

The Adelaide Metropolitan Indepth Crash Investigation Study 2002-2005

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ABSTRACT

The Centre for Automotive Safety Research (and the Road Accident Research Unit before it) has a long history of conducting indepth crash investigation dating back to the 1970s. Investigators monitor ambulance radio frequencies and drive to the scenes of road crashes at the same time as ambulances are dispatched. At the crash scene, extensive data is collected, sufficient to reconstruct the circumstances and consequences of the crash. The data include: skid marks, the final positions of the crashed vehicles, damage to the vehicles, and road conditions. An engineering survey is made of the site noting the road geometry and other relevant features. CASR interviews people involved in the crash and any witnesses at length. Each case is reviewed in detail by a multidisciplinary team to determine factors contributing to the causation of the crash and the cause of injuries sustained by those involved. In some cases this involves computer aided crash reconstruction. During 2002 to 2005, approximately 300 crashes were investigated in the Adelaide Metropolitan Area. This paper outlines the data collection activity and provides some examples of how that data has been used.

INTRODUCTION

The Centre for Automotive Safety Research (CASR) (formerly the Road Accident Research Unit), at the University of Adelaide, has been attending crash scenes and collecting data as part of various studies since the 1970s. Why the need to do this? There is considerable data on crashes in databases maintained by the police, hospitals, insurance agencies and road authorities but in many ways the data has significant shortcomings from a research perspective. These include the limited amount and type of variables recorded on each crash and frequently do not contain enough information to confidently predict crash and injury causation. The most telling characteristic of the police report database is the fact that nearly 50 per cent of driver error is attributed to inattention. Similar discrepancies also arise when considering the under reporting of the contribution of speed to a crash. Even specific crash type investigations become problematic due to the way crashes are coded. An example of this includes rollover crashes which may also be recorded as “left road out of control” or “hit fixed object” type crashes. With injury investigations, restraint usage, seating position and airbag deployment are difficult to ascertain from routine crash data. In most cases, no information is recorded on uninjured participants in a crash.

By visiting the crash scene soon after the crash, relevant information can be gathered in relation to the circumstances surrounding the collision, injury mechanisms and likely contributing factors. Many of the benefits of indepth crash investigation were summarised in the paper by McLean (2005). A very good example of the value of such studies was the finding in the early 1950s that led to vehicle door latches being modified to reduce the risk of doors opening in a crash, thus greatly reducing the risk of occupants being ejected.

At-scene investigation enables the collection of physical evidence prior to its loss or movement and comments by witnesses and crash participants can be obtained and interpreted in the context of conditions immediately following the crash. Specifically:

- The location of skid and other marks and debris can be recorded, together with the final resting positions of vehicles
- The nature and extent of vehicle damage due to the crash can be separated from damage caused in retrieval of the crashed vehicle
- The environmental conditions at the time of the crash can be noted
- The accuracy of information obtained at later stages from crash participants and any witness can be verified, or otherwise, by the investigators who attended the crash

Tyre marks can be difficult to detect and attendance soon after the crash increases the likelihood that such marks will be noticed. It is not uncommon in pedestrian crashes for vehicles incurring minor damage to be taken home and washed thus removing any scuffing marks in the surface road grime

deposited on the bodywork which provide a record of contacts between the pedestrian and the vehicle. Pressure to re-open the crash site and get traffic flowing often means that much of the physical evidence is lost. Debris may be swept up, vehicles relocated or towed away and struck objects altered to make the site safe or removed altogether. Valuable data can be obtained if the investigators arrive at the scene prior to all this happening. In addition, weather conditions such as rain may also deteriorate evidence with time. There is also a high likelihood of making initial contact with witnesses and crash participants at the scene of the crash which in itself increases the chances of participation in follow-up interviews.

