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CASR REPORT SERIES
CASR152
October 2022

Report documentation

REPORT NO.	DATE	PAGES	ISBN	ISSN
CASR152	October 2022	23	978-1-921645-90-7	1449-2237

TITLE

Options for mitigating filter right turn crashes at signalised intersections based on video footage of crashes

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FUNDING

This research was funded via a deed with the South Australian Government

AVAILABLE FROM

Centre for Automotive Safety Research
http://casr.adelaide.edu.au/publications/researchreports

ABSTRACT

Signalised intersections represent locations along the road network where traffic managers exert the greatest control on road users. However, crashes do occur at signalised intersections and because of the combination of high speeds and right angle crash configurations, they are likely to cause harm to those involved. Filter right turns present substantial danger to road users due to the complexity of decision making, risk of severe outcomes and the lack of control being placed over road user movements. The main aim of this research is to use footage of filter right turn crashes at signalised intersections to identify and analyse crash mechanisms associated with these crashes, and to develop recommendations that can lessen or eliminate the risk of filter right turn crashes should full right turn control not be able to be employed. A number of recommendations are made and include fully controlling right turns or where filter turns are allowed, reducing through vehicle speeds and control right turns at off-peak times when volumes do not warrant filter turns. It is also recommended that this study be revisited on a frequent basis and that further research be undertaken to better understand specific issues of dynamic visual obstruction and drivers' abilities to judge speed and distance at night.

KEYWORDS

Filter turn, right turn, traffic signals, intersection crashes

Summary

Signalised intersections represent locations along the road network where traffic managers exert the greatest control on road users. Theoretically, because of this high level of control they should also be locations with a very low potential for harm to occur. However, crashes do occur at signalised intersections and because of the combination of high speeds and right angle crash configurations, they are likely to cause harm to those involved. Filter right turns occur when road users are permitted to undertake right turns at signalisation without a right turn signal, thereby “filtering” between oncoming traffic. These situations present substantial danger to road users due to the complexity of decision making, risk of severe outcomes and the lack of control being placed over road user movements.

The main aim of this research is to use footage of filter right turn crashes at signalised intersections to identify and analyse crash mechanisms associated with these crashes, and to develop recommendations that can lessen or eliminate the risk of filter right turn crashes should full right turn control not be able to be employed.

Through this study, a number of attributes associated with filter right turn crashes where identified. Most prevalent among these was the propensity with which dynamic visual obstruction was a possible factor, especially during daylight crashes. Interactions between attributes were also identified and showed a distinct difference between daylight and night time crashes. Most obvious of these was the large proportion of night time crashes where the right turning driver, despite there being no opportunity for dynamic visual obstruction and very little other traffic, made no obvious effort to avoid the crash, leading to the theory that oncoming headlights may be diminishing the driver’s ability to accurately estimate the oncoming vehicle’s distance.

It is recommended that the following actions should be taken in order to reduce the risk of filter right turn crashes:

1. Restrict filter turns: Fully controlled right turns should be used wherever possible. Crashes associated with filter right turns involve high through vehicle speeds and have a substantial risk of leading to severe outcomes.
2. Speed: high through vehicle speeds (near or at the speed limit) appear to be common. Efforts should be made to reduce or restrict through vehicle speeds where filter right turns are allowed. Filter right turns should not be allowed along roads with speed limits above 50 km/h, as the risk of severe outcomes is substantially increased (Jurewicz et al. 2015).
3. Off-peak risk: the occurrence of crashes during low traffic volumes with no possibility of dynamic visual obstruction appears to be common. While these crashes occurred during both day and night times, they were more frequent at night, leading to the theory that oncoming headlights may be reducing the turning vehicle driver’s ability to accurately estimate the distance of an oncoming vehicle. It is recommended to fully control right turns during off-peak hours (particularly at night) when right turn traffic volumes do not warrant the use of filter right turns.
4. Dynamic visual obstruction: masking of oncoming vehicles to the right turning driver appears to be a significant problem. There is no obvious way to control such an issue without removing the presence of the filter right turn altogether. It is recommended that further research be undertaken into this phenomenon.

The issue of crashes associated with filter right turns is significant and so it is recommended that this study be revisited on a frequent basis to better understand pervasiveness of the issue and the effect of treatments. It is also recommended that further research be undertaken into dynamic visual obstruction and into drivers' abilities to judge speed and distance of oncoming traffic at night.

Note that this report was substantially completed in March 2018 and does not consider developments after that date.

Contents

1 Introduction

Filter right turns occur when a right turn movement is allowed while no right turn arrow is being displayed (Figure 1.1). Allowing filter right turns at signalised intersections increases the risk of severe crashes. Despite this, traffic managers may choose to not fully control right turns at signalised intersections for a number of reasons. In such situations, harm reduction techniques are required that do not rely on the full control of right turns. In order to develop such techniques, a project was undertaken that involved the analysis of video footage to identify common traits associated with filter right turn crashes. In the remainder of this report, the methods and results of this project are outlined, and the techniques derived from the study are discussed.

Figure 1.1
An example of a vehicle waiting to undertake a filter right turn at a signalised intersection

1.1 Background

Signalised intersections represent locations along the road network where traffic managers exert the greatest control on road users. Theoretically, because of this high level of control they should also be locations with a very low potential for harm to occur. However, crashes do occur at signalised intersections and because of the combination of high speeds and right angle crash configurations, they are likely to cause harm to those involved. Between 2006 and 2015 in the Adelaide metropolitan area, 22% of injury crashes involving a hospitalisation or fatality, which were reported to South Australian Police and coded into the Traffic Accident Reporting System (TARS), occurred at a signalised intersection.

