APPLICATION OF TRAFFIC CONFLICTS AND OTHER INTERMEDIATE MEASURES: AN OVERVIEW

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INTRODUCTION

Research on traffic conflicts and other intermediate variables has always been field-oriented. The need for a diagnosis tool to complement accident data in safety studies was first expressed by local traffic safety engineers in the USA, who applied for several years a simplified form of standardized observation. The relationship between the traffic events observed and actual accidents was however soon considered too loose, and research took up from this point to develop a better technique. The same pattern of events occurred in some European countries, in particular in Finland, where the administration of Roads and Waterways attempted some early practical applications of the traffic conflict concept, before turning to research.

Although the need for intermediate measures originally emerged from safety workers in the field, most applications so far have been carried out by researchers. Traffic conflicts in particular have proved a valuable research tool. Lack of flexibility of national guidelines defining "appropriate" safety measures, and lack of incentive for honest evaluation of the effects of local safety work may be, in some countries, part of the reason why local authorities, or local branches of national road administrations, did not favour in the past the use of intermediate variables.

This trend seems now to be reversing. It is gradually becoming clear that safety measures, to be at the same time effective and reasonably cheap to realize, should adapt very closely to the local problems at hand, and that their design therefore requires a thorough knowledge of the causes of unsafety and the way behaviour can or should be influenced. More and more safety schemes are thus experimental, and their effects must be assessed in the short term. Local governments and safety workers are consequently getting interested in intermediate variables, not so much for use on highways any longer, but rather on rural access roads and in urban areas. Communication between research and practice is now reaching a critical point.

The following overview is an attempt at covering most of the fields in which traffic conflicts or other intermediate variables have been applied. It is based on published documents, and the studies explicitly mentioned are only examples to illustrate a general trend and do not constitute an exhaustive listing of what has been done in the matter. Also, the fact that prac-
tioners tend to publish less on their work than researchers reduces the amount of information available on local experimentation...

DIFFERENT TYPES OF APPLICATIONS OF TRAFFIC CONFLICTS AND OTHER INTERMEDIATE MEASURES

Nine or ten Traffic Conflict Techniques (TCTs) have now been finalized, and are well documented and ready for field-use. All of them include standardized procedures for traffic observation, and can be applied to a rather wide range of issues:

1 - As accident-surrogates, traffic conflicts are useful to carry out short-term evaluation of countermeasures. Such "product-evaluation" normally involves before-and-after studies, with controls (when possible). Effects of experimental schemes can be quickly assessed, for instance in the few months following implementation, and the variations of these effects with time can also be monitored by repeating conflict observations during the "after" period and comparing results. Some methodological precautions must be taken however, when evaluating a scheme that radically alters local traffic conditions: the conflict-to-accident ratios may not be the same "after" than "before", and comparisons between the two situations must therefore be carried out in a qualitative rather than a merely quantitative way (the total number of conflicts observed may well increase, while predicted danger decreases).

There have also been attempts to use traffic conflicts for the identification of safety problems in situations where accident data was entirely missing or thoroughly unreliable, as for instance in some developing countries. The validity of results obtained is yet unproven, but it is clear that a standardized procedure to observe traffic should lead to less biased conclusions than a more subjective assessment of danger formulated without any guidance.

2 - As a complement to accident data, traffic conflicts have often been used for safety diagnoses and countermeasure design. On locations where accidents are, statistically speaking, infrequent, or when detailed accident data is not available, conflict observation gives valuable indications as to the causes of unsafety and the way to avoid it. Even when accident analysis is conclusive, conflict data can help design countermeasures which also ease the task of pedestrians or drivers, and are more acceptable to road-users in general.

Conflicts are also more and more used in addition to accident data in evaluation studies, to show, not only whether a safety measure works, but also how it works (or why it doesn't). Such "process evaluation" (or qualitative evaluation) is a way of checking the assumptions made when designing countermeasures, and should provide directions for improvement or changes.
Safety diagnosis and process evaluation are the two main tools available to local safety professionals to keep training themselves, increase their practical knowledge, and develop their own work, and these particular applications of TCTs should therefore become much wider-spread.

