METHODOLOGY OF AN IN-DEPTH ACCIDENT INVESTIGATION SURVEY

by

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ABSTRACT

The circumstances leading up to the occurrence of road accidents are so complex that a reliable assessment of accident causation can only be made with detailed knowledge of the many aspects of road environment, vehicle and road user which may have contributed to the accidents. This report describes in detail the techniques adopted for an On-the-Spot investigation into accident causation starting with attendance at the scene and ending with a full assessment of the contributing factors.

The organisation, staffing, investigating and analytical procedures used are described; difficulties encountered and possible improvements in technique are also discussed.

1. INTRODUCTION

Each year nearly 360,000 people are killed or injured on Britain's roads. Over the last 10 years there has been a check on the number of accidents due to the introduction of various safety measures e.g. introduction of the 70 mile/h limit, Road Safety Act 1967, but there are still over a quarter of a million accidents involving personal injury annually and also more than one and a half million accidents involving damage only. Accident investigation is carried out in many ways; the police collect data on a national basis pertaining to accidents involving death or personal injury and these data are collated on a standard form and computerised centrally to permit national statistical analyses. Regional and local surveys are conducted by highway authorities based normally on information supplied to the national system supplemented by additional on site information concerning traffic flows, speeds and movements. Other more specialised investigations are carried out by various organisations including universities and research bodies.

Road accidents are rarely caused by a single factor: they are usually the outcome of a combination of interacting components involving vehicle, road user and road environment; for a detailed understanding of accident 'causation' multi-disciplinary accident investigation in depth is therefore required. Past studies of this kind have tended to lack detail in one or more of the factors contributing to the accident; the project described in this report was undertaken to investigate in a comprehensive manner the contribution made by the vehicle, road user and road environment. The report outlines the methodology used: detailed procedures and basic analyses are described in related reports.

The principal objective of the survey was to identify the factors which contributed to accidents. The term contributory factor used here means something without which the accident was less likely to happen or at least to have been less serious. To investigate an accident in depth it was considered essential to visit the scene as soon as practical after the actual occurrence; an accident investigation team was formed who were
on call at all times to travel to the scene as soon as notified by the police of an accident. Following a pilot study carried out in 1968-95, a 4-year survey began in March 1970 operating in an area of South East Berkshire. The team attended over 2000 accidents within a radius of 20 km of the Laboratory. No constraint was placed on the type or time of an accident investigated; both injury and damage only accidents were investigated to the same depth as it was recognised that vastly differing patterns of injury or damage could result from similar causation factors.

2. OUTLINE OF SURVEY

On arrival at the scene a preliminary assessment of the situation was made, after which photographs were taken and extensive notes made about each vehicle, its damage and position, locations of any tyre marks, debris etc. and details were taken of the road and its layout together with other environmental features. A scale sketch-plan was also made. At a later date, and subject to their agreement, the road users involved were personally interviewed and other follow-up procedures were carried out as necessary.

2.1 Period of investigation

The investigation was carried out between 9 March 1970 and 28 February 1974;* it comprised 2130 accidents involving 3757 drivers, 3909 vehicles and 147 pedestrians and was divided into two consecutive phases (Table 1). This division enabled the first set of data to be finalised, the system for input, access and analysis of data to be developed and proved, and preliminary results on certain aspects to be obtained. Attendance at accidents was suspended during August of 1971, 72 and 73 during which time all members of the team took their main period of annual leave. With this exception the accident investigation officers were available 24 hours a day including weekends and public holidays (Table 1). There was no intentional change in the investigating techniques between the phases but the addition to the team at the end of phase 1 of an engineer specialising in automotive braking systems facilitated examination of the braking components of vehicles in much greater depth in phase 2.

2.2 Area of investigation

The selection of the area to be included in the investigation was governed by the requirement for the investigating officers to reach the scenes of accidents before much of the evidence had been disturbed. The area was mainly in South East Berkshire and covered approximately 240 sq km within a 20 km radius of the Laboratory (Fig 1). It also included two selected roads in Surrey. The area is largely rural but includes the urban areas of Windsor (population 31000 - 1971), Wokingham (population 21300 - 1971) and Bracknell (population 34000 - 1971). The main industrial areas are in Bracknell and to a lesser extent Wokingham. The basic area was that of 'D' division of Thames Valley Constabulary all of which was conveniently situated for easy access. However this area did not at that time include any motorway access or any trunk road. In order that accidents occurring on these types of roads could be included in the survey

*Until December 1973 the maximum speed limit was 70 mile/h in rural areas. In the last three months of the survey the speed limit on these roads was 50 mile/h – introduced as a fuel saving measure.
<table>
<thead>
<tr>
<th>Phase</th>
<th>Period of operation</th>
<th>Exclusions</th>
<th>Duration of survey</th>
<th>Total calls acted upon</th>
<th>Accidents investigated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0830-1700 (Monday-Friday)</td>
</tr>
<tr>
<td>1</td>
<td>9 March 1970 to 30 April 1972</td>
<td>August 71</td>
<td>25 months</td>
<td>1501</td>
<td>371 (32%)</td>
</tr>
<tr>
<td>2</td>
<td>1 May 1972 to 28 February 1974</td>
<td>August 72, 73</td>
<td>20 months</td>
<td>1324</td>
<td>285 (30%)</td>
</tr>
<tr>
<td>Total period</td>
<td>9 March 1970 to 28 February 1974</td>
<td>August 71, 72, 73</td>
<td>45 months</td>
<td>2825</td>
<td>656 (31%)</td>
</tr>
</tbody>
</table>
Table 2 shows approximate lengths of motorway, A and B class roads together with numbers of junctions with these roads within the survey area.

