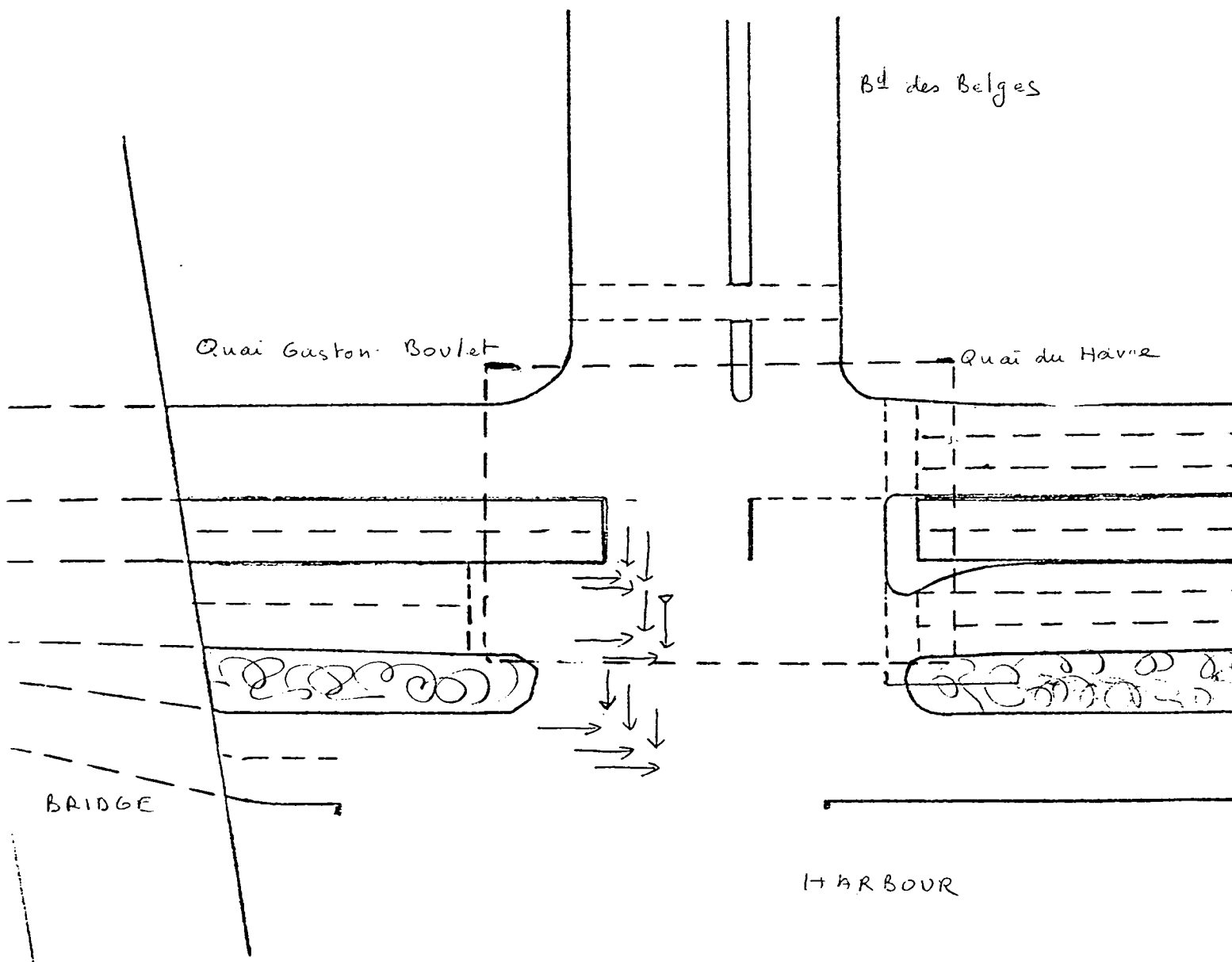
e) Countermeasures

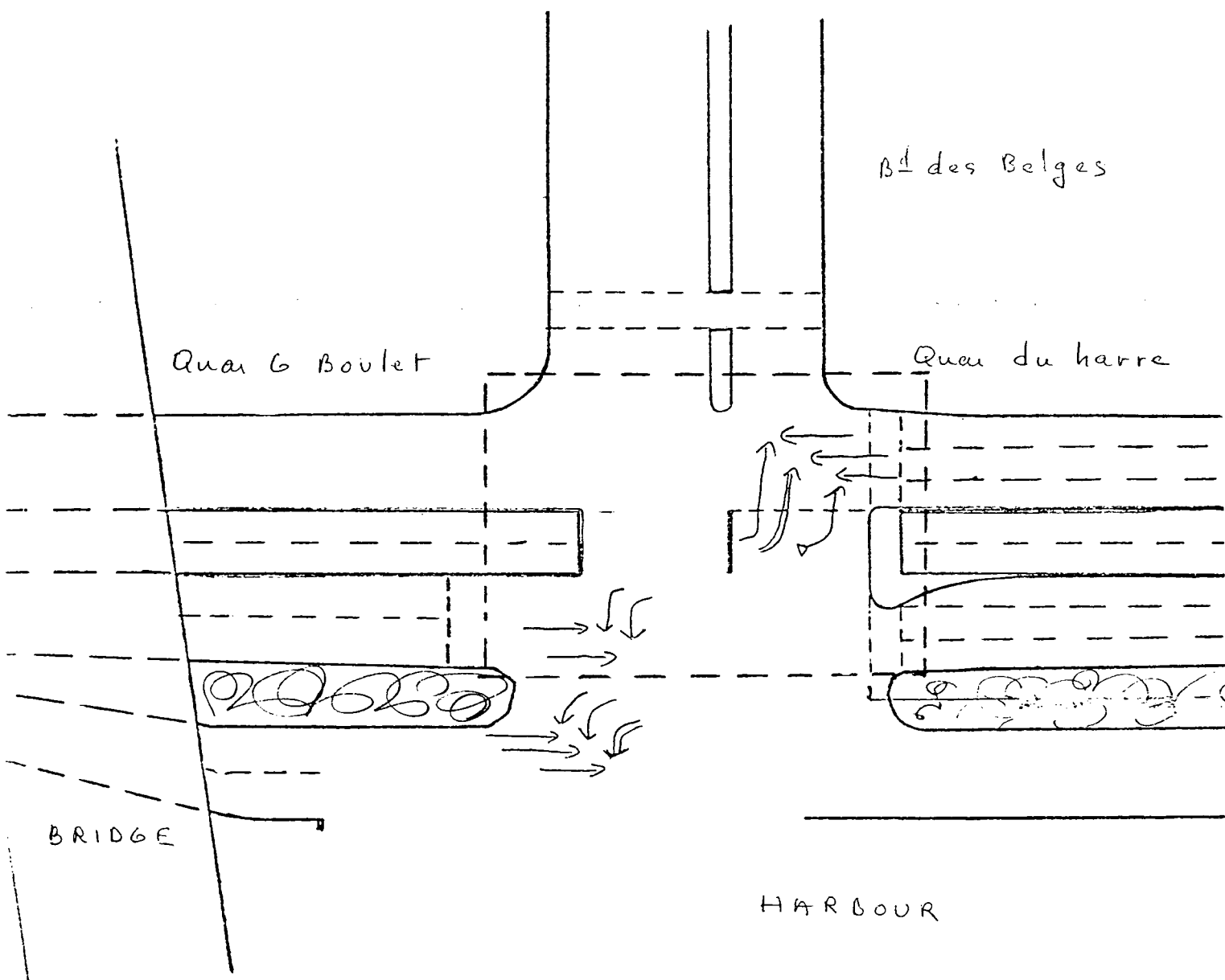
Countermeasures proposed as a priority are the following :

- to put a traffic light above the road-way on the East leg of the junction (quai du Havre)
- to improve road-marking before the bridge on the East leg of the junction, so as to guide straight-going vehicles on to the left lane ; the traffic-sign masking the lights should be removed and a second light added on the left-hand side of the road-way ; lights situated on the right-hand side of the central reservation should be reoriented
- to pre-signal the junction before the bridge on the West approach
- on boulevard des Belges, to separate right-turning and straight-going lanes by an island with a traffic light on it
- in the center of the intersection, adding traffic lights for waiting cars, so as to permit left-turns only when cars coming from the right are actually stopped by a red light.

Other measures should be added to these priority ones :

- facilities for pedestrians
- better location of the traffic islands on the harbour side, so as to guide trajectories a bit better
- improvement of road-surfacing.





2. JEANNE D'ARC

a) Accident data

Three accidents only occurred at this intersection during the last year and a half (i.e. after the local traffic changes). All three occurred during week-days, but only two of them during the periods of conflict observation.

All three accidents involved two-wheelers. In two cases, the two-wheeled vehicle was going down rue Jeanne d'Arc from the North ; in two cases, one of the road-users involved was emerging from rue Morand on the East side of the junction ; two left-turning vehicles were also involved.