The high rate of injury crashes at signalised intersections is a reflection of exposure rather than exceedingly high risk relative to other parts of the road network; signals are more likely to be placed at the intersection of high volume roads. Signalisation has the potential to reduce the risk of crashes at intersections. Austroads (2015) reports a crash risk reduction of 70% for adjacent approach crashes and 30% for pedestrian crashes when signals are installed at previously non-signalised intersections. In a review of international literature, Elvik et al. (2009) report best estimate reductions of injury crashes of 15% and 30% associated with the installation of signals at three-leg and four-leg intersections, respectively. In this regard, there is a clear benefit to placing traffic signals at locations where roads with high traffic volumes intersect.

Yet despite the potential for signalisation to reduce crashes at intersections, the potential for harm is still present. There are a number of ways in which harm can occur at signalised intersections. While various crashes not specific to intersections can occur (for example, rear-end, side-swipe and run-off-road crashes), two prevalent types are a direct result of the control imposed at these locations; crashes after proceeding through red lights, and filter turn crashes that are the focus of this study.

Despite the generally low complexity of decision-making at signalised intersections, filter right turn manoeuvres place a respectively large cognitive load on the road user. A road user must select a gap and execute the turn, with this commonly being done over multiple oncoming lanes. The risk of such manoeuvres is heightened by the high volumes and high speeds (60 km/k plus) at intersections in which filter right turns are required to be undertaken. Despite the already mentioned benefits of signalisation, Austroads (2015) reports a 90% increase in risk associated with opposing turn crashes when turn arrows are not provided at signalised intersections (as opposed to no signalisation at all).

Despite the clear benefits of removing filter right turns, there are reasons why full right turn control may not be implemented. Signalised intersections, especially those running close to capacity, may not be able to accommodate full right turn control without excessive delay being incurred. At these locations, filter right turns are used to ease delay by increasing the capacity of right turn movements. This can be especially important during peak volume times. Additionally, increased right turn queue lengths may increase with the advent of full right turn control. Such queues can extent into through lanes, further increasing congestion and potentially increasing the risk of rear end crashes. Furthermore, full right turn control may not be applied at some intersections where dedicated right turn lanes are not provided.

1.2 Research aims

The aim of this research is to use footage of filter right turn crashes at signalised intersections to identify and analyse mechanisms associated with these crashes, and to develop recommendations that can lessen or eliminate the risk of filter right turn crashes where full right turn control is not able to be employed. More detailed information can be obtained from viewing traffic camera footage than from analysing police crash data alone, such as the traffic conditions and timing of the signal phase when a crash occurs.

2 Methodology

In this study, a sample of crash footage showing filter right turn crashes is analysed. The footage is of crashes that occurred between 2013 and 2016 (inclusive). A total of forty-six crashes were identified. Footage was only included into the sample if the crash could be identified as a right turn crash occurring under filter right turn conditions and the crash was visible in the video footage (i.e. excluding aftermath footage and crashes that occurred out of sight of the video camera).

2.1 Video selection

This study was conducted using traffic camera footage collected by the Department of Planning, Transport and Infrastructure (DPTI) in South Australia. Traffic camera footage of filter right turn crashes is collected for only a small sample of all these crashes. This is because:

- Not all intersections are monitored by traffic cameras.
- Not all intersections can be continuously monitored.
- Certain intersections are actively monitored more than others.
- Crashes must be identified either through active monitoring or notification from emergency services or the public.
- Footage of crashes is not always available as traffic cameras are not always positioned in the correct direction to capture a crash.
- Once a crash is identified and footage is known to be available, a staff member must be able to record the traffic camera footage of the crash.

The nature of the collection process means that the sample of filter right turn crash footage is biased towards certain intersections and therefore may not be viewed as a true representative of the population of filter right turn crashes.

2.2 Mass crash database

The sample of crashes analysed in this study was compared to crashes recorded through the South Australian mass crash database (TARS) for the same time period of 2013 to 2016 (inclusive). This comparison was made to assess the representative nature of the sample. While there is no explicit way to determine filter right turn crashes in the TARS database, key identifiers can be used to identify crashes that are likely to be of this type. Definition for coding accidents (DCA) information can be useful for identifying crashes in further detail, but was unavailable for the entire analysis period. The key identifiers used were:

- Crashes occurring at signalised intersections.
- Crashes identified as a “right turn” crash type.
- Excluding crashes associated with a “disobey – traffic signals” error – usually referring to through movements and not turning movements.

2.3 Environmental conditions

Environmental conditions collected as part of the analysis were the lighting conditions, traffic conditions (peak or off-peak traffic) and weather at the time of the crash. Lighting conditions were categorised as:

- **Daylight:** the crash occurred when the lighting condition was determined to be with daylight and vehicle headlights were not in use.
- **Night:** the lighting condition was determined to be in the absence of daylight and vehicle headlights were in use.

Dusk and dawn were not specifically identified due to the difficulty in determining specific start and end times of these periods.

Weather conditions were categorised as:

- **Dry:** the crash did not occur in the obvious presence of rain and the road was determined to be visually dry.
- **Wet/not raining:** the crash did not occur in the obvious presence of rain and the road was determined to be visually wet.
- **Wet/raining:** the crash occurred in the obvious visual presence of rain and the road was determined to be visually wet.

Traffic conditions were categorised as:

- **Peak:** the crash occurred on a weekday, 7:00-10:00am or 3:00-6:00pm. These times were nominated following an analysis of hourly traffic flow data on a small sample of Adelaide metropolitan arterial roads.
- **Off-peak:** the crash occurred outside of a day/time defined as a peak traffic time.