2.3 Accident Occurrence

During the period of the survey 2642 personal injury accidents and 3024 damage only accidents were known to have occurred within the area of operation excluding those occurring on the M3 and A30 in Surrey. Of these the team were informed of 1467 (55.5%) injury accidents and 609 (20%) damage only accidents. Together with those accidents from the Surrey area the team were notified of and acted upon 2825 incidents of which 2130 were accidents investigated in detail by the team. Reasons for not investigating the remaining 695 are given below.

The Road Traffic Act 1972 requires that “where an accident occurs owing to the presence of a motor vehicle on a road whereby personal injury is caused to a person other than the driver of that motor vehicle or damage is caused to a vehicle other than that motor vehicle, the driver shall stop and, if required by any person having reasonable grounds for so requiring give his name and address and also the name and address of the owner and registration marks of the vehicle”. Only if this requirement is not satisfied is there
any obligation to report the accident to the police. This accounts for the relatively large proportion of accidents not being reported to the team; the low notification rate is probably due, in the main, to the large number of accidents with little or no personal injury which are reported to the police later. Police involvement is naturally more pronounced where serious injury necessitates the attendance of one or more of the emergency services. Included in the 695 incidents not investigated were:

(i) damage only accidents where the police had been called but had discovered on arrival that the drivers had already conformed to the Road Traffic Act and neither participants nor police wished to prefer charges. In such cases the vehicles were often still in a mobile condition and had either been moved from the final rest position in the collision or actually left the scene before the arrival of the accident investigation team;

(ii) accidents involving pedestrians or pedal cyclists where the injured person had been transferred to hospital and the driver had left the scene to attend the police station and hence no evidence remained;

(iii) accidents reported when the team were already committed to attendance at another accident. In some cases it was possible for one investigator to proceed to the second accident thereby keeping losses due to this cause to a minimum;

(iv) late notification of an accident or late arrival of the investigators due to insufficient or incorrect detail of location being given in the initial report;

(v) false alarms with good intent or hoax calls to the emergency services.

3. ORGANISATION

3.1 Staffing

Experience gained from the pilot study in 1968 was extremely useful in the organisation of the full scale survey. The accident investigation unit included both full and part time staff. The full time members were:

3 accident investigating officers — although there was a change of personnel during the survey the maximum of three at any time was never exceeded
1 base liaison officer
1 vehicle examiner engaged on brake inspections — phase 2 only — a change of personnel during phase 2.

The part time members were:
1 systems analyst
4 interviewers
1 qualified doctor
1 clerical assistant
The full time members were drawn from the scientific staff of the Laboratory with the exception of the vehicle examiner who was a brake expert working under contract. Their disciplines included engineering, physics and mathematics, and they had a background of research in road safety subjects which included skidding, vehicle handling, surface characteristics, street lighting, heavy goods vehicles, crash barriers, road user characteristics and accident analysis. Some of the investigators undertook further training courses in high performance driving, heavy goods vehicle driving, forensic examination of tyres and first aid, specifically for the project. The high performance car and heavy goods vehicle driving courses contributed to the appreciation of problems associated with drivers of vehicles in these categories when faced with accident situations. The forensic examination course added much knowledge to the existing background of tyre and surface characteristic phenomena in that it provided a better facility to identify not only pre and post impact damage but also causes of tyre deflation and failures. In addition to technical ability certain basic qualities are essential for an investigator; the ability to make a rapid appraisal of the situation when arriving at an accident scene without becoming distracted or too emotionally involved is of prime importance. It is essential to communicate in a rational manner at the scene with members of the emergency services who themselves are working under pressure and with accident participants who may be shocked or distressed. This type of project necessitates working unsociable hours and hence the investigator must have a flexible approach in both domestic and social life.

Full coverage over the 24 hour day with two investigators on call at all times necessitated a rather demanding schedule, each investigator being on call for 24 hours a day for a period of 14 days followed by a 7 day period of normal office and social life. The attendance at accidents is shown in Table 1 to be biased heavily towards those occurring outside normal office hours. It was proved desirable to have two investigators at the scene on most occasions to ensure that the maximum use could be made of available time before the scene was changed appreciably.

3.2 Communication

The area of operation was such that the investigators could have up to 20 km to travel to the scene of an accident assuming they were already based at home or at the Laboratory and even further if they were committed elsewhere in the area. If the on-the-spot technique is to operate to maximum advantage it is essential that the investigator reaches the scene before it is appreciably disturbed. Although it was normal for two investigators to attend any accident they travelled to the scene in the majority of cases independently. This method avoided delay in despatch to the scene, facilitated greater flexibility particularly at night or outside normal office hours and enabled different approaches to be made to accident sites when it was anticipated that accessibility might present a problem. To ensure efficient working a reliable communication system between the investigators and base and also between the investigators themselves is an extremely important facility.

The originating source of information for reporting accidents to the team was the appropriate police authority who notified the Laboratory of reported accidents at any time of the day or night. The next primary link between base and the investigator is the normal telephone system; within the Laboratory a special line was kept solely for these calls and at the home of the investigator shared or party lines were avoided. The telephone is very restrictive if used as the sole link and an essential back-up is a radio-telephone system. For this survey a land-mobile radio-telephone system was set up with a
base station of 25 watt output, two frequency VHF operation, with the aerial system at about 130m. To operate the system remote controllers were installed at three locations ensuring communication potential throughout the day and night. Each investigation vehicle was equipped with a 5 watt transmitter receiver and a portable transmitter receiver was available if an extra vehicle was needed, or for use at a remote site. The system had provision for talk through between cars but this was a facility selected on request to the base station operator. During normal office hours the base station was manned by the base liaison officer and outside this period including weekends and public holidays by the security staff of the Laboratory. In general the reception was adequate throughout the investigation area. However the telephone and the radio telephone are only satisfactory if the investigator on call remains within audible range of either system, so a radio paging system was used as a back-up. The unit was a compact device fitting easily in the pocket and the paging call was initiated by dialling a 10 digit number on the standard telephone network. Each investigator was issued with a paging unit but as the name implies this facility served only to inform the investigator that he was required, the telephone or radio telephone was then used to complete the link (Fig 2) between the investigator and base. This complete system allowed more freedom of movement to the investigator both at home and the office as well as at the scene of an accident. On several occasions reports of accidents were passed directly to investigators at the scene of an accident by the police when such accidents had been notified via the police radio network. The team also encountered several accidents during their movements in the survey area.