This paper demonstrates the way in which CASR conducts indepth crash investigations and presents the findings to the Department of Transport, Energy and Infrastructure (DTEI), the Motor Accident Commission (MAC) and Local Government to influence engineering practices and government policy. A regular forum is held with DTEI engineers to discuss safety related matters in the State road network.

The indepth work also supports other activities conducted by CASR such as the development of pedestrian impact simulation models. Speed reconstruction from indepth investigations was also the basis for the well known studies quantifying the link between travelling speed and crash risk in metropolitan and rural areas (Kloeden et al, 1997; and Kloeden et al, 2001).

METHOD

The criteria for the inclusion of a crash in the study were:

- The crash occurred in the Adelaide metropolitan area (nominally within 10 km from the CASR offices on Frome Road in the city)
- The crash involved at least one person who was injured severely enough to be transported by ambulance to hospital for treatment or was fatally injured

The sample was not intended to be representative of all crashes in the Metropolitan area. Crashes were generally attended during weekday business hours in daylight conditions, however, there were some exceptions to this and some night time pedestrian crashes were also attended. The implications of this are that caution has to be exercised in making generalisations from the investigated cases to the broader road safety situation.

CASR has crash investigation teams made up of engineers, psychologists and health professionals who travel to the crash scene once notified about the event on the ambulance radio or ambulance pager. The sequence of events for a crash investigation is as follows:

- Notification of the crash on the Ambulance service radio or pager
- Attend the crash at-scene
- Photograph the scene and involved vehicles
- Discussions with police attending the crash
- Mark the positions of the vehicles and any skid or gouge marks
- Brief introduction and discussion with participants and witnesses at-scene (where appropriate)
- Examine the vehicle(s) at the scene and/or elsewhere
- Record video footage of the site from a driver's perspective

Follow-up investigations include:

- Obtain the police report on the crash
- Obtain injury information from hospitals
- Conduct a detailed interview with consenting crash participants and witnesses
- Review site design and crash history of the site
- Review crash history of the drivers
- Review coroners file where appropriate
- Computer aided crash reconstruction where relevant and practicable
- Perform a multidisciplinary case review

Following the crash, an engineering survey is made of the site to record road geometry, the location of roadside objects and any other relevant information such as line marking and vegetation. Engineering

drawings of the road section are also obtained from the responsible road authority. Sites may also be revisited for more detailed follow-up survey work or reassessment from a road engineering perspective.

Follow up inspections are made of the involved vehicles as needed to gather any missing information or reconfirm crash injury mechanisms. The data collected for each vehicle includes:

- Photographic record of the vehicle, including detailed photos of any visible damage and evidence of occupant (or pedestrian) contact
- Recording of VIN (Vehicle Identification Number) and current registration details
- Inspection of tyres: dimensions, tread and pressure
- Inspection of seatbelts for condition and load marks
- Measurement of deformation
- Inspection for window tinting and any vehicle modifications

Follow up personal interviews are conducted whenever possible with those involved in the crash and any witnesses. The information sought during these interviews includes:

- Personal details (age, sex and, where relevant, height and weight)
- Driving experience, moving violation and crash history
- Familiarity with the vehicle driven in the crash
- Trip details
- Possible distractions
- Alcohol and drug use, if any, prior to the crash
- Emotional and fatigue factors
- Pre-existing medical and physical disabilities
- Perception of the crash and its contributing factors
- Immediate injuries and resultant disabilities
- Clarification of vehicle/pedestrian movements, positions and the crash sequence

Data on injuries is obtained from hospital records. Police accident reports are obtained to provide information about the crash as reported to, and deduced by, the police. Where appropriate, coroners files are also examined to check consistency of findings or shed further light with previously unobtainable evidence. These contain full reports from the Police Major Crash Investigation Unit, autopsy and toxicology reports together with information on any medical issues that may have existed with the deceased individual.

When all the evidence has been collected, a review is conducted of each case by a multidisciplinary group of CASR staff and factors which contributed to the causation of the crash and the resulting injuries are established.