2.4 Timing of crashes

The timing of the crash through the phase was categorised as occurring either at the start of the phase, during mid phase or at the end of the phase. These categories are defined as:

- **Start of phase:** the turning vehicle proceeded to turn and the crash occurred immediately after the through vehicle phase began (i.e. when the through vehicle was first presented with a green signal). It should be noted that this condition was difficult to determine if the video footage did not directly show the through vehicle signals.
- **Mid phase:** the crash occurred after the start of the through vehicle phase and before the yellow signal began.
- **End of phase:** the crash occurred after the through vehicle signal (or alternatively the turning vehicle signal if the former could not be seen) turned yellow. This includes the all-red time.

If neither the through nor turning vehicle signals could be seen, then the categorisation of the crash occurring either mid phase or at the end of the phase was based on when the green signal for the proceeding phase began. For a crash to occur at the end of the phase, it had to have occurred no more than seven seconds before the green signal for the proceeding phase began, based on a yellow time of four to five seconds and an all-red time of two to three seconds. Otherwise, the crash was determined to have occurred mid phase.

2.5 Through vehicle position

Three through vehicle positions were identified; a solitary vehicle (Figure 2.1), a vehicle in the platoon (Figure 2.2) and a vehicle in scattered traffic (Figure 2.3). These three categories are based on the through vehicle's position relative to other traffic travelling along the same leg. These categories are defined as:

- **Solitary vehicle:** the through vehicle was travelling with a separation of greater than four seconds from other vehicles (fore and/or aft) along the same leg.
- **In platoon:** the through vehicle was travelling within or at the front/back of a platoon such that it had less than four seconds of separation from other vehicles (fore and/or aft) within the same lane.
- **In scattered traffic:** the through vehicle was travelling with a separation of greater than four seconds from other vehicles (fore and/or aft) within the same lane, but with other vehicles in close proximity in the adjacent lane(s).

