TRAFFIC SAFETY - CAN WE BE PRO-ACTIVE?

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ABSTRACT: *The treatment of hazardous locations has traditionally been a reactive process based on historical information on crashes at sites -- the accident "blackspot" treatment approach. Traffic authorities are often asked why hazardous locations can't be treated before they become accident "blackspots" -- thus treatment programmes would be pro-active rather than reactive. This paper reports on progress with research into the development of guidelines for implementing pro-active traffic safety programmes. It concludes that further research would be worthwhile particularly directed at the application of Expert System concepts to the identification of potentially hazardous sites and the selection of appropriate treatments.*

BACKGROUND

A few years ago, the Road Traffic Authority in Victoria (RTA) closely examined the traffic safety programmes it was delivering and asked the question "How can hazardous locations be identified and treated before they become accident black spots?" Out of this question arose a research project to investigate the scope for pro-active traffic safety programmes - where information about a site's physical and traffic characteristics would be the basis for judging its traffic hazard and, hence, the need for remedial works. This paper summarises the outcomes to date of the research project.

RTA commissioned the then newly formed Monash University Accident Research Centre (MUARC) to conduct this research with the following objectives:

- to develop guidelines for traffic engineers to identify potentially hazardous locations from a knowledge of the physical/traffic characteristics of the location;
- to suggest methods for diagnosing problems at identified locations;
- to indicate the types of traffic engineering countermeasures which could be applied to hazardous locations depending on crash type and physical characteristics; and
- to suggest methods for assigning priorities for the selection of sites into treatment programmes.

REVIEW OF LITERATURE

Before commencing an extensive data collection process, MUARC initiated a literature survey to identify relevant research by others. This survey showed that pro-active approaches to the treatment of road hazards have been of limited interest to road safety researchers in the past. Apart from the important work of Fox et al. (1979) in the late 1970's - which developed a model to predict the likelihood of roadside poles being hit in out-of-control crashes - there has been very little interest in searching for relationships between physical or traffic characteristics and crash propensity until quite recently. A number of writers have drawn attention to the potential advantages of a pro-active approach (Sanderson et al., 1985; Searles, 1987) but work to examine potential predictive models has been limited.

Recently there seems to have been an increase of research activity associated with the application and development of Expert Systems (Lau and May, 1989; Chen and Cantilli, 1989; Zhou and Layton, 1989). Pro-Active programmes could be seen as a subset of a broader definition of Accident Blackspot Programmes. Hills and Elliot (1986) contend that these programmes can be classified into four distinct strategies:

"(i)	Blackspot Plans	- measures to tackle accidents at specific sites;
(ii)	Route Action Plans	- comprehensive treatment of routes with high accident densities;
(iii)	Area Action Plans	- comprehensive treatment of small areas of a town or city with high accident densities;
(iv)	Mass Action Plans	- mass application of established counter-measures e.g. application of high skid resisting surfaces."

The fourth strategy is pro-active in that measures are implemented without waiting for hazards to show up as high crash densities. Procedures for these strategies are described in the UK Accident Investigation Manual (DoT, 1986).

PRELIMINARY INVESTIGATION OF CRASH GROUPS

At the outset of the study MUARC, with the agreement of RTA, selected six categories of crash types to investigate based on considerations of size of the crash group, perceived potential for developing predictive guidelines and likely effectiveness of potential countermeasures. These groups are:

- right-turn-against at traffic signals (8%);
- intersections of major with minor roads in urban areas (21%);
- rural intersections in grid networks (6%);
- poles hit at intersections (1%);
- run through crashes at tee junctions (2%); and
- bridges and culverts (1%).

The figures in brackets represent the size of the crash group as a percentage of the over 82,000 casualty crashes reported in Victoria for the five years 1982 to 1986. There will be some crashes that are classified into more than one crash group such as with the "poles hit at intersections" and the "intersections of major with minor roads in urban areas" groups.

The intended study procedure was to rank locations according to the number of crashes of the group being investigated and then selecting, from that list, sufficient locations to provide representations of:

- sites with crash rates worse than normal;
- sites with crash rates better than normal; and
- sites with poor crash rates which have improved over time following the implementation of countermeasures.