The methodology is strongly influenced by ethical considerations and much importance is placed on the independence of CASR as an organisation and the confidentiality of voluntary witness and participant statements. CASR has maintained a privileged position in the State and has thus far had frequent access to information from Government departments in relation to crash investigations. Should access to this information be altered, the ability to take key contributing factors into account for investigated crashes will be compromised.

RESULTS

A total of 301 crashes were investigated from April 2002 to October 2005. Cases were mostly rejected on the grounds of insufficient evidence, inappropriateness (in cases with significant emotional trauma), or the fact that ambulance transport was not required. Table 1 shows the cases by the most severe outcome in the crash.

Table 1 - Summary of Crashes by Most Severe Outcome

Crash Severity	Number	Percent
Fatal	22	7.3
Hospital Admission	90	29.9
Hospital Treated	189	62.8

Total	301	100
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Rather than describing a detailed profile of the database, the following instead demonstrates how some of the information collected has been used.

Right turn “pedestrian” conflict

A case investigated involved the collision of a right turning car with a motorised wheelchair (also known as a gopher or scooter) crossing at a signalised T-junction. A plan of the site, which has a slightly unusual geometry, is shown in Figure 1.

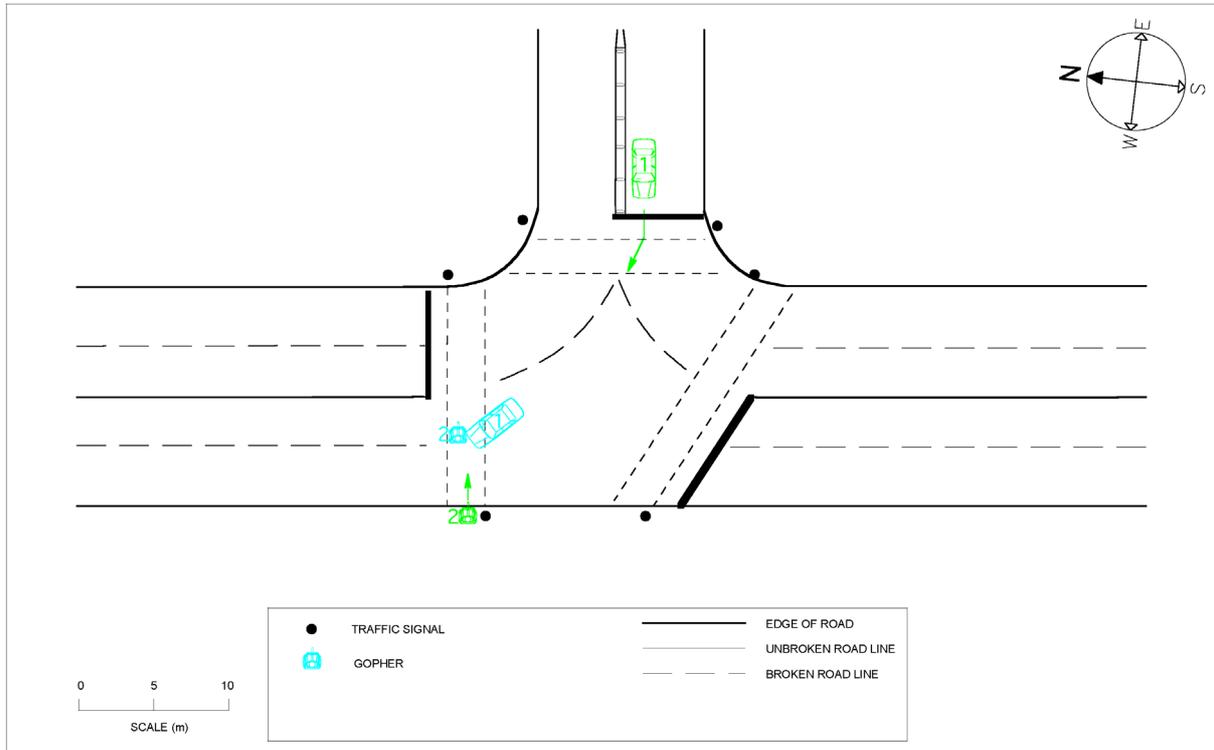


Figure 1 – Site plan showing the movements of the right turning vehicle and the gopher