3.3 Public liaison and confidentiality

Although no publicity was given to the project this did not appear to have any adverse effect on the cooperation received from the accident participants or others at the scene. The accident investigation vehicles were plainly marked and investigators and interviewers carried identification and authority documents. As will be seen from para 4.6.3, the response to the interview was also very good. The public were very willing to cooperate in the vast majority of cases; sometimes reluctance was expressed until the confidentiality of the project was explained and only a few cases met with a complete refusal. On many occasions during the survey, and subsequently, requests were received for a wide range of information pertaining to individual accidents and sites. The majority came from accident participants or their representatives. All requests for information were treated sympathetically but a strict code of practice was observed to ensure that the public need have no fears about the security of the information that they might entrust to the Laboratory. The investigators were not involved in court proceedings arising from any of the accidents investigated.

3.4 Accident Investigation Vehicles

Several different vehicles were used in the early days of the survey but it was eventually decided that an estate car offered several advantages over a saloon car for this type of work. The basic requirements are for a vehicle which is spacious enough for two investigators and occasional extra passengers and with ample space for equipment whilst providing some degree of protection against the environment for the equipment at the scene e.g. an estate car with a full top hinged rear door. The overall size of the vehicle should not be too large and good all round visibility ensuring manoeuvrability at the scene is of importance. The power/weight ratio should be fairly high to permit overtaking in safety en route to an accident. The vehicles finally used as regular accident investigation cars were two Vauxhall Victor 3300 cc estates and one Triumph 2.5 PI estate (Plates 1 and 2). These were supplied to police specification and as such, had
extra wiring for roof mounted lights, zips in the roof lining to permit fixing of roof light and radio aerial, high capacity battery, map reading light, high output alternator and auxiliary switch panel. To improve interior lighting fluorescent units were fitted over the luggage area and heavy duty sockets were fitted in the luggage area to power auxiliary mobile lighting. To compensate for heavy drain on batteries when auxiliary lighting is necessary for prolonged periods at the scene hand throttles were fitted. The vehicles were finished in white with "Transport and Road Research Laboratory ACCIDENT INVESTIGATION" displayed prominently in black lettering on each side of the vehicle. The only other external distinguishing feature was the roof mounted amber flashing beacon. Legislation does not permit the use of a flashing amber beacon on a mobile vehicle in these circumstances but it is of course of value as a hazard warning light at the accident scene.

3.5 Accident Investigation Equipment

To investigate an accident in quite considerable depth, no more than fairly basic equipment is required at the scene. The equipment carried in each investigation car, shown in Plate 1, comprised: traffic warning devices, auxiliary lighting, measuring apparatus including portable skid tester and tyre gauges, recording aids and data sheets, photographic equipment, protective and conspicuous clothing, first aid kit, tool kit, fire extinguisher.

4. INVESTIGATION PROCEDURE

On arrival at the scene of an accident a rapid appraisal of the situation is essential if efficient use is to be made of the time available to the investigator. Naturally if the investigator arrives at the scene before the police or other emergency services the priority must be to safeguard the accident scene and those involved in the accident rather than to proceed with any investigation. If however the situation is under control on arrival the order in which to undertake the various tasks is decided. Due to the urgency to open the road again to normal traffic photography is usually of high priority together with marking positions of vehicles, skid marks and other items which may assist in the final assessment as the scene can change very quickly. In general photography was not carried out whilst persons were still trapped in vehicles but if the vehicle needed to be moved to permit extrication of the occupants photography was proceeded with. To avoid confusion between impact and post impact damage when cutting away of vehicle bodywork has been necessary, this was carefully noted. The additional damage to a vehicle from this source and during vehicle recovery from difficult locations is often major. Tyre pressures also received early attention and were measured before recovery. A plan of the site is only of high priority if the positions of vehicles and other evidence have not been marked. However before any plan is attempted it is essential to ascertain if anyone at the scene knows of anything that has been disturbed since the time of impact. All items shown on the plan must be referenced back to fixed road features. Brief statements were taken from involved drivers only if they were not too seriously injured or shocked. An interview with witnesses often substantiated the driver's statement or provided a new lead if differing from that statement and was useful if no statement was readily available from the driver. Names and addresses were normally obtained from the police rather than duplicate effort in this direction.

While the initial appraisal at the scene of the accident was an important feature of the work a comprehensive set of information pertaining to each accident was also collected at the scene and this was supplemented by information from other sources for subsequent discussion by the team and eventual analysis. The hypotheses upon which the data selection were based were many and varied; they included:
(i) experience and knowledge gained from the 6-month preliminary study prior to the 4-year survey;
(ii) past experience in accident analysis and causation;
(iii) current research projects at TRRL for which information obtained in-depth could provide a useful source of data;
(iv) Government policy topics for which results from the survey could supply additional information to aid legislative decisions;
(v) questions designed to further knowledge on human factors in accidents such as interactions of alcohol with drugs or fatigue; perception etc.
(vi) data to provide a link with the national accident data system (Stats 19).