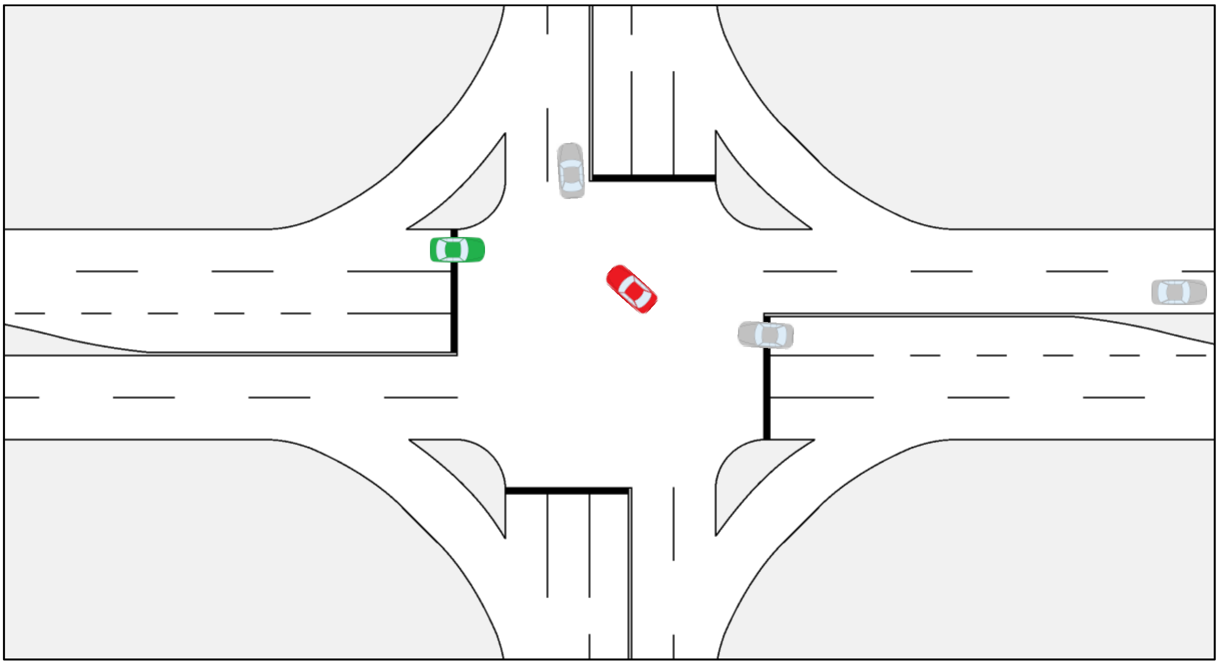


Figure 2.1
Example of a through vehicle travelling as a sole vehicle

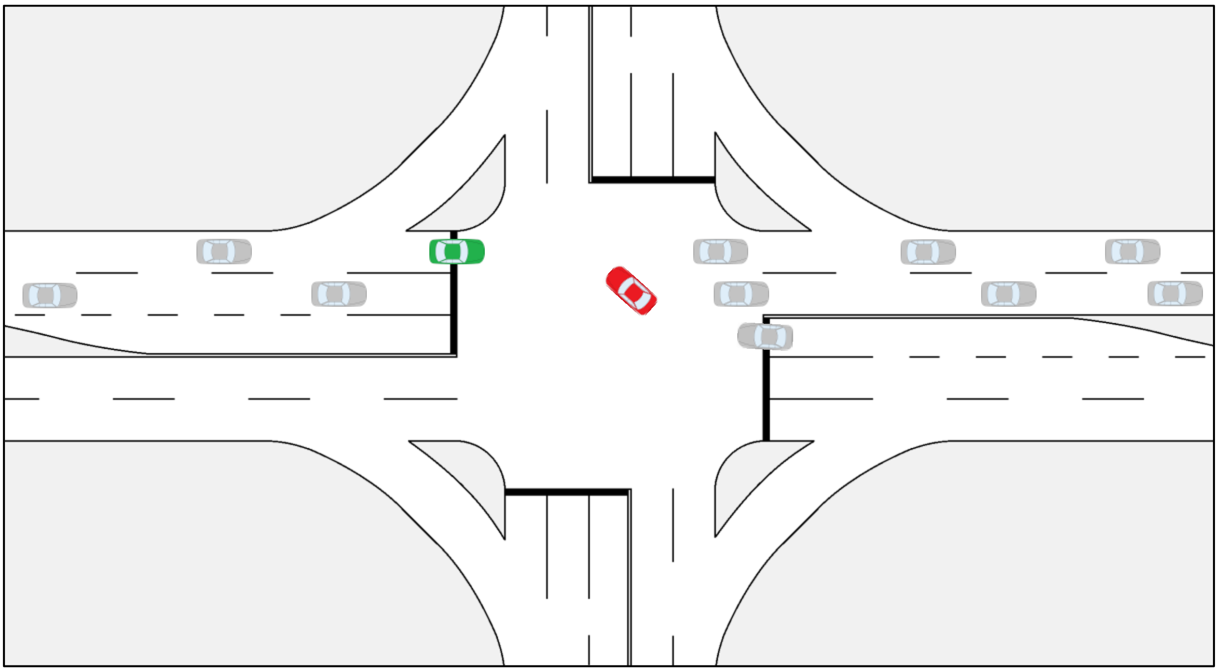


Figure 2.2
Example of a through vehicle travelling within a platoon

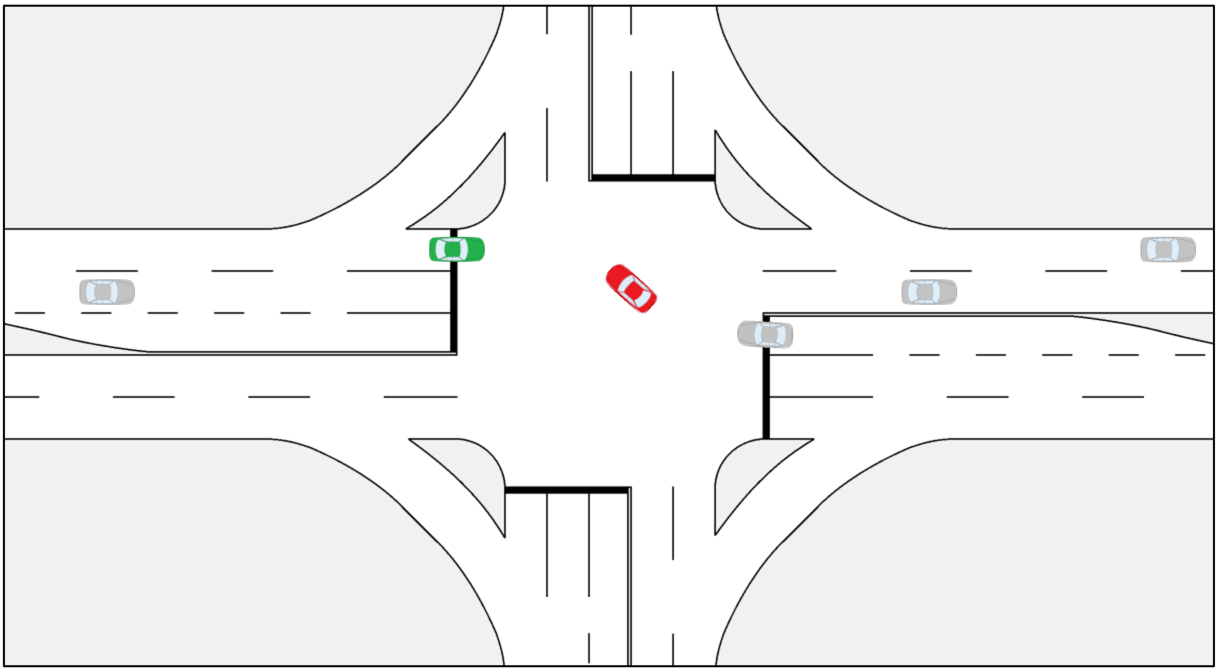


Figure 2.3
Example of a through vehicle travelling in scattered traffic

2.6 Through traffic flow

Through traffic flows preceding the crash were calculated based on through traffic counts for the preceding twenty seconds before the crash (traffic counts were based on the preceding ten seconds if enough before crash footage was not available). Traffic flows were categorised based on Level of Service (LOS) definitions for average passenger car speeds of 60 km/h (the most common speed limit for through vehicles in the sample) (Table 2.1), as defined in Austroads (2013).

Table 2.1
Level of Service categories by traffic flow (as defined in Austroads (2013))

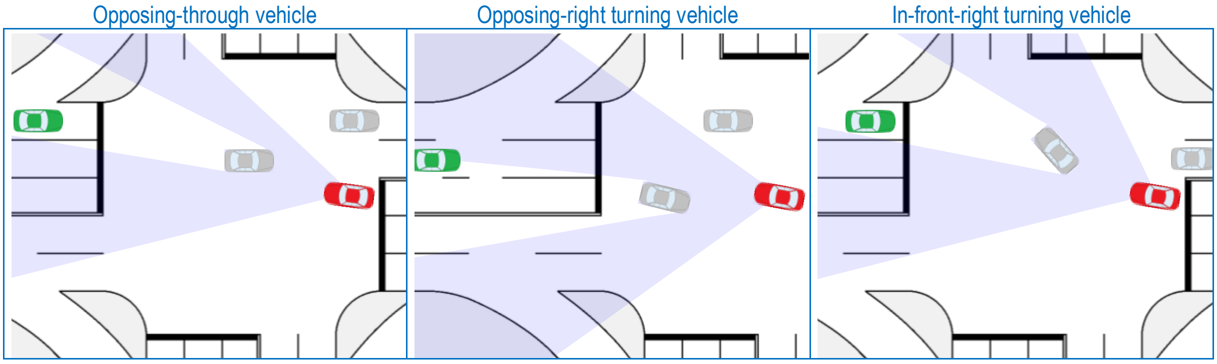
Level of Service Category	Flow (vehicles/hour/lane)	
	Lower bound	Upper bound
A	-	400
B	401	650
C	651	950
D	951	1,300
E	1,301	1,700
F	1,701	-