The view of the junction from the perspective of the driver of the vehicle is shown in Figure 2. Some modifications have been made to the right signal pole in the figure. A right turn arrow signal has been installed in addition to a “Right Turn Give Way to Pedestrians” warning sign and a flashing white signal warning motorists of pedestrians. Clearly these were attempts to address major issues with right turning vehicles interacting with pedestrians at the pedestrian crossing.



Figure 2 – Perspective of right turning driver and close up of the right signal pole

The phasing of the signals is such that when traffic from the side street is given a green light (in the form of a green orb), pedestrians are also shown the green walk signal. However, right turning vehicles are also shown a single red turn arrow which extinguishes a few seconds after the pedestrian walk signal is given. On this occasion, a vehicle pulled out of the side street to turn right and struck the gopher which had entered the pedestrian crossing, as shown in Figure 1. The gopher driver sustained contusions and abrasions to the right elbow and leg, and an abrasion to the left side of the chest and was taken to hospital for treatment.

CASR observations at the site revealed that turning through the red arrow was a common occurrence and motorists who stop for red arrows are often abused by following drivers for not proceeding. Discussions with local business owners indicated that this type of incident was commonplace.

Interrogation of the Traffic Accident Reporting Systems (TARS) containing police reports on previous collisions at this intersection revealed that there had been 11 reported pedestrian accidents dating back to 1996 involving similar circumstances. Table 2 outlines the time of year and time of day that these accidents occurred. It became evident that these cases were clustered in the mid-afternoon periods from May to August. Further site investigations revealed that at this time the sun was directly aligned with the car driver's view of the right turn arrow signal and pedestrian warning light, and any pedestrian using the crossing.

Given the presence of sun glare, the common misinterpretation of the right turn signal and the fact that pedestrians on the crossing cannot be seen by drivers in such circumstances, a totally different solution is required. It appears that a dedicated pedestrian crossing phase should be introduced (commonly referred to as a "Barne's Dance" or "scramble" crossing). That would cause some additional delay to motorists but would have the advantage of separating simultaneous conflicting movements of pedestrians and vehicles.

Table 2 – Similar pedestrian crashes at the T-junction in the last decade

Year	Month	Time	Severity
1996	14 August	3:00 pm	Doctor
1997	18 June	3:50 pm	Doctor
1998	16 May	3:45 pm	Treated
1998	29 May	3:15 pm	Treated
1999	10 May	3:30 pm	Treated
1999	21 May	3:45 pm	Admitted
1999	14 June	3:10 pm	Treated
2000	1 May	4:00 pm	Admitted

2000	31 July	3:30 pm	Doctor
2001	17 April	11:20 am	Doctor
2002	6 May	3:00 pm	Treated

Right turn crashes in congested traffic

A major three lane arterial road in Adelaide frequently encounters congestion and queuing traffic at peak times. Two cases investigated by CASR have involved vehicles turning across gaps in these queues to access side streets. Follow up interviews indicated that in each case the turning drivers were waved through by other drivers stationary in the queue. A site diagram for one of the crashes is shown in Figure 3.

Following one of the crashes, the driver of the turning vehicle suffered some pain in the spine, hip and thigh; the passenger in the same vehicle struck his head on the side window and was still unable to work six weeks after the crash. In the other crash, the driver of the through vehicle complained of neck and back pain and was transported to hospital but released after seven hours.