3 - **Conflicts as themselves** are now currently used in research studies to assess road-user performance or risk, or to analyse the concept of "subjective safety". In evaluation studies, they are also used as indicators for the quality of life environment, a traffic conflict being considered in itself as an element of stress that should be avoided, and a malfunction in the traffic system.

Other possible intermediate measures mostly include various procedures of **behavioural observation** (including monitoring speeds) or **traffic counts**. They apply to three main kinds of tasks:

- **safety diagnosis** on hazardous locations or performed in view of area-wide safety measures. Behavioural observations are defined on the basis of what is known from accident (or conflict) data, and are used to check the first assumption made on the causes of unsafety. Traffic counts are often used as background data;

- **process evaluation**. Behavioural observation or other intermediate measures are used to check that the "intermediate aim" of a countermeasure (for instance reducing speed, altering pedestrian crossing behaviour, raising drivers' awareness, etc.) is actually reached. While this may not always mean that the countermeasure will be effective in reducing accidents, it is on the contrary quite clear that if it does not fulfill its intended intermediate aim, it cannot have the expected effect on safety either. Intermediate measures are also used to check that a countermeasure does not produce unwanted side-effects which could reduce its final efficiency; traffic counts and sometimes speeds are the most frequent detectors of side-effects...;

- **evaluation of some preventive safety measures** such as educational or training programmes, information campaigns, etc. Such measures appear impossible to evaluate with the more traditional means (before-and-after accident comparisons with control groups), and well defined behavioural observation is likely to be the only way to ever assess their effects.

When compared to TCTs, other intermediate variables show a major drawback: they are not standardized, and a specific procedure must be designed again for each new case. Research may ultimately produce guidelines to facilitate the task; in the meantime, most evaluations carried out on the basis of behavioural observations have been the fact of researchers rather than practitioners.

Finally, new evaluation tools such as measuring the levels of "subjective safety" experienced by road-users, or their degree of satisfaction after countermeasures have been implemented, have appeared in the last few years, both in studies carried out by researchers and by local authorities. Although such indicators cannot be termed as "intermediate variables" as there does not seem to be any direct connection between "feelings of safety" and
an actual potential for accidents, they are used in a very similar way as an additional part to "process evaluation", when the aim of the countermeasure tested is actually twofold: improving safety, but also life conditions. This is often the case when area-wide schemes are designed for urban neighbourhoods. Subjective safety and the road-users' degree of satisfaction are also measured to gain knowledge of countermeasure acceptability.

PRACTICAL APPLICATIONS OF TRAFFIC CONFLICT TECHNIQUES

Diagnosis and evaluation studies based, totally or in part, on conflict data started being carried out ever before TCTS were completely developed or validated, and are now quite numerous. Not all of them however were successful or conclusive, but they all contributed to throw some light on the problems related to unsafety and countermeasure design. A number of studies are therefore mentioned here as representative of various fields of interest, but no results or critical viewpoints are given.

1 - Research applications

They include studies carried out by researchers themselves (although often in relation with national or local road administrations), but exclude development research (test of TCTS, validity, calibration).

Research applications of TCTS can be classified as follows:

1.1 - TCTS as a research tool for behavioural analysis and the study of risk and subjective safety

In these applications, TCTS are often associated to other forms of observation, and sometimes to interviews of the road-users observed. Studies of risk-estimates by road-users at intersections were carried out in England (G. GRAYSON, in /5/), while the relationships between subjective feelings of safety and conflicts and other traffic events were investigated in France (N. MUHLRAD, in /3/, D. CIER and al. /16/). TCTS were also helpful for the assessment of drivers' performance, in particular in studies carried out:

- in Austria, on car drivers (R. RISSE, A. SCHUTZENHOFER, in /5/): a typology of driving errors was built, and specific behaviour of particular groups of road users (foreign through-traffic) was analysed (R. RISSE, in /12/, /13/);

- in England, on car drivers, with comparisons between night and day driving behaviour (J. DARZENTAS, V. HOLMES, M.R.C. Mc DOWELL, in /2/);

- in Hungary, on car drivers at hazardous locations or in specific traffic situations (overtaking, crossing intersections, at railway/road level crossings, etc.), (M. DRASOCZ, in /13/);

