# Peer Reviewed Papers

# Driver behaviour and crash profiles at Seagull T-junctions on high speed rural roads

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## Abstract

The aim of this paper is to evaluate the safety performances of unsignalised Seagull T-junction configuration on high speed rural roads in NSW. The findings were that two types of crashes, Right Near and Right Through, were predominant among all the crashes, and those that result in casualties. Driver impairment, speeding behaviour and road environment conditions were a factor in a small percentage of these crashes.

Of the deemed to be at-fault male drivers, almost two-thirds were at and above the age of 67. However, for each of the other age groups below this, there was a higher incidence of female drivers than male drivers involved in Right Near crashes. The former is consistent with other studies on older male drivers.

Consistent with the New South Wales Roads and Traffic Authority (RTA) Safe System approach, key solutions include substantially reduced speeds for through traffic and removal of critical side impact crash types. This may require further investigation prior to implementation.

## Keywords

Seagull intersection / junction, T-junction, Road safety, Driver behaviour, Driver age, Driver gender, Crash profiles

## Introduction

Rural T-junctions commonly connect a high speed rural road with a minor road that may be controlled by 'Stop' or 'Give Way' signs. Road crashes that occur on rural roads have a greater tendency to result in serious injuries and fatalities, due to the existence of a higher speed environment, remoteness, side impacts and poorer access to emergency services.

In New South Wales, more than 400 crashes occur at rural T-junctions every year. To reduce the road toll, a better understanding of the relationship between road environments and crash patterns is required, and from these findings, recommendations can be made for a better design of T-junctions.

A major road safety study on rural T-junctions is being conducted by the New South Wales Centre for Road Safety. The aim of this study is to quantify the road safety performance of common T-junction configurations. The four T-junction configurations selected for this study are: Basic Right Turn (BAR), Auxiliary Lane Right Turn (AUR), Channelised Right Turn (CHR) and Seagull junction. This outcome of the study will provide measures of the relative crash frequencies and severities at these four T-junction types.

This paper will present findings on Seagull T-junctions only. Findings on other T-junction configurations will be published at a later stage of the project.

## What is a Seagull junction?

A Seagull junction is a common 'at grade' treatment for three legged T-junctions. It consists of a channelised deceleration lane for vehicles turning right into the minor road and a protected acceleration lane for vehicles turning right out of the minor road. These two lanes form the 'wings' of the Seagull when viewed from the air.

An advantage of the Seagull layout is the separation of conflicting vehicle paths. Motorists turning right from the stem of the T-junction need to worry about traffic from one direction only at any time. A typical Seagull layout diagram is in Figure 1.

## Methodology

### Site identification

The first step in the study was to identify the locations of Seagull junctions on the road network. Fifteen state highways known to have high speed rural sections were investigated based on the following criteria:

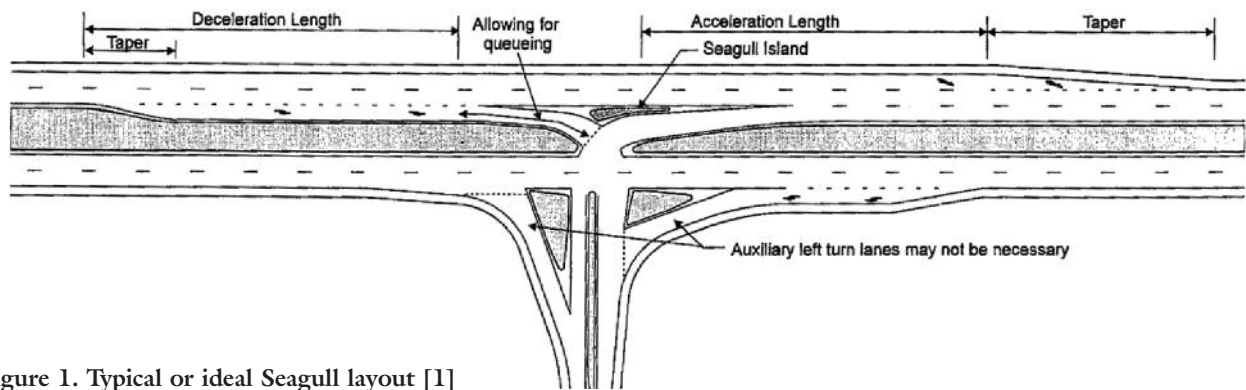- Seagull junctions
- on rural undivided roads

**Figure 1. Typical or ideal Seagull layout [1]**

- with speed limit 90 km/h or above
- having significant traffic volume.

The RTA's Gipsicam[1] system, which allows the investigator to view the intersections from the driver's perspective in various directions, was used to identify these locations. Visual clues used include the following:

- regulatory signs showing speed limit of 90 km/h or above
- presence of a tourist sign, directional sign or other destination signage, which is an indication of a significant traffic volume.

After the Seagull junctions along the highways were identified, the sites for the study were selected. The sites selected were sites where the Seagull junction was in operation for a reasonable length of time and where crashes had occurred. Twenty-three Seagull T-junction sites were identified by using this method.

An added complication is that the configuration of the intersections changes over time and it was difficult to identify the exact installation date for all the sample sites. Some sites may have also been upgraded to their current state from a different configuration.

Hence, in the investigations stage, there was a need to identify the operation period of the configuration at each site and to disregard any crash data that is not applicable to the specific configuration. Historical Gipsicam images were used to determine the definite operation period of the Seagull junction.