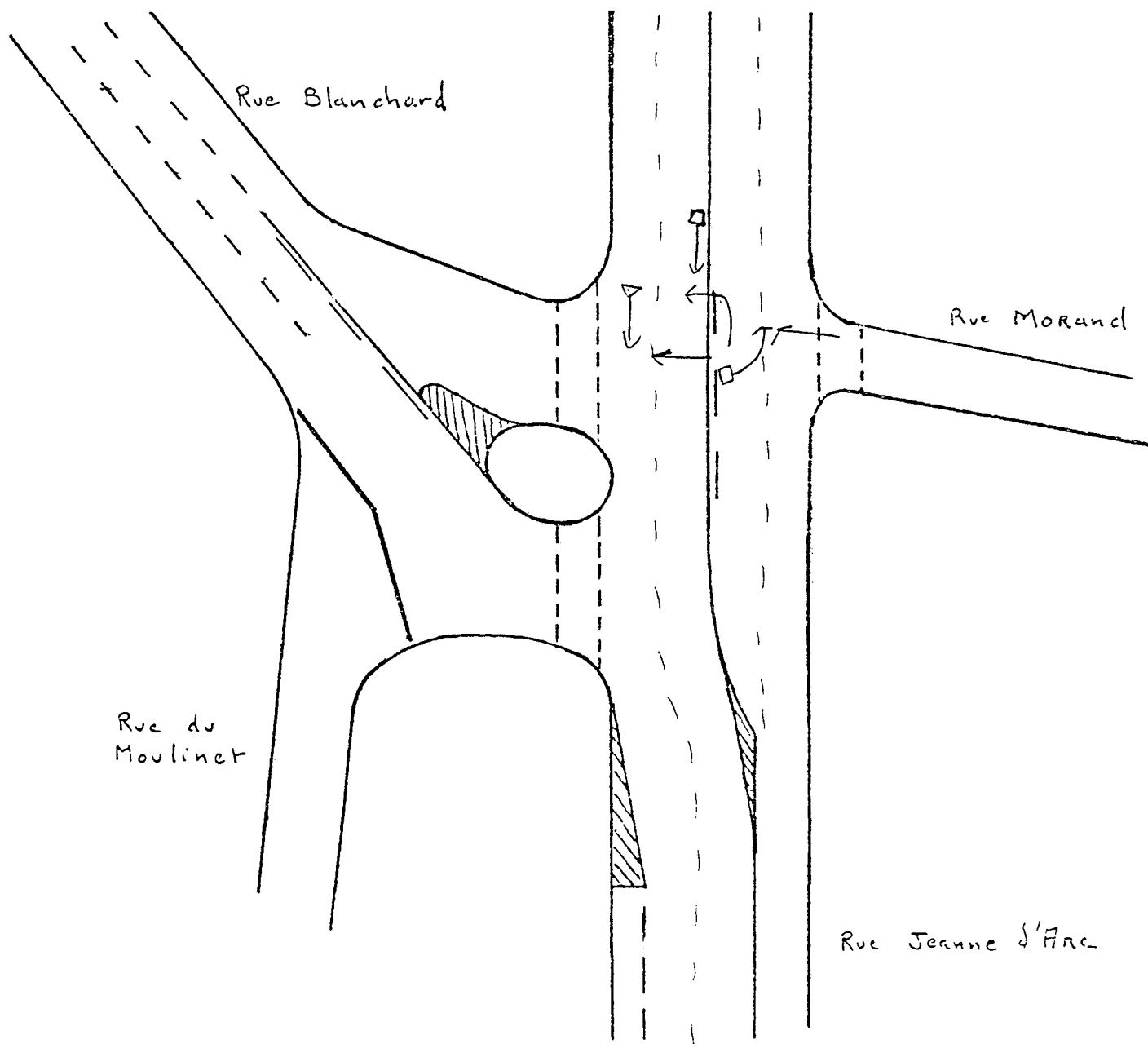
b) Possible causes of accidents

Accidents are too few to give much information. However, some possible factors can be put forward :

- speed of vehicles on rue Jeanne d'Arc
- intensity of traffic on rue Jeanne d'Arc which may prevent road-users from rue Morand or rue Blanchard to find suitable gaps
- high frequency of left-turn manoeuvres on a junction which is not meant for heavy traffic from the side streets
- difficulties for left-turning vehicles to define their waiting-place.

c) Countermeasures

Accident data was not sufficient for the design of actually efficient countermeasures. The accident situation seems to result from the present traffic organisation on a wider area around the location ; strictly local countermeasures may not be the best solution to improve safety on the intersection itself.



10. Discussion of the results

a) Severity levels - conflict detection

The severity scales used by three of the four teams (Germany, Great-Britain and France) are not in a good agreement. Comparisons between these scales and the time-to-collision calculated for each conflict on the video-tape of the Swedish team show that severity and time-to-collision are not really related. At the most, it can be said that the limit of "serious" conflicts for the English technique (2+ and over) corresponds roughly to a time-to-collision of 1.3 seconds.

In fact, the meaning of the severity index appears quite different for all the teams. While in the British technique severity is defined directly as a probability of an injury-accident occurring, for all the others, severity is only one of the factors to include in risk-calculation in order to predict danger. It is therefore natural that the three severity scales currently in use should not quite correspond. The following table gives the main variables entering the risk-calculation process for the four teams :

Variables used to calculate risk on a given location

Germany	Sweden	France	Great-Britain
<ul style="list-style-type: none"> - number of conflicts - severity levels (taken into account differently according to the type of conflict) - number of encounters (only for left-turns and pedestrians conflicts) - type of intersection signalled not signalled approach to junction 	<ul style="list-style-type: none"> - number of conflicts - type of intersection <ul style="list-style-type: none"> . high-speed . low speed intersection . low speed manoeuvres in high speed intersection 	<ul style="list-style-type: none"> - number of conflicts - severity levels - type of intersection (signalled or not signalled) - type of road-user (4 classes) - type of manoeuvres - speed before evasive action 	<ul style="list-style-type: none"> - number of serious conflicts (conflicts classified by type of manoeuvres and by road-users)
risk related to total number accidents	risk related to injury accidents	risk related to injury accidents	risk related to injury accidents

Conflict detection rates varied a lot according to the team. In-depth analysis of a number of conflicts recorded on video-tape was carried out, in order to clarify why some conflicts were noted by some observers and not by others. Disagreement on the existence of a given conflict appeared in a limited number of situations, which can be listed as follows :