Data on physical and traffic characteristics for these selected sites would then be collected as a basis for searching for associations between these characteristics and crash rates. This approach has been used on a limited basis for right-turn-against crash sites but has not been used for other crash groups.

Computer files of crashes, by the six groupings described previously, were used to generate listings of locations and the number of crashes of the particular type for each location. These listings of sites were then sorted by number of crashes and used to plot cumulative percentage of crashes against cumulative percentage of sites as shown in Figure 1. Cumulative plots were prepared for groupings of sites by the following classifications where appropriate:

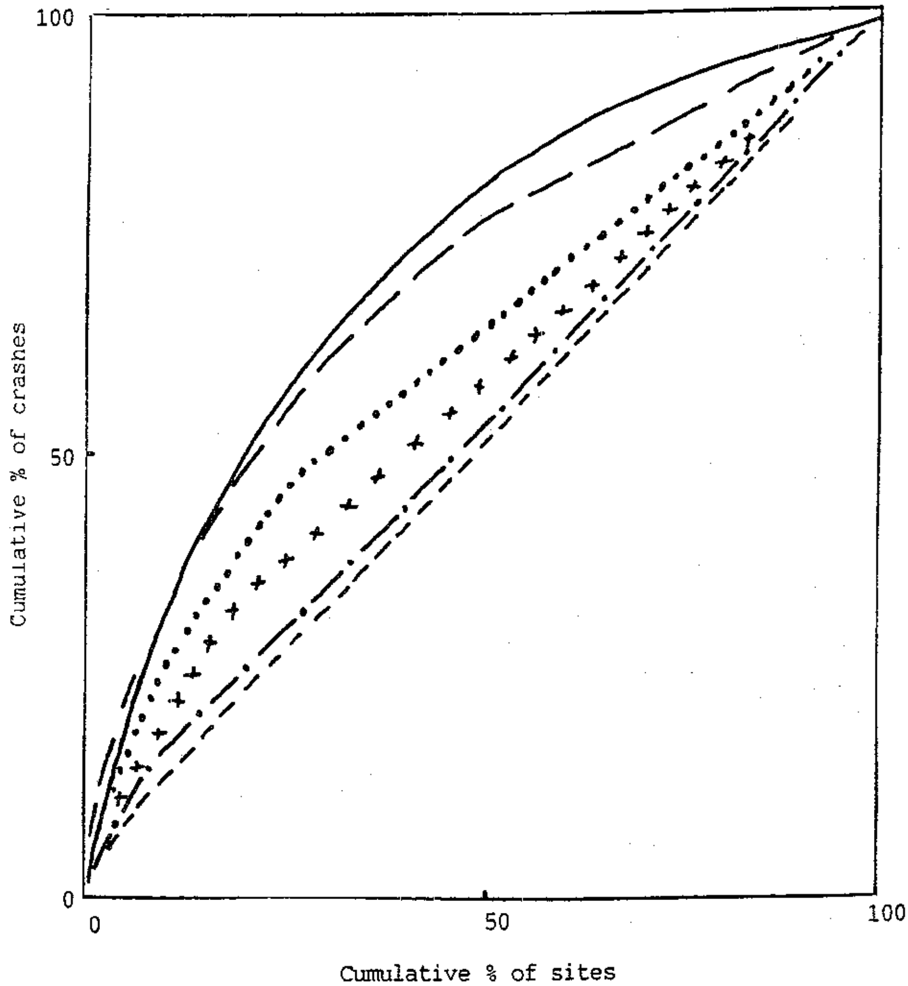
- metropolitan intersections and mid-blocks in local streets;
- metropolitan arterial road mid-blocks and intersections of arterials with local streets;
- metropolitan arterial to arterial intersections; and
- intersections and mid-blocks in non-metropolitan areas.

For the purpose of illustrating the results of this technique, a sample plot for each crash group is shown on Figure 1.