2.7 Dynamic visual obstruction

The presence of dynamic visual obstruction was determined to be possible when the turning vehicle driver's line of sight to the through vehicle was fully- or partially-obstructed by the presence of another vehicle in the preceding seven seconds before the crash occurred. This time was estimated to be within the time that a driver would take to decide on the presence of a sufficient gap (three seconds), react (two seconds) and execute the turn (two seconds – based on observed footage). The decision and reaction times were based on those given in Austroads (2010a; 2010b). The presence of dynamic visual obstruction was not always well-defined as determining a straight line between the turning vehicle and the through vehicle was often difficult. As such, the determination of dynamic visual obstruction being present should be taken as a possibility and not a definite.

Three categories of dynamic visual obstruction were identified as (Figure 2.4):

- **Opposing-through vehicle:** another through vehicle along the opposing leg (other than the through vehicle involved in the crash) was determined to be visually masking the involved through vehicle.
- **Opposing-right turning vehicle:** a right turning vehicle along the opposing leg was determined to be visually masking the through vehicle.
- **In-front-right turning vehicle:** a vehicle making a right turn in front of the involved turning vehicle was determined to be visually masking the through vehicle.



Opposing-through vehicle

Opposing-right turning vehicle

In-front-right turning vehicle

Figure 2.4
Examples of the three categories of dynamic visual obstruction based on the position and movement of the vehicle determined to be visually masking the through vehicle. From left to right: opposing-through; opposing-right; in-front-right. The blue shading represents the right turning driver’s field of vision.

3 Results

3.1 Comparison to mass crash database

When compared to crashes contained within the TARS mass crash database, the sample of crashes contained in the analysed footage shows similar traits (Table 3.1). This suggests that, for the attributes being assessed in this comparison, the sample of crashes is similar to the population of filter right turn crashes in South Australia over the same time period.

Some attributes were not represented in the sample cases that were present in the mass crash database. While ten percent of crashes contained within TARS occurred while it was raining, no crashes of this kind were captured in the video sample. Other attributes which comprise a very small proportion of crashes contained within TARS, such as fatal crashes and crashes occurring in lower or higher speed limit zones were not captured in the sample.

Table 3.1
Comparison of sample crashes analysed in this study
and filter right turn crashes contained within the TARS mass crash database

	Sample crashes		TARS crashes	
	Number	Proportion	Number	Proportion
Total crashes	46	100%	2,354	100%
Weather				
Raining	0	0%	233	10%
Not raining	46	100%	2,121	90%
Lighting				
Daylight	27	59%	1,576	67%
Night	19	41%	778	33%
Speed limit				
<50	0	0%	12	1%
50	1	2%	345	15%
60	42	91%	1,891	80%
70	3	7%	72	3%
80	0	0%	34	1%
Severity*				
PDO	19	58%	1,499	64%
Treated by private doctor	1	3%	156	7%
Treated in hospital	12	36%	640	27%
Admitted to hospital	1	3%	57	2%
Fatal	0	0%	2	<1%

*Severity for thirteen sample cases was unable to be identified

3.2 Crash attributes

3.2.1 Environmental and traffic conditions

The sample dataset contained footage for a substantial number of crashes in both daylight (27 crashes) and night (19 crashes) lighting conditions (Figure 3.1). As such, it may be appropriate to comment upon mechanisms that are influential during both of these periods.

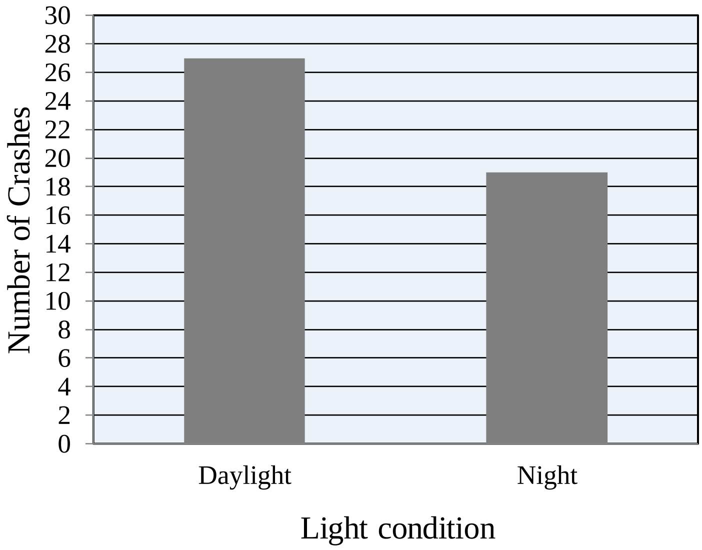


Figure 3.1
Numbers of sample crashes occurring during different light conditions

Nearly three-quarters of all crashes occurred during off-peak times (Figure 3.2). Peak traffic timing is well-correlated with lighting conditions – all crashes defined as occurring during peak times also occurred during daylight. Different crash mechanisms were observed to be influential for daylight/night light conditions and peak/off-peak traffic conditions, and are discussed below.