- α. The conflict is very slight, on the borderline between conflict and normal traffic manoeuvre. This is usually the cases when time-to-collision is about 1.5 second and/or speed of the road-users involved is very low.
- β. The evasive action that has been observed may not have been necessary (there is doubt whether a collision would have occurred even if the evasive action had not taken place). This is a problem of appreciation of the collision course; this appreciation can vary according to where the observer is placed on the junction. In such a case , a conflict may have been noted as quite severe by one of the teams, while for another it won't have been a conflict at all.
- γ. There is doubt on the existence of the evasive action. This is an observation problem : some actions are difficult to detect (for instance, pedestrian stopping) and can be missed by some of the observers ; again, the place from where they survey the studied location may have an influence.
- δ. The manoeuvre creating the conflict may be considered as deliberate and controlled. (a car forcing its way through in full view of the others for instance). Some teams would not note such a situation as a conflict, while some others consider it quite dangerous. A similar situation occurs where an evasive action seems to have been taken deliberately late by one of the road-users, and was consequently much more intense than should have been necessary ; this first raises the question whether the delay was actually deliberate or not ; some of the teams would accept the event as a conflict in both cases anyway (Sweden and Great-Britain). For the others, a conflict situation must be unexpected and not quite controlled. This is a serious problem of interpretation of the traffic situation, and of conflict definition.
- ε. Some observers missed a conflict which they should have noted. This may be due to human failure, but also to technical problems (two conflicts occurred too close to each other, the conflict-point was temporarily hidden from the observers, etc...)
- ν. The British team didn't take into account some conflicts which would have had a very low probability of ending into an injury-accident (for instance very low speed, rear-end collision ...) This is related to differences in the definition of severity scales.

b) Technical aspects

The Rouen experiment did not quite take place in the same conditions that the four teams would have had at home. Normal requirements would have been the following :

Team	Sweden	Germany	France	Great-Britain
BELGES	4 or 5 observers 3 to 5 days (6 hours a day)	8 observers 1 day, early morning to after- noon peak (7-8 hours)	4 observers 2 to 3 days (17 hours, 7 a.m. to 10 p.m.)	8 observers 2 days (20 hours, 8 a.m. to 6 p.m.)
JEANNE D'ARC	2 observers 3 to 5 days (6 hours a day)	3 observers 1 day (7-8 hours)	4 observers 2 to 3 days (17 hours)	2 observers 2 days (20 hours)

The number of observers required varies quite a lot, which is related to the way they share the work (less observers are needed when each of them observes an area than when each of them deals with a different set of manoeuvres). The French technique requires a constant number of observers.

It has been stressed that the length of the observation period is related to the aim of the conflict study. When conflicts are used for a diagnosis on the location, a lot of information may be required which calls for a longer period of data-collection. The length of time stated by the Swedish team is the highest, but it is the only case where the significance of the number of conflicts collected has been examined. All teams found that on junctions like BELGES where night-accidents are a problem, an additional period of observation should be carried out to cover the late evening.

Two of the four teams used cameras which created some technical problems (difficulties for placing the cameras, restrictions on the observation field...). In fact, all four teams operate in regular conditions with only observers on the ground and no cameras. Video and films are mostly used for research purposes, or in particular cases when additional information, not generally noted by the observers, may be required. When only observers are used, any junction can be studied by all four teams with only minimal preparation.

The amount of data collected by the observers on the ground varies according to the team, as appears in the following table :

Data collected on the ground :

Germany	France	Sweden	Great-Britain
type of manoeuvre for each flow of traffic (conflicts and encounters are noted in the same way)	- type of manoeuvre	- type of manoeuvre (on diagram)	- type of manoeuvre
type of road-user (main)	- road-users (main and secondary)	- road-users (main and secondary)	- road-users, vehicle types (main + secondary)
severity level	- severity level	- distance to collision	- severity level
time (exact or 5-10mn intervals)	- exact time	- time to collision - exact time	- exact time
part of the junction on which the conflict occurs (junction divided in 8 sections)	- weather and surface condition - light - highest speed of one of the main road-users before evasive action - verbal description - diagram	- weather and surface condition - light - speed of both road-users before evasive action - verbal description - diagram - age and sex for pedestrians and cyclists	- weather - estimation of speed if faster than it should be - comments

For most teams, one more observer may be needed to count traffic, unless that can be done from films.

The length of time required to note a conflict varies between a few seconds (Germany) to half a minute (France, Great-Britain, Sweden). For the French team, filling the data-sheet may take a bit longer when the two observers that work together disagree on a severity level and have to discuss it.

In some cases, the time necessary to note, at least for three of the four teams, may be cause of a conflict being missed (see above).

Comparisons between data-sheets in order to determine which conflicts were observed by several teams at the same time were not always easy...

c) Reliability

It has not been possible so far to analyse in details the problems which may have been related to a low reliability of observations. It is however assumed that some of the differences found in conflict detection may have been caused by the observer themselves.

The four participating teams have agreed to perform in the near future an analysis of the reliability of their own observers, based on the video-tapes provided by the Swedish team and the TRRL time-lapse film. Internal as well as external reliability will be checked. The four sets of results will be subsequently compared.

d) Diagnosis

Little had to be added to the safety diagnoses on the two locations drawn by each team immediately after the experiment. Discussion on these diagnoses led to the following conclusions :

- on JEANNE D'ARC, conflict data was absolutely necessary as the period available for accident-data collection was limited, and accidents not numerous enough to bring information. Two days of conflict-observation were sufficient. The main safety problems were correctly detected ; the pedestrian problem that was emphasised by conflicts has not appeared yet in terms of accidents, but this is likely to change in the near future.
- on BELGES, data on injury-accidents was sufficient to draw a diagnosis. However, it was agreed that any measure taken on this intersection should be evaluated in a before-and-after study based on conflicts rather than accidents (quick results, possibility of evaluating temporary measures, detection of possible negative side-effects). The conflicts collected during the before-period can also add valuable information to accidents and be therefore used in the diagnosis. Conflicts may in particular be useful to give an idea of the whole accident situation (damage as well as injury).
- conflicts are never sufficient in themselves as a basis to a safety diagnosis. Field-measurements and observations (speed, visibility, etc...) must always be carried out as an addition to the analysis work.