This analysis gives a first indication of the crash groups that have potential for predictive models. As sites within a crash group are unlikely to be homogeneous, a straight line on the plot indicates that there is no association between crash propensity and physical or traffic conditions - that is, crashes are randomly distributed between sites. A dependency between crash propensity and site characteristics - physical or traffic - could be expected to result in clustering of crashes at some sites. The cumulative plots will tend to be arched upward.

As shown in Figure 1, there are strong indications of associations for right-turn-against crashes, crashes at major roads with minor roads in urban areas and cross intersections on rural arterials. For crashes involving poles at urban intersections, the indication of association is weaker. Crashes involving objects hit at tee junctions - run through crashes - and crashes at rural bridges and culverts show practically no clustering and the likelihood of finding associations between crash propensity and site characteristics is very small.

FIGURE 1: Cumulative Crashes -vs- Cumulative Sites for Six Crash Groups



———	right-turn against crashes at signals
— —	crashes at major/minor intersections
—·—	crashes at rural bridges and culverts
———	objects hit at T intersections
......	crashes at rural cross intersections
+++++	poles hit at urban intersections

At the time of preparing this paper, more detailed investigations had been commenced on three crash groups: (i) right-turn-against; (ii) crashes at bridges and culverts; and (iii) crashes at intersections of major and minor urban roads. Results of these investigations are discussed in the following sections.

RIGHT-TURN-AGAINST CRASHES

Right-turn-against crashes at signalised intersections are hypothesized to result from an inability of the turning driver to select suitable gaps in the opposing traffic stream (Howie and Ambrose, 1989). The performance of drivers in selecting suitable gaps is probably affected by combinations of the following factors:

- restricted visibility to on-coming traffic due to poorly placed road furniture, large vehicles in opposing right turn lanes and restricted horizontal or vertical curvature;
- high approach speeds of opposing through traffic;
- multi-lane opposing approaches; and
- pedestrian movements preventing completion of the turn.

To examine the validity of this hypothesis, physical characteristics of some 60 intersections, with the highest number of right-turn -against crashes, were surveyed. These data were analysed by intersection approach to identify associations between crash rates and measures of physical characteristics - median width, number of opposing lanes, number of right turn lanes, presence of driveways and visibility. Student's t statistic was computed to assess whether there are real differences between crash rates for intersection approaches grouped by physical characteristic. For example, are the crash rates for approaches with narrow medians statistically different to those for approaches with wide medians and so on. Table 1 shows the results of the analysis of right-turn-against crashes per approach versus median width.

Table 1: Right-turn-against Crashes by Median Width:

Median Width	Number of Approaches	Casualty Crashes per Approach		Std. Error of Mean	t test with	
		Mean	Std. Dev.		Wide	Narrow
None	61	2.75	2.44	0.31	sd	ns
Narrow	14	3.43	3.08	0.82	ns	
Wide (<3m)	80	4.39	3.06	0.34		
Unknown	1	-	-	-		
All	156	3.65	2.91	0.23		

Legend: ns = no significant difference $p>0.05$
ps = probably a significant difference $p<=0.05$ and $p>0.01$
sd = significant difference $p<=0.01$

(Derived from Howie and Ambrose, 1989)

This analysis suggests that crash rates are significantly greater for approaches with wide medians than for approaches with no medians. This difference may also be associated with conflicting traffic flows and this aspect needs to be investigated before drawing conclusions about the relative safety performance of wide versus narrow medians.

Similar analysis of other physical characteristics - based on a limited and probably somewhat biased sample of sites - suggests that wide medians, three or more lanes and exclusive turn lanes are all indications of right-turn-against problems. Restricted visibility is also a possible indicator of potential right-turn-against crashes. These are indicators of the need for measures to improve the safety for right turners at signalised intersections. Further work is needed to validate these tentative conclusions. This work could include surveys of signalised intersections with mid-range and low numbers of right-turn-against crashes and adjustments of crash rates by a suitable measure of exposure.