This information, associated with vehicle, road user and road environment was collated from the following sources.

4.1 Accident investigators at the scene of the accident

This was the primary source of information for the majority of the data collected on road environment and certain aspects of vehicle damage and defects.

Detailed proforma are given in the companion report. The forms contain mainly basic facts as follows:

Road environment and attendant circumstances: date and time; speed limit; location; light condition and road lighting; weather condition and state of road; surface texture; road curvature – horizontal and vertical; severity of accident; persons involved and injuries; plan of site indicating road layout, final position of vehicles, skid marks etc.

Vehicle factors: type; colour; condition; index of damage; details and defects related to tyres, brakes, steering and lights; loading conditions (commercial vehicles).

4.2 Additional examination of vehicles at garages after recovery

This is often necessary when conditions at the scene are such that insufficient time is available to examine all vehicles probably because of the need to clear the area and re-establish traffic flow or if on-site examination reveals a need for additional or confirmatory information.

4.3 Follow up visits to the accident site

Further useful information does occasionally come to light if extra visits are made to the scene although great care must be exercised to ensure that any fact accepted from such a visit is relevant to the accident under investigation. The primary reasons for a repeat visit are examination of accident site in daylight in the case of night accidents or to confirm visibility existing at the time of the accident. Driving through the site under similar environmental conditions will often highlight problems that could have been contributory to the accident even though the driver involved in the accident has not been knowingly aware of them.
4.4 Detailed examination of vehicle braking systems by a vehicle examiner

At the commencement of phase 2 an engineer having a wide knowledge of automobile braking systems was attached to the team. As a follow up procedure the engineer, whenever practical, examined in great detail the braking systems of cars and car derivatives involved in the accidents investigated by the team. These inspections were in general limited to vehicles not roadworthy after impact and excluded any vehicle which the police intended to have examined by their own examiner. In these cases the findings of the police examiner were accepted for inclusion in the TRRL investigation to supplement the information. In phase 2, 436 vehicles were the subject of detailed brake examination.

The examination, which took about 1½ hours to complete, included the level of fluid in the master cylinder reservoir, brake pedal and handbrake lever travel, adjustment, wear and condition of all linings and other friction surfaces and the condition of wheel cylinders. All other components, pipework and joints were examined for integrity, external leakage and damage. Samples of brake fluid were taken and were chemically analysed to ascertain the level of contamination from water, rubber, ferrous and non-ferrous metals and also compatibility of the fluid with the rest of the system was assessed.

4.5 Vehicle examination by a police vehicle examiner

When an accident involves fatal injury vehicles are invariably examined by a police vehicle examiner. These examinations are carried out in considerable depth and the team did not disturb the vehicle or components at the scene but relied on the police report where any areas of common interest existed.

4.6 Questionnaires completed with the cooperation of road users involved in accidents investigated by the team

In order to obtain road user information concerning such factors as driving experience, knowledge of the road used, alcohol or drug intake, as well as first hand details of events leading up to the accident, as many as possible of the drivers, riders and pedestrians were interviewed personally a short time after the accident using a standard questionnaire. This technique was developed in the early stages of the survey and introduced in January 1971.

4.6.1 Procedure Each road user was asked if he/she was agreeable to an interview taking place, whenever possible, in their own home. It was emphasised that all information disclosed in the interview would be treated in the strictest confidence. All interviews were entirely voluntary and a refusal to answer any question was respected. It was usual to wait a short while after the accident before attempting an interview to permit the completion of any police procedures; injured persons were normally interviewed after discharge from hospital. Road users living within a reasonable distance of the Laboratory were visited by one of the interviewers by prior appointment whenever possible. If contact proved difficult the interviewer would make several visits at various times and if this method failed, a letter was sent inviting the interviewee to contact the Laboratory to arrange a mutually acceptable appointment for either a visit or a telephone interview. In general interviews were conducted within a few weeks but if no contact was made within about 6 months the interview was abandoned.
When interviewing children or young persons under 15 years of age the parents were always invited to be present during the interview. This did not appear to inhibit the respondent and normally the parents would encourage the child to be truthful and cooperative. Children as young as 5 years were occasionally interviewed and responded well to a tactful approach by the interviewer.

The interview could be completed in about 20 minutes but frequently took longer as some respondents became more at ease often elaborating on many details.

4.6.2 Questionnaire format

Two separate questionnaires were used, one for drivers and riders and one for pedestrians. Only brief details of the accident together with the name and address of the respondent were given to the interviewer and the removal of this information after the completion of the interview ensured subsequent anonymity.

Driver Questionnaire

The first questions required the respondent to describe the accident and the events leading up to it and the majority of the remaining questions needed short factual or yes/no answers concerning detail of perception, knowledge of road and vehicle, fatigue, illness and alcohol. The respondent was also invited to give brief details of previous road traffic accidents and motoring type convictions.

Pedestrian Questionnaire

The opening questions took a similar form to that of the driver but subsequent questions included detail on their conspicuity, possible impairment of hearing, illness, fatigue and alcohol. Pedestrians were also invited to give details of previous involvement in road traffic accidents as a pedestrian and also a driver if applicable.