The relationship between conflicts and accidents could not be checked on any of the two locations : on JEANNE D'ARC, the accidents were too few, and on BELGES, the accidents were also too few during the observation period, or the length of the latter was too small... To relate conflicts to injury-accidents, the duration of the Rouen experiment should have been quite longer.

11. General conclusions

The Rouen experiment was considered quite successful by the participants, as they felt their understanding of the different techniques in use had been considerably imposed. It was felt that work so far had progressed too much in separate directions, and that some features of a given technique could valuably be used in other countries to solve particular problems.

It was not considered possible however to reach one common conflict technique for use in all an countries : traffic conditions and road design vary a lot from place to place, and the choice of observation techniques should remain quite flexible to adapt to each situation. Also, validity of each technique should be studied more in-depth before further conclusions can be drawn on this subject.

It has appeared during the experiment that each team "juged" traffic situations and appreciated conflicts in a different way, related for a good part to the particular driving habits to be found in their own country. This makes conflicts observation performed abroad very interesting and informative, and should encourage new experiments of the type of the Rouen one.

Another reason for going on with joint conflict observation is that we couldn't reach any answer as to how accidents and conflicts are related according to each technique, because of the little time available. If other comparative studies are to take place in different countries, observation periods should be longer, and experimental conditions nearer to home ones (adequate number of observers for instance).

Because of practical difficulties arising when comparing individual conflicts, it appeared that the first step in any new series of common conflict observations should be for all the teams to agree on the same data-sheet, at least for the length of the study. This would greatly simplify all the analysis-work.

Video-recordings were very useful in the data-analysis phase as well as in the discussion one : they were the only direct reference left of the traffic situations studied and they were used easily and quickly. The time-lapse film may also prove useful in the longer range in bringing additional information. However, it was felt that films (camera or time-lapse) can never become a substitute to human observers, and their main interest will therefore be for research purposes.

G. MALATERRE

N. MUHLRAD

With contribution of B. SPICER

H. GSTALTER, C. HYDEN, P. GARDER

L. LINDERHOLM.

PARTICIPATING TEAMS

GREAT-BRITAIN

Brian SPICER
Allan WHEELER
Martin TODD

TRRL, Road user characteristics division
Crowthorne, Berks RG 11 6 AU
tel. 443/446 31 31

SWEDEN

Christer HYDÉN
Leif LINDERHOLM
Per GÅRDER
Sverker ALMQVIST

Department of traffic planning
LUND Institute of technology
Fack
S 22 00 7 LUND
tel. 46/46/124 600/1762

GERMANY

Bernhard ZIMOLONG
Herbert GSTALTER
Jochen GASSNER
Wolfgang GOTTLIEB
Sigrid MATTUSSER

Abteilung für Angewandte Psychologie
Spielmann strasse 19
3300 BRAUNSCHWEIG
tel. 0531/391 25 47

FRANCE

Gilles MALATERRE
Nicole MUHLRAD
Raymond HUET
Pierre COQUEREL
Michel PARMIGIANI
Jacques POIGNANT

ONSER
BP 28, 94114 ARCUEIL CEDEX
tel. 581.12.12

UNITED STATES

B. BAKER
T.K. DATTA (joining in later)

OTHER PARTICIPANTS TO THE JOINT EXPERIMENT

Guy DUPRÉ

DES - CETE de Rouen (Ministère des Transports)

Philippe BLONDEL

SERES, Ministère des Transports

Mr LE REVEREND

Directeur adjoint aux Services Techniques de Rouen

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Bundesanstalt für strassenwesen, Köln

National Roads Administration, Stockholm

Volvo, Göteborg

Department of Transport, TRRL, Crowthorne

7.2 SESSION 6: DISCUSSION REPORT

The discussion was mainly taken up with the conclusions drawn by the individual countries' teams from the joint Rouen experiment summarised in the introductory paper. It included the presentation by participants from the U S A of the results of their later study of one of the Rouen sites. This showed a close agreement in the problems it identified with those found by the other teams in the joint study.

The discussion then developed around the possibilities of further co-operative studies and is best summarised by the following proposal:-

That an International working group be established by this body to pursue all or any one of the following objectives:

1. Recommend an experimental design for conducting a conflicts validation study
2. Implement an experimental design for a joint international validation study
3. Implement an experimental design for a joint international calibration study *

Rough Definitions

"Validation" - Establishing the functional relationship between accidents and conflicts.

"Calibration" - Establishing the functional relationship between conflicts derived from the use of one technique with those derived from the use of other techniques.

Reason For Objective No. 1

Enables the results of conflicts studies done in one country to be accepted as valid by researchers in other countries.

Reason For Objective No. 2

Enables a more consistent application of the procedures developed in the experimental design.

Reason For Objective No. 3

Enables us to understand data obtained in other studies and to predict results

which would have been obtained if our own technique had been used. (Does not imply validity)

* It should be considered that the Rouen experiment is a calibration study.