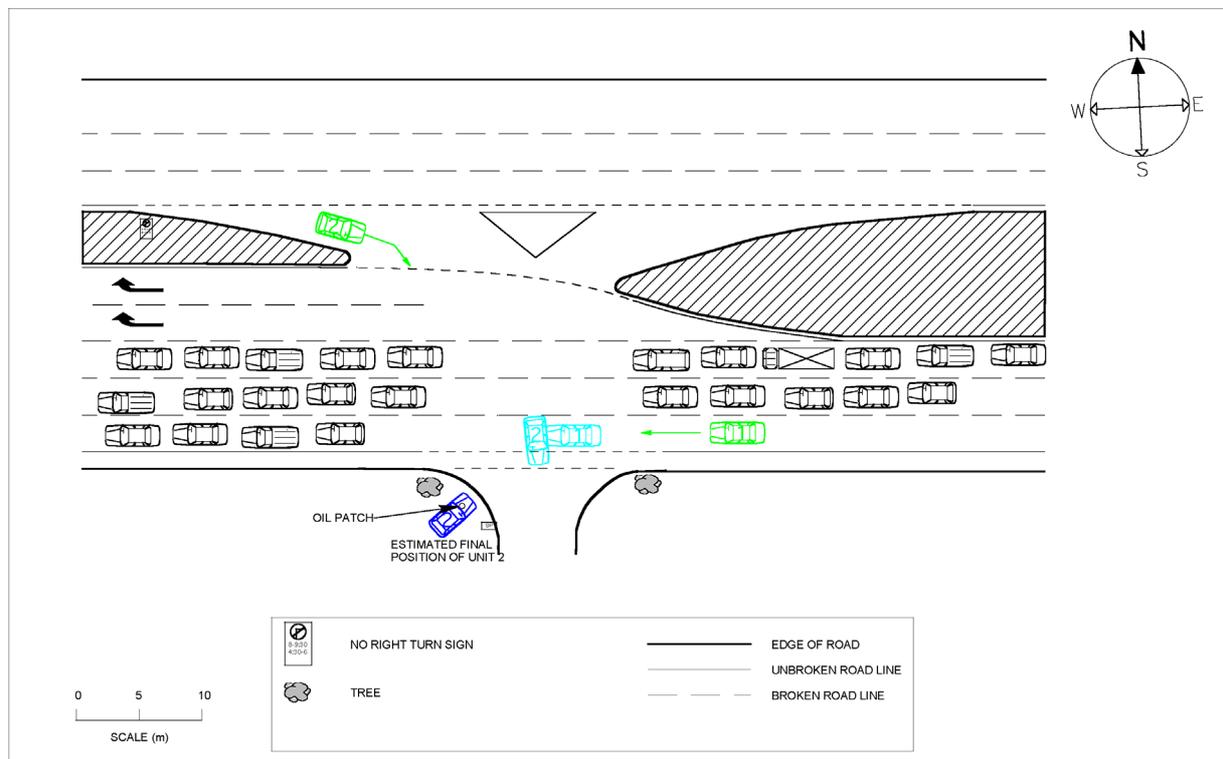


Figure 3 – Site diagram showing the right turn and through vehicle manoeuvres leading to the collision

It is evident that the combination of queuing traffic adjacent to uncongested lanes and the practice of courteous drivers waving turning drivers through was contributing to crashes. A study of the TARS database for the section of road upstream and downstream of the two collision sites revealed a high number of right turn and right angle collisions. Although there are signs at some locations prohibiting right hand turns into side streets during peak periods, many such crashes still occur. Table 3 outlines the crash incidence along a 3.5 km section of the road.

In some cases the number of right turn and right angle crashes at the local road T-junctions outnumbers those at the major signalised junctions. Furthermore, crash severity is disproportionately higher at these junctions when compared to the metropolitan area as a whole. The time at which the majority of these crashes occurred indicated that the problem was mainly associated with the morning and late afternoon/evening peak periods, the time during which such manoeuvres are prohibited. Although enforcement could be targeted at these sites, it is unlikely to provide a permanent solution. Closing off the road to right turners would eliminate the crash risk at these sites but that may not be an acceptable solution. Introduction of legislation prohibiting overtaking stationary vehicles on the left may provide a partial solution, as is the case on British motorways.