4.6.3 The response

In phase 1 of the survey 40% and phase 2, 83% of road users were interviewed (Table 3), the lower percentage in phase 1 being due solely to the delayed start of the interviewing procedure. There were only about 5% outright refusals to cooperate but some respondents needed reassurance to overcome concern regarding the confidentiality of the system. No contact was made in a number of cases because of:

(i) fatality involvement (see 4.9)
(ii) road users suffering injuries resulting in permanent loss of memory
(iii) driver not traced in hit and run accidents
(iv) no permanent address available
(v) no forwarding address available when changing residence
(vi) temporary visitor to Great Britain
(vii) language problems

Most respondents were quite forthcoming even in the detail concerning sensitive topics such as alcohol intake, previous accidents and motoring offences but occasionally some replies were obviously guarded and some exaggerated. Since the interviewers were given only brief information relating to the accident they were able to record the replies and reactions to the questions without any preconceived opinions of their own. All responses to the questions were recorded verbatim and when the assessment of reliability made by the interviewer was taken into account it was considered that in general the vast majority of the replies were truthful.
TABLE 3
Road user involvement in standard questionnaire

<table>
<thead>
<tr>
<th>Class of road user</th>
<th>Phase 1</th>
<th>Phase 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number interviewed</td>
<td>Total in class</td>
</tr>
<tr>
<td>Driver/rider</td>
<td>839</td>
<td>2049</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>18</td>
<td>83</td>
</tr>
<tr>
<td>Total</td>
<td>858</td>
<td>2132</td>
</tr>
</tbody>
</table>

4.6.4 The value of personal interviews  Postal questionnaires and personal interviews were considered as alternatives for obtaining road user information and the choice of the personal interview for accident investigation (including causation assessment) was considered a correct one. The high percentage of completed questionnaires and the personal assessment of the reliability of the respondent certainly outweigh the extra effort involved in conducting the personal interview. The manner in which the road user responded to certain questions often gave the team an insight into his/her attitude to driving, the law and life in general and this in turn helped in the difficult final assessment of the factors contributing to certain accidents.

4.6.5 The interviewer  Throughout the survey a team of fully qualified female interviewers were used. They were very experienced in dealing with all sections of the public, over 25 years of age and endowed with essential qualities of smart appearance, tact and perseverance. It was found that they were readily able to gain the confidence of the respondents and thus achieve a maximum response to the questionnaire.

4.7 Police accident records

Just before the final assessment of each accident, the information on the police records appropriate to the accident was compared with the information already collected.

4.8 Hospital injury records

Details of the severity of injury to those road users transferred to hospital from the scene were ascertained by medical staff attached to the team. Only brief details of injuries were recorded sufficient to categorise the accident. The classifications of injuries were - nothing abnormal discovered (NAD), ie mainly shock but not sufficient to warrant hospital treatment, minor, moderate, severe and fatal: these correspond roughly to AIS ratings 1, 1, 2, 3-5 and 6 respectively. (AIS is the internationally agreed Abbreviated Injury Scale.)

4.9 Attendance at Coroners' Courts

In accidents involving fatal injury a slightly different investigating procedure was adopted. At the scene the normal routine prevailed except that any interviews were kept to a minimum and vehicle
examination involving disturbance of any component was left to the police vehicle examiner. The personal
interview was omitted to avoid unnecessary distress to those involved. In an effort to obtain some of the
information lacking because of this change of procedure an investigating officer attended the inquest held
by the coroner though not taking part in the proceedings.

4.10 Photography

Although not intended primarily as a method of data collection photography was often useful to
confirm fact or establish detail inadvertently overlooked at the scene. Colour prints from colour negative
stock were adopted as standard, being easier to handle in discussion. Whenever possible overall views of
the accident scene (Plate 3) were taken together with views of individual vehicles (Plate 4) and where
appropriate views of individual components, road scenes and street furniture. With the limited time
available at the scene it was found most convenient to use hand held camera and flash equipment. This
method was found to suffice for most occasions but with night accidents the overall accident scene or other
long distance views were not possible.

4.11 Photographic survey

In addition to on-site photography by the accident team aerial photography was carried out at selected
sites in an effort to identify possible problems associated with road layout in plan form. Plate 5 shows an
example of a T junction between a single carriageway unclassified road and a dual carriageway A class road.
For aerial photography to be useful it was necessary to use it in conjunction with views taken at ground level.

At the end of the investigation a driver’s-view survey was carried out of all A and B class roads and
motorway in the investigation area together with certain unclassified roads of interest. This survey used a
system of 35 mm colour photography with a vehicle-mounted camera situated at driver eye height and
correctly positioned transversely in the vehicle to agree with normal driving position. Individual frames of
film were taken at the rate of 100 or 200 per mile over the selected lengths of road in the area in both
directions of travel. Plate 6 shows a sequence of six consecutive shots of a junction approach. This facility is
useful as an aid in identifying problems associated with visibility, road layout and road signing.

5. ASSESSMENT OF ACCIDENTS

When all available information relative to each accident was to hand, the accident was discussed by the team
in great detail taking the form of a verbal reconstruction. The type of evidence fell into 3 categories:

1. factual evidence obtained by observation eg date, time, class and character of road including
   layout and speed limit, weather and lighting conditions, class of road user involved, number
   and types of vehicles and the damage sustained by them, roadside evidence including damage
   to property, etc

2. evidence based on interview eg driving experience, familiarity with road scene and vehicle,
   distance from home and length of driving time, impairment features such as alcohol, drugs,
   fatigue etc, wearing of seat belt or crash helmet; in addition the road user’s own version of
   events leading up to the accident helped in the verbal reconstruction

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(3) the evidence of assessment of errors made by the road user, of defects in the vehicle and of adverse features of road environment; the allotment of responsibility for the accidents to the different features of road user, road environment and vehicle.