CRASHES AT BRIDGES AND CULVERTS

An analysis of data for the five year period 1982 to 1986 shows that crashes at bridges and culverts in Victoria represent a small proportion of all casualty crashes - about 1% (Ogden, 1989). However, bridge and culvert crashes are more severe than crashes as a whole - about 3.5% of persons killed were involved in bridge or culvert crashes. This compares with findings by Hollingsworth (1983) that some 6.7% of road fatalities in Queensland were associated with bridges. In terms of location, about 44% of bridge and culvert crashes were in the Melbourne metropolitan area. Most bridge and culvert crashes were coded as:

- left or right off carriageway into fixed object;
- off left or right hand bend into fixed object;
- striking a permanent obstruction; or
- rear end collision between vehicles.

Metropolitan crash patterns differ considerably from rural patterns - metropolitan crashes tend to be multi-vehicle in which the bridge is not struck while in rural areas there is a higher proportion of single vehicle crashes at which the bridge, its approach, or another fixed object is struck. Small vehicles - passenger cars in the main - are dominant in bridge crashes, although large vehicles appear to be over-represented in on-path crashes, especially in the metropolitan area. This higher representation may be due to high vehicles hitting over-bridges with substandard headroom.

In the majority of bridge crashes, the bridge and its approach safety rail are not struck; these features were struck in about 27% of metropolitan and 39% of rural bridge crashes. Countermeasures will, therefore, need to be directed not only at preventing collisions - or alleviating the consequence of collisions - between vehicles and the bridge or its approach, but also at vehicle/vehicle and vehicle/other fixed object collisions. Single vehicle crashes at bridges mostly involve a collision between a vehicle and the bridge or its safety rail - although even here, a significant proportion of crashes involve a collision with another fixed object. Horizontal curvature could be a contributing factor, especially in rural areas. Very few multi-vehicle crashes result in the bridge or its approach safety rail being hit - the presence of the bridge seems to be coincidental rather than contributory. Crashes at bridges and culverts do not appear to be associated with light conditions or road conditions - ie. road surface.

There is little concentration of bridge and culvert crashes - see Figure 1 - and, hence, a mass application, pro-active approach to the implementation of countermeasures is more appropriate than a reactive approach based on crash history. Cost effective countermeasures are likely to be low cost treatments applied to a very large number of bridges. A few bridges may have sufficient clustering of crashes to qualify for "black-spot" treatment but in most cases this approach will not be appropriate.

Development of mass application treatments for bridges can draw on a wealth of experience reported in the literature (Ogden, 1989). The NAASRA Roads Study (NAASRA, 1984) provides a lead with a bridge assessment table which can be used as a starting point in assigning priorities for treatment of bridges and culverts. Work by Gandhi, Lytton and Das (1984) also provides a basis for developing a bridge safety index using the following factors:

- bridge width;
- bridge length;
- traffic speed;
- traffic volume;
- traffic composition;
- grade continuity; and
- shoulder reduction.

The extended model of Gandhi et al. (1984) is probably not appropriate for ranking bridge treatments in Australia because of the extensive need for data about bridge sites. However, there are three powerful, and relevant, observations which can form the basis of a simplified ranking procedure. These are:

- bridge width is more important than traffic flow in assessing bridge safety;
- bridge width is the most important factor; and
- bridge length is the next most important factor.

These conclusions lead readily to a suggested priority ranking for the treatment of bridges which meets requirements of simplicity and measurability (Howie, 1988). These are:

(i) all bridge sites which are identified as "blackspots" be treated as such (small number of sites);

(ii) all remaining bridges be considered for treatment in a priority determined by:

   (a) the NAASRA bridge assessment table ("poor", "fair" and "good);

   (b) within each NAASRA category of "poor", "fair" and "good", the narrowest bridges to be treated first; and

   (c) for bridges in equivalent width categories, treatment be in order of bridge length.

Treatments for bridges and culverts can be formatted into three programme elements. These are:

(i) delineation - guideposts, bridge width markers, edge lining, raised reflective pavement markers and chevron signs;

(ii) safety barriers - guard fencing in accordance with current design manuals; and

(iii) other - transitions from guard fencing to bridge end posts, maintenance of guard fencing, improvements to road alignment, and safety audit procedures for bridge design and construction.