- in The Netherlands, on bicycle riders at intersections (E. TENKINK, in /13/).
1.2 - Conflicts as a tool for safety diagnoses and countermeasure design

In these applications, TCTs are mostly used to complement accident data: the conflict data collected is thus necessarily detailed, and descriptive of the traffic processes leading to critical situations. Black-spots or hazardous locations were particularly investigated this way; for instance:

- in Austria, in urban areas; follow-up studies were also carried out on the countermeasures designed (installation of islands and pavement markings). (K.J. HOFFNER, A. SCHUTZENHOFER, in /2/);

- in France, in rural and suburban areas (G. MALATERRE, N. MUHLRAD, in /2/);

- in Israel, within a project of residential area improvement (A.S. HAKKERT, in /5/);

- in Austria again, where an international conflict study took place and produced safety diagnoses on rural and suburban intersections which are "seasonal" black-spots (the Trautenfelds study, in /12/, J.H. KRAAY, A.R.A. VAN DER HORST, in /8/).

Safety diagnosis has also been carried out on specific traffic situations, as for instance in Germany on bicycle traffic at 45 intersections (G. RUWENSTROTH, in /13/).

Finally, attempts at using existing TCTs or derived techniques in replacement of missing accident data to identify or analyse specific safety problems have also taken place within the framework of scientific cooperation with Developing Countries, in particular in the City of Nairobi, Kenya (cf. C. HYDEN), and in two provinces of the Republic of the Philippines (N. MUHLRAD, in /17/).

1.3 - Traffic conflicts as an intermediate variable for the evaluation of safety measures

Quite a number of new countermeasures or experimental schemes have already been subjected to short-term evaluation based on conflicts. Some of the studies carried out were only concerned with "product-evaluation" with conflicts as the safety indicator in before-and-after comparisons, while others were rather more qualitative, with conflicts as one of several measures used to assess "process" and effects; in particular, TCTs and some behavioural observations were often associated. The main categories of countermeasures investigated are the following:
- junction lay-out: left-turn facilities in urban areas were studied in Germany (G. ZIMMERMANN, G. RIEDIGER, in /4/), as well as in Norway (F.H. AMUNDESEN, H.D. LARSEN, in /1/), mini-roundabouts in suburban areas were investigated in England (J.J. OLDER, J. SHIPPEY, in /1/), and safety of at-grade and grade-separated intersections on rural highways was also compared in Norway (F.H. AMUNDESEN, H.O. LARSEN, in /1/);

- traffic light installment and operation: the effects of turning traffic-lights to flashing amber at night or off-peak hours were analysed in Israel (D. MAHALEL and al., in /4/, A.S. HAKKERT, in /5/), in France (N. MUHLRAD, G. DUPRE, in /5/), and in Norway (F.H. AMUNDESEN, H.O. LARSEN, in /1/). Comparisons between different forms of traffic-light operations were carried out in France (G. DUPRE, in /5/), and in Germany (G. HOFFMANN, R. SLAPA /11/), and the effects of installing traffic lights at urban and rural intersections were followed up in England (J.J. OLDER, J. SHIPPEY, in /1/);

- facilities for unprotected road-users: different types of pedestrian crossings and refuges were studied in Austria (L. SCHUTZENHOFER, in /2/), in Finland (R. KULMALA, in /3/, /4/), and in France (G. DUPRE, in /5/). Experimental cycleways were investigated in The Netherlands (A.R.A. VAN DER HORST, in /3/, /4/, /5/), and priority zones for bicyclists in Germany (G. RUWENSTROTH, in /13/). The evaluation of specific safety measures for unprotected road-users is also the object of continuing research in Sweden (cf. S. ALMQVIST);

- speed reduction measures in urban areas: the effects of speed humps, road constrictions, special paving, etc. were assessed in The Netherlands (A.R.A. VAN DER HORST, in /5/), in Sweden (C. HYDEN, P. GARDER, L. LINDEHOLM, in /4/), and in Germany (H.W. FECHTEL, W. RUSKE, in /10/), while speed limits in school areas were investigated in Sweden (C. HYDEN, in /1/);