8.1 THE SECOND INTERNATIONAL TRAFFIC CONFLICT TECHNIQUE WORKSHOP: A PERSONAL OVERVIEW

M R C McDOWELL, ROYAL HOLLOWAY COLLEGE

Traffic Conflict Technique - if it didn't exist would we wish to invent it?

The question is, are there sufficient advantages which this technique or rather set of techniques have over any alternative approaches? If so, what are they? In what circumstances is it useful? Are these different for operational use and for research?

The main theme of this workshop seems to me to have been the use of variants of the TCT as an operational tool in assessing 'deficiencies' of existing road traffic layouts. Very little attention has been paid to validation in terms of conflict measurement as a predictor of expected number of accidents. Most groups who use the technique seem to assume that such validation has already been carried to a sufficient level.

If I can take Mr Ludvigsen's report as typical high quality use of the technique to assess situations and suggest remedial measures, it seemed to me to be marked by two major advances, (first introduced by Mr Hydén's Swedish team) firstly the simplification of what should be regarded as a serious conflict to events in which the estimated time to collision is ≤ 1.5 secs, with some account taken of type of road users involved and of speed range, combining these into an evaluation of risk. This appeared to be a useful operational tool, but leaves a lot of room for manoeuvre. That is until the definitions are refined, and the coefficients validated, it seems to me doubtful if the same results would necessarily be obtained if other individuals had followed his procedure at the same sites, at the same time. Until one can assess that that is the case, then we do not have a scientific tool - if this is what we want.

Perhaps this is where the question of training of observers, their consistency and reliability comes in. Any use of these variants of TCT reported in session 3 may become such a scientific tool if

- 1) observers can be adequately trained
 - 2) the results can be related to accident histories
- or
- 3) they reveal unsuspected design problems which experts feel may lead to accidents.

One important new aspect of the Swedish work seemed to be that the subjective assessment of occurrence of a serious conflict as seen by observers did not in most cases (62% - 80%) coincide with the participants assessment. This suggests that drivers could be much better trained to judge the potential hazards of a situation. Conflicts chosen from video tapes could be developed into useful driver education or re-education tools.

Almost all of the work reported referred to urban junctions, although severe injury accidents would seem to be more likely in non-urban situations, except for specific high risk categories of road user, ie children, pedestrians, drivers of 2-wheeled vehicles. Is there any way of extending the technique to non-urban accidents? If so can this only be done at junctions, or could we find a way of extending the method to non-junction accidents?

In this urban situation very gross simplifications seem to be applied. At most accidents or conflicts were classified by broad categories of road user type, severity class, and manoeuvre. Few reports except for Dr Datta on the last morning gave any detailed consideration to the many other variables which might be relevant, ie proportion of regular users in each traffic stream, age and sex of drivers, road surface conditions etc etc. Our studies, not reported here, suggest that some measures of risk, for the types of manoeuvre involved in TCT work, are increasing functions of flow and rapidly increasing functions of speed. There is also some evidence of strong age and sex effects; for example old male drivers are most at risk. Do the studies reported here ignore these factors, simply because they can't be cured by changing the junction layout? The effects of flow are well established by both TRRL (and reported here by Spicer, Wheeler and Older) and Prof. Hauer's group. The exact form of the relationship is relatively unimportant, but it is clear that for many classes and severity types of conflict that numbers may be represented by a function of the product of the intersecting flows, over most flow ranges of interest. A similar measure can be established for reported injury accidents: this suggests a direct approach to validation.

On the other hand the German work (Zimolong paper 19) finds that all classes of conflict are a better predictor (summed over severities) of accidents, than are severe conflicts alone. This seems to be at variance with the Swedish and Danish work but consistent with the TRRL Amersham data. The German work confirms that the ratio of observed conflicts to expected accidents is site dependent. Can we aim at classifying sites in such a way that we can say they have a similar value for this ratio, even if we don't know its absolute value? That is, what properties of a given site, apart from flow, affect this unknown constant?

Little work was reported on automatic or semi-automatic measurement of conflicts. The possibilities of doing this have been transformed since the Oslo Workshop by the availability of cheap microprocessors. The cost of on-site data collection and analysis will continue to decrease dramatically. Can we meet the opportunity by developing the systems and software needed to produce a generally applicable technique of objective measurement of conflicts? It is clear that the problem of pedestrian involvement in urban areas is still beyond the foreseeable capacity of such techniques but non-urban junctions, in pedestrian free environments, should be well within our capabilities. The military have already solved much more complex vehicle movement detection problems. The problem is to do it cheaply; and to bring it when developed from a research to an operational tool.

Semi-automatic methods may help in reducing the number of observers required at urban sites, by recording positions and speeds of individual vehicles, and leaving observers to concentrate on specific events. Portable, cheap and reliable equipment is becoming available. This should enable operational groups to overcome many problems of subjective assessment of severity, or of estimating TMTC etc.

Dr Hakkert's work shows that while swerving may be an important factor in subjective assessment of severity, it will rarely be found to play an important part in an objective measure of the absolute value of the decelerations involved. This seemed to be confirmed by experience at TRRL reported by Mr Older. If this is so, then simpler detection systems will suffice.

One important feature of this meeting has been the wide range of operational uses of variants of TCT reported, in assessing proposed safety measures (4-way stops), possible legislation (wide loads), and in investigating unusual traffic situations. This work deserves careful and detailed description in the literature as there may be many other useful applications.