CRASHES AT URBAN MAJOR/MINOR INTERSECTIONS

For this group, the hypothesis is that the majority of crashes are a consequence of the difficulties for drivers in the minor road trying to enter or cross the major road flow (Howie, 1989). With the introduction of Stop and Give Way controls at these intersections, the driver of the vehicle from the minor road is required to judge gaps in both crossing streams of traffic effectively at the same time. This task is greatly intensified where:

- visibility is restricted by poles, vegetation and/or parked vehicles;
- the intersection is some distance from signalised intersections;
- major road vehicle speeds are high; and/or
- there is inadequate or no space for entering vehicles to wait between opposing flows of traffic on the major road.

An analysis of crashes in metropolitan Melbourne - Table 2 - shows that right-near - right turning vehicle hit on drivers side - right-angle and right-turn-against crashes each comprise almost 12% of all casualty crashes at intersections of major and minor roads. This finding is similar to findings reported by Cairney (1986). However, in terms of persons killed, crashes involving vehicles hitting pedestrians are dominant with pedestrian-near-side and pedestrian-far-side each comprising over 14% of fatalities. Persons hospitalised, medically treated and minor injury categories are each dominated by the top three vehicle to vehicle crash groups; all in higher proportions than their representation in all casualty crashes.

Table 2: Casualties and Casualty Crashes By Crash type at major/minor urban intersections from 1982 to 1986 inclusive.

			Persons by Extent of Injury									
			Fatal		Hospital		Medical		Minor		None	
Crash Group	Crashes	%	No.	%	No.	%	No.	%	No.	%	No.	%
Right near	1943	11.9	30	7.7	877	11.7	1777	12.7	232	15.1	2799	12.4
Right turn against	1932	11.9	40	10.2	1052	14.1	1749	12.5	275	17.9	3004	13.3
Right angle	1900	11.7	40	10.2	1072	14.3	1920	13.8	286	18.6	3056	13.6
Ped. near side	679	4.2	55	14.1	362	4.8	299	2.1	16	1.0	812	3.6
Ped. far side	598	3.7	57	14.6	350	4.7	231	1.7	5	0.3	711	3.2
Other	9251	56.6	169	43.2	3763	50.3	7973	57.2	721	47.1	12169	53.9
Totals	16303	100	391	100	7476	100	13949	100	1535	100	22551	100

(Derived from Howie, 1989)

Further analysis of this data, by type of location, shows that right-near crashes are strongly associated with Tee junctions controlled by STOP or GIVEWAY signs - about 77% of these crashes. These crashes involve a right turn vehicle from the minor street being hit on the driver's side by a through vehicle on the major street. Right-angle crashes are strongly associated with intersections controlled by STOP or GIVEWAY signs - some 74% of these crashes - and cross intersections controlled by traffic signals - some 22%. Presumably the crashes at STOP/GIVEWAY intersections are the result of minor road drivers misjudging gaps in the streams of traffic on the major - through - road. Right-turn against crashes are spread across tees and crosses with STOP/GIVEWAY or signal control - 30% at Tees with STOP/GIVEWAY signs and 25% at crosses with signals.

From a brief inspection of the list of locations with high numbers of right-near crashes, the common physical characteristic is a lack of a central divider in the arterial road. However, before drawing conclusions from this observation there is a need for further analysis using some measure of exposure.

The analysis completed so far suggests that while intersections of major and minor roads generally do not individually rank high in terms of numbers of crashes there are dominant crash types which are associated with particular types of intersections - right near crashes with tee junctions and right angle crashes with cross roads. Both types of crashes would probably be mitigated by the installation of central islands in the side road - in combination with linemarkings in the major road - to more clearly define vehicle paths. A mass application of suitable treatments may be appropriate with sites being selected on the basis of the following features:

- undivided main road;
- side road serving as a collector street;
- visibility difficulties for drivers in the side road (e.g. parked vehicles); and
- high speeds in main road.

More research is needed on the likely costs - installation of islands and pavement markings at a target group of intersections - and the benefits - expected reduction in the target group of crashes - before proceeding with such a programme.

FURTHER RESEARCH?