- area-wide measures in urban areas: new schemes or experimental projects for traffic restraint or speed reduction in residential areas were evaluated in The Netherlands (V.A. GUTTINGER, in /1/, /5/, T. JANSSEN, in /7/, and J. KRAAY, J. GOOS, in /13/), in Germany (R. ALBRECHT, in /4/), and in Sweden (C. HYDEN, P. GARDER, L. LINDEHOLM, in /4/);

- highway design: in Europe, TCTs were less used in research on rural safety than in towns. However, the effects of acceleration lanes at grade separated intersections on a four-lane divided highway, and of the replacement of a crawling lane by an overtaking lane have been studied in Finland (R. KULMALA, in /3/, /4/).
1.4 - Traffic conflicts as a pedagogical tool

Intentions of using traffic conflicts, and in particular video-films of conflicts actually observed on the road, as an educational tool have been expressed in several countries. Practical applications are actually taking place in Sweden (cf. C. HYDEN, S. ALMQVIST).

2 - Applications of TCTs by National Road (or Safety) Administrations

National Road Administrations started working with the TCTs in the early 70's, mainly in the USA and in Finland. Swedish and Dutch Administrations became interested a little later on, than the French one, although in a limited way. The main applications can be classified as follows:

2.1 - Diagnosis and countermeasure design on hazardous (or potentially hazardous) locations on highways

These activities have been systematically carried out, both in Finland since 1972 (M.J. MERILINNA, in /1/, R. KULMALA, in /5/, U. LINDSTROM, in /13/), and in Sweden (M.O. MATTSON, in /5/). In Sweden, it is now a continuing task, with one or two new cases investigated each year.

Apart from hazardous junctions, the Finnish Road and Waterways Administrations has also been studying climbing lanes, and petrol-filling stations (R. KULMALA, in /3/, U. LINDSTROM, in /13/).

2.2 - Evaluation of safety measures

This kind of work is less common than safety diagnosis, and is mostly now in preparation or in progress. The effects of installing traffic lights on a highway junction were studied by the Swedish Road Administration around 1982 (M.O. MATTSON, in /5/), and the Swedish Traffic Safety Administration is now currently investigating 2 to 4 cases a year of new or alternative countermeasures. Several projects were announced by the end of 1984, as in Finland evaluating changes in speed limits (R. KULMALA, U. LINDSTROM, in /13/), and in The Netherlands 10 to 15 other evaluation studies (J. KRAAY, J. GOOS, in /13/).

2.3 - Promoting TCTs for local safety work

Although this is not in itself an "application", it is worth mentionning that several national administrations now play an active part in promoting the use of TCTs in local traffic safety work. In particular:
recommendations for wider use of TCTs have been issued by Transport Canada in the 70's (J. LAWSON, in /3/), a task which is now taken up by British Columbia Insurance Corporation (G. BROWN and al. /6/); recommendations were also issued by the Ministry of Transport and Public Works in The Netherlands (G. GOOS, in /13/); finally, after successful validation of the American TCTs, the Federal Highway Administration is encouraging as widely as possible its applications as a tool to predict danger before accidents actually occur (D.J. MIGLETZ, W.D. GLAUZ, K.M. BAUER, in /9/, and W.T. BAKER, in /13/);

the National Road Administration in Sweden has organized a training programme for local road administration personnel, while in France, CETUR (Centre for Urban Transport Studies, Ministry of Planning and Transport) has recently been offering training seminars and information on TCTs to local authorities participating in the national programme "Safer City, Accidentless Neighbourhoods".

3 - Applications of TCTs by local authorities

Little data is available on the work carried out by local authorities, who do not usually feel compelled to report on it... However, we know that training packages or manuals exist in several countries (for instance in Sweden, Germany, Great Britain, and France), and that TCTs are actually in use in many cities or rural districts.

Local applications of traffic conflicts seem to have been mostly restricted so far to safety diagnoses, as an addition to what little information is available on accidents. This is the case in particular with a number of British local authorities (G. GRAYSON, in /5/), in Norway (F.H. AMUNDSEN in /1/), and with at least one large city in Sweden, Gothenburg (B. WASSENIUS, in /7/, /13/). Some local authorities also envisage to use TCTs systematically on rural access roads, where accident information is scarce (BRAMWELL, in /13/).