It is important to recognise these three levels because the reliability of evidence varies between them. Recording of factual evidence by observation is subject to little error. Evidence based on interview is less reliable in that it depends on the memory, honesty and reliability of the interviewee; an experienced interviewer however can usually assess whether or not the respondent is telling the truth. The third level, the assessment, is open to subjective error. Different investigators with different or even similar backgrounds might well make different assignments of responsibility. It is often not possible to state categorically that the accident would not have occurred or that it would have been less severe if the contributory factor had not been present: the decision may be qualified by some degree of doubt and so the importance of a contributory factor in any one accident, based on available evidence, may be partly a matter of opinion. Nevertheless this is not as serious a problem as might appear at first sight, given that the investigators recognise the multiplicity of factors which may play a part and that where there is insufficient evidence to make a decision this is duly recorded. The experience gained from the pilot survey enabled the site observations and the interview questionnaires to be designed to obtain the most suitable information for use in this final assessment and to eliminate as many uncertainties as possible.

The team made every effort to maintain a uniform standard of assessment throughout the survey although this was difficult to achieve with interchange of staff especially in the case of full time members; however detailed analysis has shown that results for the two phases of the survey were largely in accord. The conclusions reached by the team were independent of police findings and the confidential information given in the course of the personal interviews with road users could sometimes be at variance in some aspects with that obtained by the police.

6. ANALYTICAL PROCEDURE

The team had access to an ICL 4-70 Computer, and although an edge punched card system was experimented with in an attempt to simplify procedures, it was found necessary to make use of the computer to handle the amount of data available.

6.1 Preparation of data

A standard form was devised to collate all the detail on the road environment, the vehicle, the road user and the contributory factors as assessed by the team. Limitations of size of the computer made it necessary to restrict the numbers of drivers/vehicles and pedestrians which could be reported upon in detail; this limit was set at 3 drivers/vehicles and 1 pedestrian since few accidents exceeded these limits. Where more drivers or pedestrians were involved the total number was recorded and details of the 3 primary vehicles and the most seriously injured pedestrian selected. In total up to 400 items of information might be recorded for each of the 2130 accidents investigated. All computer runs to handle the data were carried out within limits of 150k bytes of core store and 10 minutes elapsed time.

The detail of layout of the form, together with a glossary of terms is given in a companion report.

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6.2 The use of the computer

The accident data were transferred from the coded sheets into the computer bank. FORTRAN programs were written to manipulate the information and the flexibility of this system enabled a very varied programme of analysis to be carried out. The standard tabular output is shown in Table 4—5, (summary of data in phase 1 of the survey). Table 4 summarises factual data related to the accident:- road features, vehicle movements, severity of injury, ages of road users, date and time, severity of accident, and assessment of contributory road environment factors. Table 5 summarises data related to the driver, his actions, the vehicle and the pedestrian. In addition to the tabular output, (one scan of the data file could output up to 30 different tabulations), it was possible to carry out statistical tests and locational analysis for identification of high risk areas.

From these lists the program allows up to 10 factors to be selected to give detailed breakdowns for analysis and indication of interacting factors. An example of the way in which the data bank may be interrogated, selecting 3 factors only, follows. The question asked is "How many accidents occurred in daylight during Phase 1 of the survey involving lack of care on the part of at least one car driver".

It is necessary to make logical requests for information involving the use of 3 operators AND, OR and NOT in the select statement (in this example AND is used). A syntactically correct selection statement will produce a result but if the logic of the statement is muddled the table will not be the information which is required; it is important that care is taken at this stage to define questions correctly. Three standard tables, restricted to the accidents fulfilling all three factors, are produced in answer to the questions posed above.

The first, similar to Table 4, lists the different factors requested and summarises the road and environmental information for all accidents satisfying the required criteria. The table also gives the relevant accident reference numbers providing the total number of accidents is not greater than 300. The limit was set at 300 since it would not be practical to extract further information from the individual files by hand searching large numbers of files. A total of 214 accidents met the requirements of the original question.

The second table, similar to Table 5, summarises driver factors, driver actions, vehicle and pedestrian details relating to every driver and vehicle involved in the 214 accidents, in other words this table gives a summary of everyone involved in 214 accidents in each of which at least one driver 'lacked care' and was in a car.

The third table is similar in layout to the second but omits the pedestrian detail and summarises only the information relating to the individual drivers satisfying the criteria of the original question (ie. car drivers with a 'lack of care' feature). So now there is a complete record concerning the accidents meeting the requirements of the question.

By studying the print-outs in detail many avenues of further investigation into other factors associated with accidents of this type may be revealed. This method of producing results has enabled many questions concerning the survey's data to be answered without any delay — a series of tables of basic features and some involving interacting features can cover a very wide range of information. Other methods of obtaining results rely on suitable questions being asked of the data in the first instance suggesting that the questioner knows what to look for or that the answers are already known and the data merely being used for confirmation only. There is no doubt that the method of handling information from this survey is conducive to in-depth research and has allowed many interacting features to come to light and be studied for the first time.
### Table 4: SUMMARY OF DATA FROM WHOLE SURVEY: PHASE 1 — ROAD AND ENVIRONMENT DETAIL

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<tr>
<th>ON THE SPOT ACCIDENT DATA</th>
<th>PHASE 1 9/3/70w30/4/72</th>
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7. RESULTS

Detailed results of the survey are being reported elsewhere: a number of analyses have already been published and others are well in hand.

General results

1. A descriptive paper of the Survey highlighting the interacting roles of the road environment, vehicle and road user has already been published. It discusses the relative importance of the different contributory factors in broad terms.

2. Basic statistical analyses comparing the depth investigations with the national statistics and presenting detailed tabulations of contributory causation factors and their interactions are reported in a companion report to the present one.

The Road User

3. A detailed analysis of the role of alcohol and other impairment features has been prepared and published. The paper deals with this one aspect of the contribution to accidents made by the driver, namely his fitness to drive.

4. Analysis is well in hand on the overall subject of errors and actions by the driver in the accidents studied. The report will discuss the part played in accidents by the driver by his actions and shortcomings and show how different errors lead to different kinds of accident situations. The complex interaction of the driver with the environment and his vehicle is also discussed.