The research completed to date has demonstrated that there is a role for pro-active traffic safety programmes which can range from the development of models which relate crash propensity and site characteristics through to the mass application of proven low cost crash countermeasures to sites of a like type. There is clearly a need for more research to determine which technique is applicable to the various categories of crashes and to develop innovative ways to treat hazardous sites.

A promising area for further research and development is in the application of Expert Systems technology to provide more systematic methods of analysing and interpreting information about potentially hazardous locations. Expert systems are "designed to provide the level of performance of a human expert in a specific professional domain and enable a computer to assist people in analysing specified problems using that expertise" (Zhou and Layton, 1989). Such systems can "relieve engineers and researchers from some of the routine duties which require in-depth knowledge but no imagination and thus allow more emphasis on complex tasks which require human judgment and new ideas" (Lau and May, 1989). Any system which can help focus professional energy on innovative and creative ways of improving traffic safety is surely worthy of research support.

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REFERENCES:

Cairney,P.T. (1986) Major/Minor Intersections and Junctions - A greater accident problem than we think? Proc of combined 13th ARRB/5th REAA Conference, Vol 13, Part 9 of 9 parts, pp 78-79, Adelaide.

Chen,X. and Cantilli,E.J. (1989) An Expert System for Analyzing Intersection Safety. Paper to the American Society of Civil Engineers First International Conference on Applications of Advanced Technologies in Transportation Engineering, San Diego, CA. Feb. 5-8, 1989.

Department of Transport, (1986) Accident Investigation Manual, (2 volumes) London.

Fox,J.C., Good,M.C. and Joubert,P.N. (1979) Collisions with Utility Poles. Office of Road Safety, Canberra.

Gandhi,B.V.R., Lytton,R.L. and Das,B. (1984) An improved bridge safety index for narrow bridges, Transportation Research Record 960, pp 40-48.

Hills,B.L. and Elliott,G.J. (1986) A Microcomputer Accident Analysis Package and its use in Developing Countries. Paper presented at Indian Road Congress Road Safety Seminar, Scrinager, September 17th/19th 1986.

Hollingsworth,G.H. (1983) Road Crashes at bridge sites - their nature and difficulties with their prediction. Institution of Engineers Australia, Queensland Division Technical Papers 24 (7), pp 11-18 (I.E. Aust. Brisbane).

Howie,D.J. and Ambrose,C. (1989) Pro-active Traffic Engineering Safety Study: Progress Report Part 2 - Right-turn-against crashes at traffic signals. (Monash University Accident Research Centre, Melbourne).

Howie,D.J. (1989) Pro-active Traffic Engineering Safety Study: Progress Report Part 3 - Crashes at Major/Minor Intersections. (Monash University Accident Research Centre, Melbourne).

Howie,D.J. (1988) Pro-active Traffic Engineering Safety Study: Progress Report, (Monash University Accident Research Centre, Melbourne).

Lau,M.Y-K. and May,A.D. (1989) Computer Intensive and Knowledge-Based Systems for Accident Surveillance and Improvement Studies. Paper to the American Society of Civil Engineers First International Conference on Applications of Advanced Technologies in Transportation Engineering, San Diego, CA. Feb. 5-8, 1989.

National Association of Australian State Road Authorities (1984) The NAASRA Road Study, 1984: Report on the Australian Road Network, Report R4, (NAASRA, Sydney).

Ogden,K.W. (1989) Pro-active Traffic Engineering Safety Study: Progress Report Part 4 - Crashes at Bridges and Culverts. (Monash University Accident Research Centre, Melbourne).

Sanderson,J.T., Cameron,M.H. and Fildes,B.N. (1985) Identification of Hazardous Road Locations: Final Report. RACV Consulting Services report for Office of Road Safety, Canberra, (ix) and 166p.

Searles,B. (1987) Roading, Road Safety and Transport in New Zealand. Summary Report. N.R.M.A. Publication, Sydney.

Zhou,H. and Layton,R.D. (1989) Development of a Prototype Expert System for Roadside Safety. Paper to the American Society of Civil Engineers First International Conference on Applications of Advanced Technologies in Transportation Engineering, San Diego, CA. Feb. 5-8, 1989.