Table 3 – Number of crashes occurring along a section of arterial road based on junction type (1994-2002)

	Junction Type	All Crashes	Casualty Crashes
Junction 1	Signalised cross road	34	7
Junction 2	Local Road T-junction	4	0
Junction 3	Signalised cross road	73	24
Junction 4	Local Road T-junction	3	1
Junction 5	Local Road T-junction	17	4
Junction 6	Local Road T-junction	54	17
Junction 7	Signalised cross road	53	18
Junction 8	Local Road T-junction	10	2
Junction 9	Local Road T-junction	42	8
Junction 10	Signalised cross road	29	8
Junction 11	Local Road T-junction	27	10
Junction 12	Signalised cross road	5	0
Junction 13	Local Road T-junction	27	3
Junction 14	Signalised cross road	31	8
Junction 15	Local Road T-junction	12	2

Crash barriers and their end terminals

Crash barriers are used extensively throughout the road network to protect errant vehicles from roadside hazards. Their use has spanned several decades and consequently there are many types of crash barriers in existence based on what was considered best practice at the time of installation. As understanding of crash barrier performance in crashes has improved, so too has crash barrier technology. Unfortunately, the legacy of obsolete technology and practices remains throughout the road network.

This is no more pronounced than with the use of barrier terminal end treatments with many different types of treatments being used over the past decades. What is of concern is that many of these systems are implemented, but little monitoring is undertaken of their performance in the field should they be struck.

On a weekday afternoon, a 1999 Holden Statesman was travelling on a multilane road in the kerbside lane in a 70 km/h zone. The vehicle failed to negotiate a slight right hand bend and struck the end of a section of Armco guardrail installed to protect motorists from an overhead signal gantry. The guardrail section was fitted with a gating drum end terminal consisting of a tensioning wire rope and two wooden break away posts (Figure 4). Upon impact the Armco speared into the vehicle, through the engine firewall and into the driver's compartment. The driver, who was the sole occupant of the vehicle, was pinned by his legs with his upper torso over the front passenger's seat. A small fire started which soon engulfed the vehicle, killing the driver. Bystanders tried in vain to extract the injured driver and put out the fire.



Figure 4 – Photo showing the terminal end section of the guardrail intruding into the driver's compartment. The square to the left shows the burnt out remains of the driver's seat. The inset to the right shows the type of terminal end used.

The guard rail was installed to current standards but despite this it is evident that the terminal end performed inadequately. Through routine maintenance, the sections of guardrail were repaired and replaced with exactly the same terminal end treatment. In such cases, the TARS crash database is unlikely to be useful in identifying collisions with guard rails let alone terminal ends. No feedback is obtained from maintenance crews and so it is unlikely that follow up assessment is conducted by road authorities. In depth investigation was instrumental in demonstrating the deficiency of the treatment and has highlighted the need for the continual monitoring of any new treatments adopted to ensure that they are performing as intended.

Filter Right Turn Crashes

On a weekday afternoon, a driver who was the sole occupant of a vehicle had to conduct a filter right turn at a signalised intersection. The driver entered the intersection and proceeded to turn right (having a green orb signal on display) and was struck by a rigid truck and shunted into a traffic signal pole. Although trapped in the vehicle, the driver only suffered minor cuts and abrasions despite the significant damage to the vehicle (see Figure 5). Follow up interviews revealed that the driver had two jobs which had been causing some stress and fatigue. On the day of the crash, she was called in early to her second job and had less sleep than normal the previous night. She was turning at the intersection to access some shops on her right and looked but did not notice any oncoming vehicles until just prior to impact.