5. The differences observed between male and female car drivers was the subject of another report recently completed. This showed that although the 2 sexes were at fault in approximately the same proportions of accidents, the types of errors committed and the kind of accidents they were involved in were quite different.

6. The vulnerable road users i.e. pedestrians, cyclists and motorcyclists, are the subject of an analysis in hand at this time.

The Road Environment

7. Analysis of the road environment factors is planned to look at intersections, manoeuvre conflicts, misleading layout, road surface conditions and other allied matters.

8. A note of the visual features of the road situation (i.e. obstructions etc) and other environmental features is planned.

9. Progress is being made on analysis of sites where accidents tended to cluster (black spots); the sites are described in detail and suggestions for possible remedial measures are discussed.
The Vehicle

10. A paper concerning brake defects in cars based on the analysis of the detailed brake examinations carried out in Phase 2 of the Survey was presented to the Institution of Mechanical Engineers in March 1976. It discusses the number and types of defects present in the vehicles inspected and their effect on handling and safety\textsuperscript{10}.

11. A paper on the different aspects of vehicle loss of control in accidents was presented to the same I.M.E. Conference as the above paper on brake defects\textsuperscript{11}.

12. Analysis has been done on the part played in accidents by the colour and conspicuity of vehicles. A leaflet is available\textsuperscript{12}.

8. DISCUSSION

A multi-disciplinary depth investigation undertaken specifically to increase understanding of how and why accidents occur and to assess the relative importance of different contributory factors has both advantages and disadvantages.

8.1 Limitation of technique

The levels of reliability into which evidence fell for each accident was discussed earlier (Section 5) for without any doubt the most important limitation was the subjectiveness of the assessment of contributing factors especially in terms of the road user. Researchers vary in their acceptance of the assessment of contributory factors but with an awareness of the many facets of road safety and the benefits of earlier studies the team were confident in their ability to assess correctly the major contributory factors in the accidents studied. Where there was insufficient evidence for an assessment this was clearly stated. It is interesting to compare the results of this in-depth survey with those of an American study\textsuperscript{13}. Despite differences in methodology, environment, vehicles, legislation etc the levels to which the various features contributed to accidents were very similar.

It could be argued that every item known about the accident played a part but this present study chose to adopt a higher level of causal factors. On the human side the factors chosen to be contributory were those regarded as necessary for a driver to perform in order to complete successfully the driving task at that time. In addition, factors concerning the driver’s fitness to drive (impairment) were taken into consideration and from all the available evidence a judgement was made as to whether or not this also played a part. The same approach was adopted for pedestrians. Some difficulties were experienced with the vehicle factors; preliminary analysis of Phase 1 suggested vehicle factors contributed to more than 20 per cent of accidents but a reappraisal of vehicle characteristics made it clear that a more precise distinction was necessary between defects which were merely present and those which almost certainly contributed to the accident. With the exception of the special brake examinations in Phase 2 the vehicle inspections were largely carried out in situ at the accident scene. Needless to say the circumstances were far from ideal and there was often pressure brought to bear for vehicle recovery and for the re-opening of the road to normal traffic; consequently it was only possible to examine the vehicle for obvious defects to the major components such as brakes, tyres, steering, lights etc. Care was required to distinguish between pre-impact damage, impact damage and recovery damage. The special brake examinations, by their very nature, accounted for a substantial increase in the number of brake defects noted (in the 2nd phase) but there was no corresponding increase in the assessment of contributory brake defects.
The factors concerning the road environment were not as subjective as those in the other two categories since it was possible to see or measure misleading situations or deficiencies in the road system etc and so by recording factual evidence a judgement could be made as to the likelihood of these factors playing a part in the accident.

Initially the Survey was divided into 2 phases to enable a system for analysis to be developed and preliminary results to be studied; a by-product of this division was the ability to compare the two phases for continuity and to ensure that the methodology of investigation had not changed with time and changes in personnel. The similarity of the 2 phases with regard to assessment of contributory factors showed there was such a continuity.

In-depth accident investigation on the scale described in this report can only be carried out in relatively small areas mainly because of the impracticability of travelling long distances to the scenes of accidents. The operational costs are relatively high. It was calculated that the cost of each accident attended in the survey was between £75 - £100; this included the purchase of all the hardware (vehicles, radio installation and maintenance, equipment etc) as well as the staff costs and overheads.

8.2 Advantages of an in-depth approach to accidents

Accident analysis can cover a wide range of levels from the broad perspective of the national scene, through regional studies to the very detailed study of single accidents by attendance at the scene which is the ultimate in local depth investigation. Any system of accident analysis using the national data whether for the whole of Great Britain or for smaller local areas is obviously limited by the items recorded on the Stats 19 form — this in turn is limited to accidents involving personal-injury only.

The overwhelming advantage of the in-depth approach in localised areas is its unique ability to collect minute details of importance from the scene and persons involved and so build up a very detailed picture of the pre-crash situation, the accident itself and the post-crash scene. The personal contact with the road users is extremely valuable since far more information can be obtained this way regarding experience, actions, and attitudes of mind than could ever be obtained by, say, reading the statements made to the police. The strict confidentiality encouraged the road users to divulge information to TRRL which might not have been mentioned to the police, eg. impairment.

Both injury and non-injury accidents can be studied by this technique — it was shown that the pattern of accidents was similar in both instances.

An important outcome was the assessment of the contributory roles of the road user, the road environment and the vehicle and their interactions. The technique of analysis adopted allowed for many interactions between the different features to be investigated for the first time; this in turn led to “hidden” interactions which by any other method could have been unnoticed.