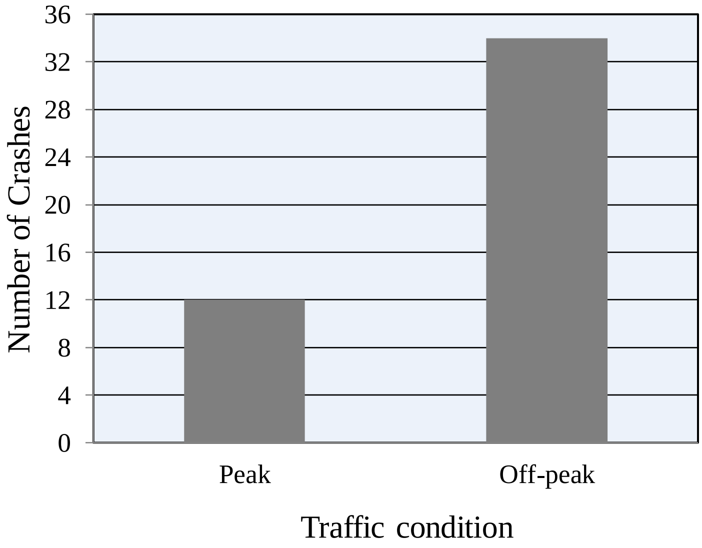


Figure 3.2
Numbers of sample crashes occurring during peak and off-peak times

Nearly all crashes were observed to occur during dry weather conditions (Figure 3.3). As such, mechanisms that may influence crashes occurring during non-dry conditions cannot be commented upon. The influence of the observed crash mechanisms may differ in other weather conditions and other crash mechanisms not identified in this study may also become influential.

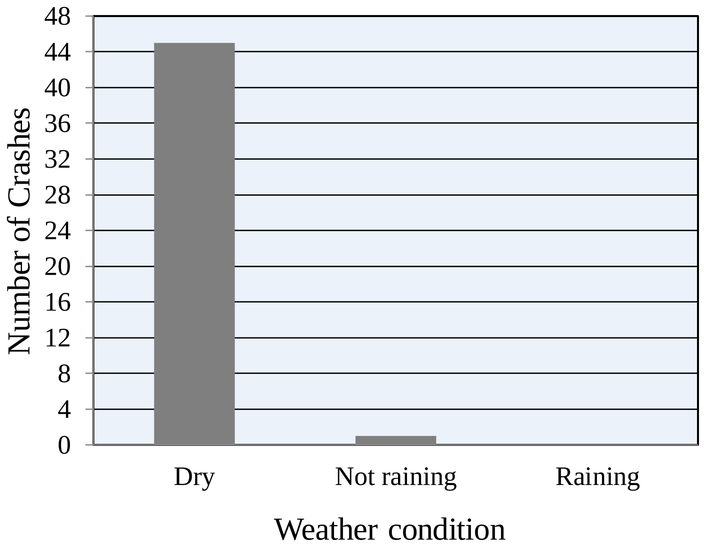


Figure 3.3
Numbers of sample crashes occurring during different weather conditions

3.2.2 Timing of crashes

Most crashes were observed to occur either mid-phase (i.e. while the through vehicle signal was green) or at the end of the phase (i.e. after the through vehicle signal had changed to yellow) when through vehicles are more likely to be travelling at or near the speed limit (Figure 3.4). Only two crashes were observed to occur at the start of the phase, when through vehicles are travelling at a slower speed (i.e. the turning vehicle proceeded immediately after the through vehicle signal turned green).

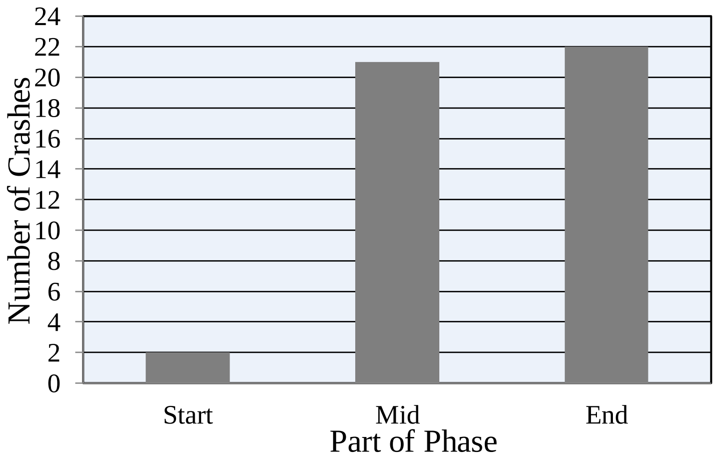


Figure 3.4
Numbers of sample crashes occurring during different parts of the filter right turn phase

3.2.3 Level of service

Level of service (LOS) could be calculated for 44 of the 46 crashes (Figure 3.5). The most common was LOS-A, comprising half of all crashes with a known LOS. Six crashes each had an intermediate LOS, while two crashes each had a higher LOS.

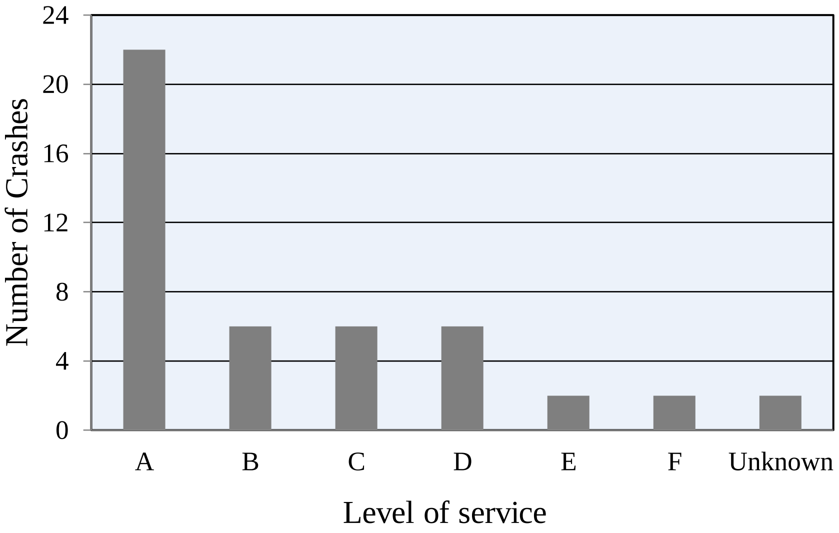


Figure 3.5
Level of service based on traffic volumes in the preceding 20 seconds before the crash

3.3 Interaction of attributes

The crash attributes discussed above are highlighted in Table 3.2 and their interactions are discussed within this section. In-line with expectations, all peak hour crashes occurred during daylight hours and had a generally higher associated level of service (LOS) category of traffic volumes at the time of the crash. In the majority of these crashes, dynamic visual obstruction was a possibility; mostly from other (non-involved) oncoming through traffic. The right turning vehicle was also more likely to have stopped before proceeding to turn.