Prof. Hauer helped us greatly by clarifying what needs to be done in assessing the validity of conflict measurements as an estimator of expected numbers of accidents. We seem fairly well agreed on how to obtain sufficiently accurate estimates of the rate of conflict occurrence. The real difficulty is to find the coefficient of proportionality between conflict rate and accident rate, and to assess its accuracy (we need to know its mean and variance). One problem is that $N(C)$ is large (particularly if we include all severity classes) but $N(A)$ is small and has itself large variance. Site effects may be a problem.

This and some way of comparing multiple measures, to allow an alternative to a

'weighted sum of accidents by severity' are essential to providing the safety criterion Hauer is asking for. Much more theoretical work is needed in this area. The breakup achieved here into

$$\langle N(A) \rangle = (k \pm \delta k) \cdot N(C)$$

with $N(C)$ determined in terms of both reliability (of observation) and repeatability (from day to day) was of great value. We seem to agree that there has been adequate study of repeatability but there seems much less conviction that we can trust the available results on reliability. More studies are needed: for example Storr raised the important point of the effect of the presence of observers: they can be highly conspicuous, and on at least a few occasions have been known to induce collisions.

One of the most exciting sessions gave most of us our first opportunity to hear the preliminary results of the Rouen collaboration. Here the pleasant surprise was that there was a large area of overlap between each of the four groups identification of conflicts; the different subjective observation techniques do seem to some extent to be measuring the same thing. Just how much this is so must wait for a proper statistical examination of the data. Again there was impressive agreement at both sites on the diagnosis offered by each team and by the US participants, and on the corrective measures proposed.

Such collaborative projects in which different experimental techniques are compared at the same site at the same time are crucial in the validation process. One should not expect complete agreement; what is important is that the error bars on the measured values overlap, ie that the measures are consistent. We need to go on to show that

- a) they are independent of observers by having eg the UK team use the Swedish technique and vice-versa
- b) they are site independent. We ought to carry out similar joint projects of which at least half a dozen different types of site are examined. For these purposes it would be preferable to use high reported accident rate sites to shorten the necessary observational period.
- c) at least one such project of this type should be carried out as soon as possible on an instrumented site, or at least on a site where portable partial instrumentation of different types can be installed. This would help evaluate automatic (?objective) methods of measurement, and again reinforce the value of the present subjective methods.

Finally may I make a plea for wider publication of the results in the general literature: many traffic engineers and scientists don't know of this work, and won't unless it is carefully described in the literature; again this is the only way we can get independent criticism. Don't bury it in National Lab reports or private working papers.

8.2 REPORT ON SESSION 7

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE ACTION

At the opening of the session the need for surrogate measures of safety was again outlined in a paper(Paper 1) presented by Dr Datta dealing with a project in progress in the USA to assess any such measures for use in analysing highway safety hazards. This re-emphasised what has been the motivation for the development of the Traffic Conflict Technique (TCT) and also served to place the TCT in the wider context of other surrogate measures.

The papers presented at this workshop, and the discussions held during the previous sessions, showed that there have been developments in the use of the technique since the First Workshop was held in Oslo. Mostly these have been refinements in the techniques used by the individual research groups working in this area. In addition, however, two other movements are noticeable; one is the continued growth in the use of Traffic Conflicts as measures of operational deficiency in traffic systems and not necessarily as measures of safety; the other is in the carrying out of comparative studies between different forms of the technique in the same situations.

The discussions at this Workshop emphasised a number of important points which need further resolution. These are summarised below:-

1. Further comparative studies of the use of the different techniques in the same situations are necessary as being the only way in which a meaningful assessment can be made of the differences in working procedures and definitions which still appear to exist. Too many differences in definition of terms such as severity, safety and accidents exist at present to allow such assessment to be made from existing independent studies
2. Since the different techniques have developed in different countries the comparative studies referred to in 1) require a considerable degree of international co-operation.
3. The successful pilot international study initiated by the French team from ONSER and the Swedish team from Lund Institute of Technology indicates the feasibility of such studies and already shows encouraging similarities in the findings.
4. Careful consideration needs to be given to identifying the objectives and selecting the appropriate experimental design for these further co-operative studies.

5. There is a need for an agreement on what constitutes an effective validation study and how international co-operative studies can assist in improving validation. This should result in a more consistent approach to validation and allow the results of studies in one country being accepted as valid in another.
6. One objective of further co-operative studies also should be to "calibrate" the different techniques one against another. This should enable each team to understand and interpret data obtained in other countries and predict the results which would have been obtained with their own technique.
7. Apart from further studies there is a need to summarise the present position in a "state of the art" report. This is justified by the considerable body of papers and results now available. The state of the art report should include the following topics: The origins and purpose of the technique; observer training and reliability; repeatability of conflict counts(day to day variations); validation and a glossary of terms.
8. There is a continuing need for an information clearing house to deal with the distribution to Workshop members of research results and details of work in progress.

The final discussions at the Workshop showed that there was wide agreement that there should be some continuing form of organisation if the needs outlined in the previous section were to be met. The present Workshop format was not suitable for this purpose. After much discussion it was agreed that the most effective form of organisation was:-

- 1) A steering group of four people who had a direct interest in one or other of the topics mentioned. This group could invite, for assistance on working parties, or to carry out certain tasks, individuals from:-
- 2) A wider group representing the range of international interests in the Traffic Conflicts Technique.