It is not possible to research into the finer points of accident causation except by this method of approach and a far better understanding of how and why accidents happen has resulted from this project.
8.3 Technique changes in the light of experience

The ideal situation for any scientific project involves sufficient time for careful planning of the whole scheme before it ever begins — special attention to complete data collection and an analysis procedure are also required. In practice the ideal is rarely achieved and often information is requested concerning details which were not obtained at the time but easily could have been with forethought.

The early difficulties experienced in recording vehicle defects emphasised the very real need for a clear understanding of exactly how to record the data, how the results were to be presented and just what was required of them.

There are always difficulties when dealing with factors on two levels, ie.

(i) factors unique to the accident such as day of week, time, weather, road/environment details etc and designated ‘accident features’

(ii) factors relating to individual drivers and their vehicles within the one accident.

It is possible to have for example; one accident, two drivers, three vehicles (one parked) and it is easy to forget that the number of drivers is not necessarily the same as the number of vehicles. The method of analysis adopted for the survey (6.2) coped with both levels but care was needed in interpretation and it was obvious that all the terms used in analysis needed to be closely defined.

During detailed analysis of the data it became clear that insufficient note had been made of information which could be described as ‘control data’. For instance the photo-logging system described in 4.11 would have been an excellent way of monitoring the roads in the area for changes in layout and design had such a technique been available from the start. Such monitoring every 6 months or so throughout the survey on the major roads would have answered many queries on the system changes in addition to identifying problems associated with visibility, layout etc from the drivers’ point of view. Regular traffic flow figures, including composition of traffic, at key points on major roads in the area would also have been very useful. Some system of being kept informed of road-works, road changes etc by the local County Authorities is worth pursuing in any future investigation. Annual checks in the Survey area for such data as colour, makes, models of vehicles, seat belt usage, sex of driver, and so on could also prove useful.

One criticism levelled at any interpretation of the data is that there is no comparison with non-accident data. It is not easy to define a non-accident but if the accident data can be allied to control data of some kind its validity is more easily accepted. The data can also be compared with the National situation establishing how representative a sample one has bearing in mind the characteristics of the survey area (eg urban, rural, industrial, seasonal traffic fluctuations etc).

In the light of this experience a few minor changes would be desirable in any future survey. The schedule followed by the site investigators was extremely demanding and for a project on this scale a minimum of 4 investigators is essential. Minor changes in the paperwork would ease the transition of the data into the computer bank. Many enquiries relating to photographs and plans were received from the road users or their representatives both during the survey (3.3) and for at least 2 years afterwards so it is very important to document carefully all such requests noting exactly what information has been released.
9. CONCLUSIONS

The survey described in detail in this Report was set up to investigate accident causation in-depth — in particular its object was to study the contribution to accidents made by the traditional trichotomy, the road user, the road environment, the vehicle and their interactions one with another. The size and depth of the investigation have resulted in a unique collection of data which has already been used to give information for policy formation and other research both within and beyond the Department. This dissemination of information is a valuable adjunct to the primary objective of increasing the understanding of accident causation.

The various methods of accident analysis using the data based on police reports of injury accidents have advantages and disadvantages; a very large data-bank exists covering many years so that trends and overall before-and-after effects of legislation can be studied on a national basis. On the other hand information is limited to basic facts concerning the casualties and vehicles; it is not possible to ascertain contributory factors directly relating either to the road environment or to the road user. Certain facts are recorded concerning vehicle defects but again it is impossible to judge if any recorded defect played a part in the accident.

The most important outcome of the On-the-Spot Accident Survey was this assessment of the contributory factors — research into the finer points of accident causation cannot be carried out effectively without a multi-disciplinary approach. This survey has shown that even with the limited manpower available it was possible to carry out a highly successful investigation into accident causation.

Although only a limited area can be covered, the results can be compared in part with national accident figures and their representativeness determined. It would be possible to set up similar surveys in different areas of the country to study particular problems pertaining to that area and the detailed information obtained together with local knowledge could make an important contribution to remedial measures for the accident situation.

A more readily applicable approach however would be for some aspects of these on-the-spot investigations to be adopted by the Local Authority Accident Investigation Units. Retrospective on-site investigation which includes examination of the road scene, traffic flow and composition, already forms part of the engineer's procedure: it might be possible to extend this work to include interviews with drivers involved in accidents, or observations by driving through the site to identify adverse features in road design.

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The support team included:

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11. REFERENCES


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Fig. 1 MAP OF ACCIDENT INVESTIGATION AREA
Accident

Police

TRRL

Investigator at office or home

Investigator at accident or telephone contact not possible

Investigator mobile

Telephone

Pager

Radio telephone

Accident investigator

Accident

Fig. 2 COMMUNICATION SYSTEM
Plate 3 THE ACCIDENT SCENE
Plate 5 AERIAL PHOTOGRAPH OF ACCIDENT SITE
Plate 6 APPROACH TO JUNCTION FROM PHOTOGRAPHIC SURVEY
ABSTRACT

Methodology of an in-depth accident investigation survey: G C STAUGHTON, C Eng MIMechE and VALERIE J STORIE: Department of the Environment Department of Transport, TRRL Laboratory Report 762: Crowthorne, 1977 (Transport and Road Research Laboratory). The circumstances leading up to the occurrence of road accidents are so complex that a reliable assessment of accident causation can only be made with detailed knowledge of the many aspects of road environment, vehicle and road user which may have contributed to the accidents. This report describes in detail the techniques adopted for an On-the-Spot investigation into accident causation starting with attendance at the scene and ending with a full assessment of the contributing factors.

The organisation, staffing, investigating and analytical procedures used are described; difficulties encountered and possible improvements in technique are also discussed.

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