There were a large number of crashes occurring during LOS-A traffic volumes, comprising half of all crashes with a known LOS. The majority of these crashes occurred mid-phase and when the involved right turning vehicle was following directly behind another right turning vehicle. In the few cases where dynamic visual obstruction was a possibility, it was identified as coming from visual obstruction by the in-front right turning vehicle. For the majority of these cases, the right turning vehicle did not stop before proceeding to turn.

Night time crashes showed general differences to those that occurred during daylight conditions. Most night time crashes occurred during lower LOS conditions, with respectively less involving the opportunity for dynamic visual obstruction. Stopping before proceeding to turn and directly following another right turning vehicle were also less common attributes.

Table 3.2
List of crashes and identification of influential features

Crash ID	Lighting	Peak/ off-peak	Timing	LOS Category	Through vehicle position	Following another turning vehicle?	Stopped before turning?	Possibility of dynamic visual obstruction?
1	Daytime	Off-peak	Mid-phase	B	In platoon	No	Yes	Yes
2	Daytime	Off-peak	Mid-phase	A	Solitary	Yes	No	No
3	Daytime	Off-peak	Mid-phase	A	Solitary	Yes	No	Yes
4	Daytime	Off-peak	Mid-phase	A	Solitary	No	No	No
5	Daytime	Off-peak	Mid-phase	A	In platoon (front)	No	No	No
6	Daytime	Off-peak	Mid-phase	A	In platoon (front)	Yes	No	No
7	Daytime	Off-peak	Mid-phase	A	Solitary	No	No	No
8	Daytime	Off-peak	Mid-phase	A	Solitary	Yes	Yes	Yes
9	Daytime	Off-peak	End of phase	F	In platoon	No	Yes	Yes
10	Daytime	Off-peak	End of phase	-	In platoon	Yes	Yes	Yes
11	Daytime	Off-peak	End of phase	F	In platoon	Yes	Yes	Yes
12	Daytime	Off-peak	End of phase	D	In platoon	No	Yes	Yes
13	Daytime	Off-peak	End of phase	D	Solitary	No	Yes	Yes
14	Daytime	Off-peak	End of phase	C	In platoon	No	No	Yes
15	Daytime	Off-peak	End of phase	A	Solitary	Yes	No	Yes
16	Daytime	Peak	Mid-phase	C	Solitary	No	No	Yes
17	Daytime	Peak	Mid-phase	-	In scattered traffic	No	Yes	Yes
18	Daytime	Peak	Mid-phase	C	Solitary	Yes	No	Yes
19	Daytime	Peak	Mid-phase	B	In scattered traffic	No	No	Yes
20	Daytime	Peak	Mid-phase	B	Solitary	Yes	No	Yes
21	Daytime	Peak	Mid-phase	E	In platoon	No	Yes	Yes
22	Daytime	Peak	End of phase	A	Solitary	Yes	No	No
23	Daytime	Peak	End of phase	C	In scattered traffic	Yes	No	Yes
24	Daytime	Peak	End of phase	A	Solitary	Yes	Yes	Yes
25	Daytime	Peak	End of phase	C	In platoon	No	No	Yes
26	Daytime	Peak	End of phase	D	In platoon	No	-	Yes
27	Daytime	Peak	Unknown	D	In platoon	Yes	-	Yes
28	Night	Off-peak	Mid-phase	A	Solitary	No	No	No
29	Night	Off-peak	Mid-phase	A	Solitary	No	Yes	No
30	Night	Off-peak	Mid-phase	B	Solitary	No	No	No
31	Night	Off-peak	Mid-phase	A	In platoon (front)	No	Yes	No
32	Night	Off-peak	Mid-phase	A	In scattered traffic (front)	No	No	No
33	Night	Off-peak	Mid-phase	A	Solitary	Yes	No	Yes
34	Night	Off-peak	Mid-phase	A	Solitary	No	No	No
35	Night	Off-peak	Start of phase	A	In platoon	No	No	No
36	Night	Off-peak	Start of phase	A	Solitary	No	No	No
37	Night	Off-peak	End of phase	D	In platoon	Yes	Yes	Yes
38	Night	Off-peak	End of phase	E	In platoon	No	-	Yes
39	Night	Off-peak	End of phase	B	In scattered traffic	No	No	Yes
40	Night	Off-peak	End of phase	A	In scattered traffic	No	No	No
41	Night	Off-peak	End of phase	B	Solitary	No	Yes	No
42	Night	Off-peak	End of phase	A	Solitary	Yes	-	No
43	Night	Off-peak	End of phase	A	Solitary	Yes	No	Yes
44	Night	Off-peak	End of phase	A	Solitary	No	No	No
45	Night	Off-peak	End of phase	D	In platoon	No	Yes	Yes
46	Night	Off-peak	End of phase	C	In platoon	No	Yes	No