The terms of reference of the steering group should be:-

1. Decide objectives, plan design and execution of further international studies on calibration and validation of techniques
2. Prepare a "state of the art" report
3. Organise an efficient research report distribution system and information clearing house.
4. Organise future meetings as necessary, whether full workshops, or small meetings on more specialised aspects.

The following members of the Workshop were invited to become the steering group:

1. Mr Christer Hyden(Sweden) as Chairman,with special responsibility for organising future international studies
2. Prof. E Hauer(Canada), with special responsibility for editing a state of the art report
3. Mr J Kraay(Netherlands) with special responsibility as bibliographer and for organising a literature clearing house.
4. A fourth member, as yet unnamed, who could act as a technical secretary and meeting organiser.

In addition to those already involved in the steering group participants from organisations in the following countries expressed their willingness to be members of the wider group: Austria, France, Germany, Great Britain and the USA.

It was understood that a final commitment to join either of these groups could not be made by individuals at the meeting as it would depend on obtaining the approval of their sponsoring organisations.

It was agreed by the members of the Workshop that some source of finance for travel to Steering Group meetings, co-operative experiments and possible future workshop meetings would help participation. The extent of possible support from organisations such as OECD, NATO Science Division, Social Science sub-committee and the International Driver Behaviour Research Association were discussed.

It was agreed that enquiries should be made and the results of these given to the Steering Group.

9. Participants at the 2nd International TCT Workshop

(Paris 10, 11, 12 May 1979)

AUSTRIA	A Schützenhöfer	Kuratorium für Verkehrssicherheit Neutorgasse Nr.51 8010 GRAZ Austria
	W-D Zusan	Kuratorium für Verkehrssicherheit Südtirolerplatz 3 5021 SALZBURG Austria
CANADA	B Allan	Traffic Research Group Dept. of Civil Engineering Mc Master University HAMILTON Ontario Canada L8S 4L7
	E Hauer	Dept. of Civil Engineering University of Toronto TORONTO Canada M5S 1A4
DENMARK	J Christensen	Danish Council on Road Safety Research Academivej, build. 371 DK-2800 LYNGBY Denmark
	U Engel	Danish Council Road Safety Research Academivej, build. 371 DK - 2800 LYNGBY Denmark
	H S Ludvigsen	The Road Directorate The Secretariat for Safety Road Improvement Skallegardsvej 2 DK-4700 NÆSTVED Denmark
FRANCE	G Malaterre	National Organisation for Road Safety (ONSER) BP 28 2 Av. du General Malleret-Joinville 94110 - ARCUEIL France
	N Muhlrad	National Organisation for Road Safety (ONSER) BP 28 2 Av. du General Malleret-Joinville 94110 - ARCUEIL France
	M Dupre	Local Technical Service of Ministry of Transport CETE of Rouen Chemin de la Poudriere 76 GRAND QUEVILLY France

FRANCE	A Douvier	Centre for the Study of Urban Transport 8 Ave. Aristide Briand 92220 BAGNEAUX France
WEST GERMANY	H Gstalter	Institut für Psychologie Abteilung für Angewandte Psychologie Technische Universität Braunschweig Spielmannstrasse 19 3300 BRAUNSCHWEIG West Germany
	B Zimolong	Technische Universität Braunschweig
	G Zimmerman	Bundesanstalt für Strassenwesen(BAST) Brühlerstrasse 1 Postfach 510530 5000 KOLN 51 West Germany
GREAT BRITAIN	S J Older	Transport and Road Research Laboratory (TRRL) Old Wokingham Road CROWTHORNE Berks RG11 6AU United Kingdom
	J Shippey	TRRL (as above)
	J Darzentas	Royal Holloway College EGHAM Surrey TW20 OEX United Kingdom
	M R McDowell	Royal Holloway College (as above)
	P A Storr	Royal Holloway College (as above)
	J Wennell	Royal Holloway College (as above)
	A Lightburn	Dept of Psychology University of Nottingham NOTTINGHAM NG7 2RD United Kingdom
ISRAEL	A S Hakkert	Road Safety Centre Technion City HAIFA Israel
THE NETHERLANDS	V A Guttinger	Netherlands Institute for Preventative Health Care (TNO) Wassenaarseweg 56 LEIDEN Netherlands

THE NETHERLANDS	J H Kraay	Institute for Road Safety Research (SWOV) P O Box 71 VOORBURG 2119 Netherlands
	S Oppe	SWOV (as above)
NORWAY	T O Pedersen	Institute of Transport EconomicsTØI) Post-box 6110 Etterstad OSLO 6 Norway
	N-E Bogsrud	Public Roads Administration POB 8109 Oslo Dep. OSLO 1 Norway
SWEDEN	P Gärder	Dept. of Traffic Planning and Engineering Lund Institute of Technology (LTH) Fack S-22007 LUND Sweden
	Chr Hyden	LTH (as above)
	L Linderholm	LTH (as above)
	G Nilsson	National Swedish Road and Traffic Research Institute Fack S-58101 LINKÖPING Sweden
	L-B KRITZ	Transport Research Delegation Sveavägen 166, 14tr. S-11346 STOCKHOLM Sweden
USA	W T Baker	Office of Traffic Operations HTO-31 Federal Highway Administration 400 7th Street, S.W. WASHINGTON, DC 20590 USA
	T K Datta	Goodell-Grivas Inc. 17320 West Eight Mile Road SOUTHFIELD, Michigan 48075 USA

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