A site diagram is shown in Figure 6. There is a slight kink in the western approach that was being used by the truck however the site satisfied current design standards. A comparison of right turn crashes at the major signalised intersections upstream and downstream of the site was made. These intersections had much higher traffic volumes but proportionately less right turn crashes than the crash site (Table 4).

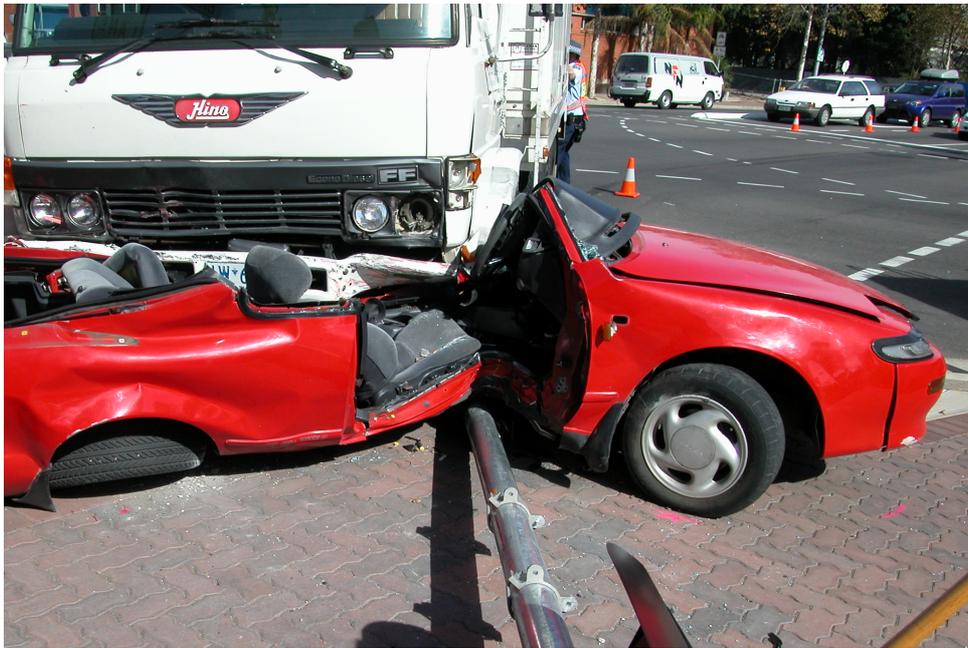


Figure 5 – Damage to the vehicle that collided with a rigid truck showing final resting position and significant intrusion caused by the truck and traffic signal pole (emergency services have removed the roof of the vehicle)