4 Discussion

Dynamic visual obstruction was frequently identified as a possible mechanism both for crashes that occurred during peak traffic times and for crashes that occurred at end of phase. During the former scenario, high traffic volumes increase exposure to the possibility of dynamic visual obstruction and therefore increase risk. While dynamic visual obstruction was not necessarily the main contributing factor in these crashes, it increases the complexity of the decision making process, increasing the risk of errors being made. The cognitive load placed on a driver undertaking a filter right turn is high, with scanning for gaps in oncoming traffic forming only part of the required task. Greater activity (e.g. during peak traffic times) and increased pressure to undertake the filter turn (e.g. at end of phase) may further increase cognitive load. In such situations, gap selection is likely to be based on visual cues gathered at discreet intervals rather than on a continuous basis (i.e. the driver will be looking for gaps only part of the time). Dynamic visual obstruction, even if only masking part of an oncoming vehicle or masking a vehicle for a short period of time, has the opportunity to interrupt a driver’s ability to adequately scan for oncoming traffic and allow the driver believe an adequate gap is presented, even if it is not (Dewar and Olson 2007). Behaviour reminiscent of this is present in much of the crash footage where dynamic visual obstruction is possible; an oncoming vehicle easily identified from the camera’s point of view is seemingly oblivious to the right turning driver (i.e. the driver made no obvious attempt to avoid the crash at any stage after starting the right turn). While this study may not conclusively determine the extent to which dynamic visual obstruction is a problem, its prevalence in the crash footage suggests that its presence is creating additional risk to road users in situations where high cognitive load is already imposed.

Many crashes involved right turning vehicles that did not stop before undertaking the right turn. Such behaviour was commonly associated with the involved right turning vehicle following another right turning vehicle. Following another vehicle through the right turn without stopping reduces the amount of time that a driver has to scan for gaps and decide whether it is safe to proceed. The addition of having another car also performing a right turn in front commonly increased to possibility of dynamic visual obstruction. Under such circumstances, it is possible that the oncoming vehicle involved in the crash was masked by the right turning vehicle.

Half of all night crashes occurred when the right turning vehicle did not stop and no dynamic visual obstruction was possible. Such circumstances present a relatively low cognitive load on a driver; often very low traffic volumes and no possibility of an oncoming vehicle being masked. It is possible that drivers faced with this situation were aware of the oncoming vehicle but misjudged their own ability to execute the turn before conflict arose. Behaviour reminiscent of this is present in much of the crash footage, with the right turning driver seeming to make no obvious attempt to avoid a crash. While untested in this study, other research has shown the effect of an oncoming car’s headlights to reduce a driver’s ability to estimate the distance of the oncoming vehicle (Castro et al. 2001). As such, the presence of darkness may be decreasing a driver’s ability to make appropriate judgements when selecting gaps, adding to the risk of the filter right turn manoeuvre.

Considering the short period of time when drivers are presented with a yellow signal, there were a relatively large number of crashes occurring during these periods (end of phase crashes). In such cases, the right turning vehicle proceeded to turn a few seconds after the signals had turned yellow. In such a situation, the turning driver may think that all oncoming vehicles will stop. Where an oncoming vehicle fails to stop, the risk of a crash may be increased as both drivers may assume the other will give way. As many of these crashes occurred exactly on or after the change from yellow to red, it can be suggested that the late entrance into the intersection by the through vehicle was a significant contributor to the crash. In the few end of phase crashes where the presence of other through vehicles was able to be seen, most showed another (non-involved) through vehicle stopping for the yellow/red signal while the involved through vehicle proceeded through the intersection. This is likely to further increase the likelihood that the right turning driver thinks it is safe to proceed.

4.1 Limitations

Because of the biased nature of the traffic camera footage used in this study (discussed above), a true statistical analysis to ascertain the prevalence of specific crash mechanisms is not feasible. Instead, the results of this study should be taken as indicative that certain mechanisms may contribute to the likelihood of a crash (i.e. repeated presence is indicative that a mechanism may be related to the potential for a crash to occur, rather than being a random occurrence unrelated to the crash itself).

5 Recommendations

It is recommended that the following actions should be taken in order to reduce the risk of filter right turn crashes:

1. Restrict filter turns: Fully controlled right turns should be used wherever possible. Crashes associated with filter right turns involve high through vehicle speeds and have a substantial risk of leading to severe outcomes.
2. Speed: high through vehicle speeds (near or at the speed limit) appear to be common. Efforts should be made to reduce or restrict through vehicle speeds where filter right turns are allowed. Filter right turns should not be allowed along roads with speed limits above 50 km/h, as the risk of severe outcomes is substantially increased (Jurewicz et al. 2015).
3. Off-peak risk: the occurrence of crashes during low traffic volumes with no possibility of dynamic visual obstruction appears to be common. While these crashes occurred during both day and night times, they were more frequent at night, leading to the theory that oncoming headlights may be reducing the turning vehicle driver’s ability to accurately estimate the distance of an oncoming vehicle. It is recommended to fully control right turns during off-peak hours (particularly at night) when right turn traffic volumes do not warrant the use of filter right turns.
4. Dynamic visual obstruction: masking of oncoming vehicles to the right turning driver appears to be a significant problem. There is no obvious way to control such an issue without removing the presence of the filter right turn altogether. It is recommended that further research be undertaken into this phenomenon.

The issue of crashes associated with filter right turns is significant and so it is recommended that this study be revisited on a frequent basis to better understand pervasiveness of the issue and the effect of treatments. It is also recommended that further research be undertaken into dynamic visual obstruction and into drivers’ abilities to judge speed and distance of oncoming traffic at night.

Acknowledgements

This research was funded via a deed with the South Australian Government. The managing organisation was the Department for Infrastructure and Transport; the project manager was Alex Duerden.

The views expressed in this report are those of the authors and do not necessarily represent those of the University of Adelaide or the funding organisations.

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