Two French cities, Rennes and Mützig, are now applying a TCT for the evaluation of area-wide improvement schemes, within the national programme "Safer City, Accidentless Neighbourhoods".

It is clear that evaluation work with traffic conflicts has often been impaired by the fact that conflict observation is time-consuming and relatively costly. Local evaluations can be carried out only if some local personnel can train as observers and perform the field-investigations on their regular working time. Local authorities with limited personnel often have to give up conflicts...

PRACTICAL APPLICATIONS OF OTHER INTERMEDIATE VARIABLES

We will give here a few indications of what can be done in this field, but it is in no way exhaustive!
1 - Behavioural observations as a complement to accident analysis for diagnosis or process evaluation

For this kind of task, the observation procedure is defined in view of the first conclusions of accident (or conflict) analysis. Applications have been made in France to black-spot treatment (F. FERRANDEZ, E. FLEURY, C. MALATERRE, in /16/), in Denmark to the evaluation of safety measures in a residential area (U. ENGEL, in /4/), or in the Philippines to safety diagnosis in some critical situations as overtaking or crossing a junction with a STOP sign (F. SAAD, in /18/).

2 - Behavioural observations as a surrogate to accident analysis

In this case, the observation procedure is defined in view of the assumptions made as to how a countermeasure or particular features of the traffic environment should influence road-users. Applications have particularly applied so far to the traffic problems opposing car drivers and unprotected road-users. For instance, space-sharing by pedestrians and vehicles was studied in England (E. DALBY, in /15/), and in France (N. MUHLRAD, J.L. MONSEUR, in /14/); junctions or experimental cycleroutes were investigated in The Netherlands (A.R.A. VAN DER HORST, in /4/).

Behavioural observation has also played an essential part in the evaluation of educational programmes, as for example in The Netherlands (J.A. ROTHENGATTER, H.H. VAN DER MOLEN, in /4/).

3 - Speed measurements

They are used to test the intermediate aims of countermeasures and apply therefore mostly to speed reduction devices and area wide improvement schemes for residential areas. Sometimes, speed measurements can also indicate undesirable side-effects of other countermeasures.

Testing speed limits has been done almost everywhere. Speed humps were thoroughly investigated in England (C.J. BACULEY, in /4/), and area-wide measures in Denmark (U. ENGEL, L.K. THOMSEN, in /5/), and in The Netherlands (T. JANSSSEN, in /7/); a new type of street design for speed reduction in a town centre has been monitored in Mützig, France. Finally, speed changes at junctions on new cycleroutes were analysed in The Netherlands (A.R.A. VAN DER HORST, in /4/). These are only a few among many examples...

4 - Traffic flows measurements

They are usually used to monitor traffic restraint schemes, or indicate possible side effects of countermeasures, as in the case of speed humps for instance (C.J. BACULEY, in /4/). Other attempts at using traffic counts as accident predictors have so far been successful only under limited conditions, and have not really been very much applied in practice.
5 - Measurements of road-users satisfaction

Variations in the level of road-users satisfaction have been measured by researchers to assess the acceptability of various countermeasures, especially for speed reduction, for instance in Norway (F.H. AMUNDESEN, S. LUNDEBYE, in /4/), in Australia (R.E. BRINDLE, in /4/, /7/), in Great Britain (C.J. BAGULEY, in /4/), and in the Netherlands (J.H. KRAAY, S. OPPE, in /7/). Practical applications of such methods have also been undertaken by local authorities in order to evaluate some measures on criteria not directly related to safety, but complementary, for instance in the City of Amsterdam in The Netherlands (P.W. VAN DER KROON, in /4/), or in the towns of Mutzig, Corbeil, etc. in France within the programme "Safer Cities, Accidentless Neighbourhoods".

CONCLUSION

Applications of traffic conflicts and other intermediate variables are expanding, but not as quickly in practice as safety work would require, due to various problems, of which the main ones are insufficient communication between researchers and field-workers, and economical restrictions. The new orientation of traffic safety work towards more localized and experimental measures or safety schemes, which is now observable in many countries, should make intermediate variables even more useful in the future.

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