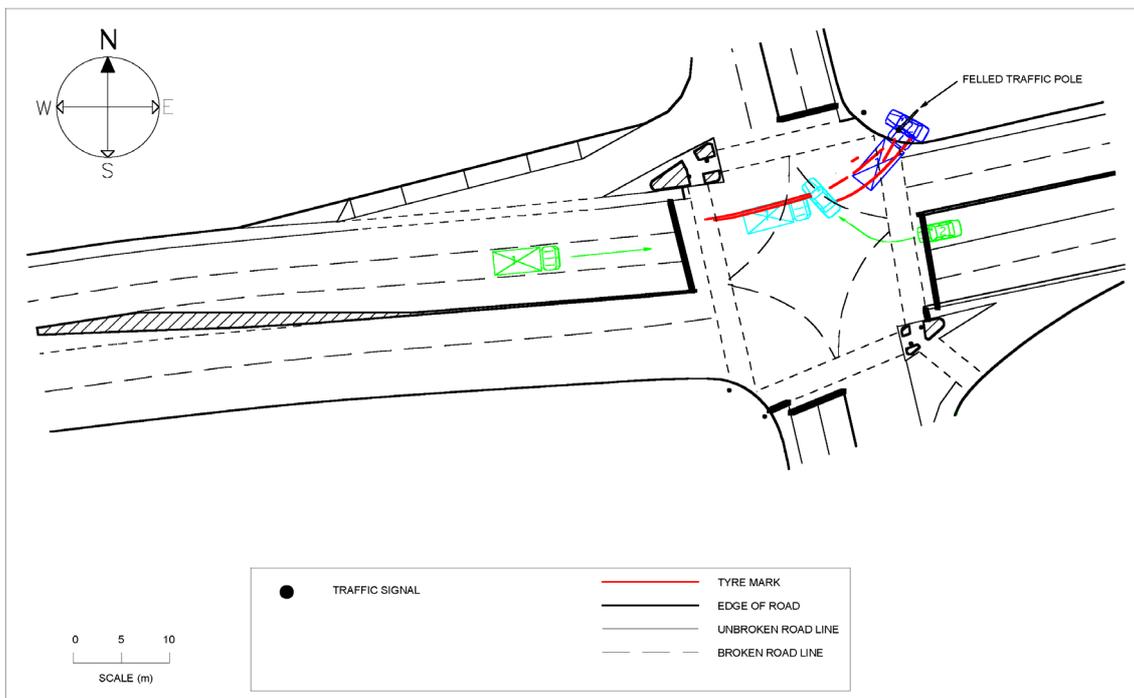


Figure 6 – Site diagram showing intersection geometry, initial vehicle paths and final resting places

Table 4 – Comparison of crash history for the crash site with upstream and downstream signalised intersections (1981 to 2002)

Site	All Crashes	Right Turn Crashes	Proportion
Crash Site	337	102	30.3 %
Downstream Junction	502	68	13.5 %
Upstream Junction	700	44	6.3 %

Filter right turns at signalised intersections are an accepted traffic engineering practice that permit a higher throughput of vehicles and avoid delays to mainstream traffic due to controlled right turn signal

phases. However, it is well known that right turn crashes in such circumstances feature strongly in crash databases. There have been attempts to make motorists aware of this danger by using flashing yellow arrows or LED signs (as provided for in the Australian Road Rules), none of which were in operation at the crash site.

It is likely that a fully controlled right turn phase would have prevented the crash from occurring. This is known to significantly reduce right turn crashes by up to 80% (Bui, Cameron and Foong, 1991), yet the filter right turn is still used extensively on the basis of network efficiency.

CONCLUSIONS

Indepth crash investigation can contribute significantly towards the understanding of crashes and injury mechanisms. Conventional crash databases commonly used by road authorities often lack the necessary information to achieve a heightened understanding of the factors that are contributing to crashes at a specific site. Often an understanding of the crash situation is predominantly based upon a history of crash types. The interpretation of this aggregated data can be enhanced with the type of data collected through indepth crash investigation because the type and quality of data collected is highly relevant to the identification of contributing factors. Evidence that would otherwise be lost is noted and most importantly, the perspective of the crash participants and witnesses is taken into consideration.

CASR has used its indepth investigations as a tool for working with road and vehicle engineers to better understand safety related matters. Such investigations are also capable of highlighting inadequacies in the road and vehicle environment even when current practices, standards and guidelines have been adhered to.

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REFERENCES

- Bui, B., Cameron, M., & Foong, C. W. (1991). *Effect of Right Turn Phases at Signalised Intersections. Part 1 - Safety Performance*. Melbourne: Monash University.
- Kloeden CN, McLean AJ, Moore VM, Ponte G. (1997). Travelling speed and the risk of crash involvement. Volume 1 - Findings. CR 172. *Federal Office of Road Safety*. Canberra, Australia.
- Kloeden CN, McLean AJ (2001) Rural speed and crash risk in *Road Safety Research, Policing and Education Conference*. Proceedings, 18-20 November 2001, Melbourne, Victoria, Australia, vol.II. Melbourne: Monash University, pp.163-168
- McLean A J (2005). Fifty years of at-scene crash investigations: methodological considerations. *Australasian road safety research, policing, education conference*, 14-16 November 2005, Wellington, New Zealand.