For example, Figure 2 shows three Gipsicam images of the same location taken in different years. By comparing the three images, it can be confirmed that

- a Seagull junction was operating by 3 December 2006
- Channelised Right Turn (CHR) treatment operated between 23 February 2001 and 18 February 2004.

In such cases, often the exact date of operation of the Seagull junction could not be ascertained, but for the purpose of this study, only crash data occurring after the date shown on the images showing a Seagull junction was considered for the analysis.

**Crash data analysis**

For this study, crash data were extracted from the Roads and Traffic Authority's Crashlink database, which contain records of all road crashes that occurred on the New South Wales classified roads and local roads network from 1996 onwards.

The data include information on crash location, time of day, surface and lighting conditions, speed limit, road user movements, number of vehicles involved and directions of travel for all reported fatal, injury and tow-away (property damage) crashes. The data used in the study were crashes that occurred between the years 1996 and 2008.

To make the data appropriate for the purpose of this study, the raw crash data were filtered using the following criteria:
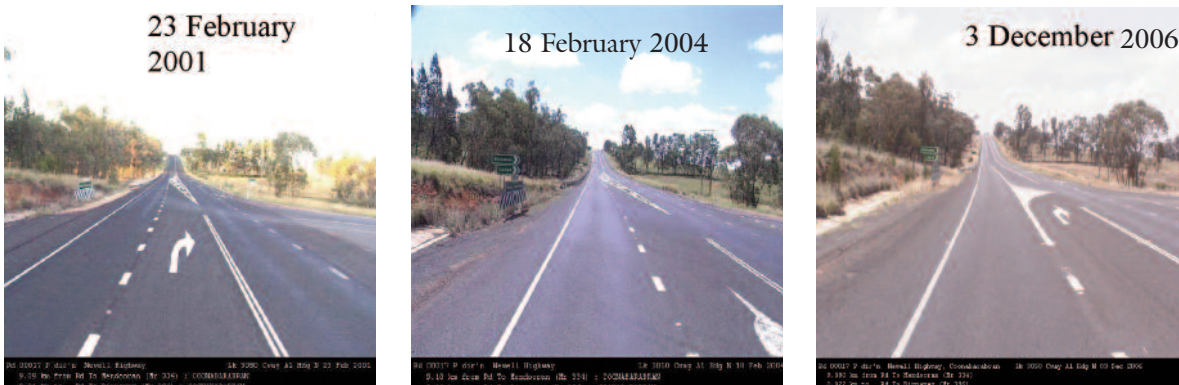


**Figure 2. Gipsicam images of the same junction over a period of years**

- Only crashes occurring within 100 metres from the node on any of the three legs of the Seagull junction were included in the analysis.
- Crashes that were not within the operation period of the Seagull junction (described in the previous section) were excluded from the analysis because these crashes were unlikely to be affected by the Seagull junction.
- Only intersection-related crashes were included. Other crashes such as Off Road on Straight, Off Road on Curve and Hit Animal were excluded, as they are unrelated to the presence of the Seagull junctions.

The selected crashes were analysed in terms of crash severity, crash types, behavioural factors, road environment factors and road user factors. During the analysis, it was noted that some of the crashes were coded as Cross Traffic crashes. This was considered to be in error, as Cross Traffic crashes cannot occur at T-junctions. These crashes were re-coded as Right Near crashes, which were nearest equivalent crash type to a Cross Traffic crash.

## Results

These results are based on an analysis of all intersection related crashes that occurred at the 23 chosen Seagull junctions within the period of study as defined in the methodology.

A total of 153 reported crashes were analysed. Table 1 summarises these crashes by the degree of crash severity. There were 4 fatal crashes (4 fatalities), 82 injury crashes (154 injuries) and 67 tow away crashes. More than half of the crashes (57%) were casualty crashes, involving at least one person being killed or injured.

| Degree of crashes | Number of crashes | |
|---|---|---|
| Fatal | 4 | 3% |
| Injury | 82 | 54% |
| Tow away | 67 | 44% |
| TOTAL | 153 | |

**Table 1. Number and degree of crashes**

### Behavioural factors

Behavioural factors such as driver fatigue, alcohol usage and excessive speeding were also assessed. None of the crashes involved were identified as driver fatigue crashes. 6 crashes (4%) were known to involve alcohol and only 4 (3%) of the crashes had speeding identified as a factor. The low rate of identification of speed may have occurred because the errors are apparent in crashes at Seagull intersections (especially failure to give way), yet clear evidence of speed is difficult to obtain.

| Behavioural Factors | | | |
|---|---|---|---|
| | Fatigue identified | Known alcohol | Speeding identified |
| Yes | 0 | 6 | 4 |
| No / Unknown | 153 | 147 | 149 |
| **TOTAL (all crashes)** | **153** | **153** | **153** |

**Table 2. Behavioural factors involved in analysis of 153 crashes**

### Road environment factors

Of the total number of crashes, 73% occurred during daylight with dry surface conditions, 15% during daylight with wet conditions, 9% during darkness with dry conditions and 3% during darkness in wet conditions. Despite 18% of the crashes occurring in the wet surface, only 14 motor vehicles out of 315 (4%) involved skidding and sliding.

| | Surface condition | Dry | | Wet | |
|---|---|---|---|---|---|
| Natural lighting | Darkness | 14 | 9% | 5 | 3% |
| | Daylight | 111 | 73% | 23 | 15% |
| **TOTAL (all crashes)** | | | **153** | | |

**Table 3. Road environment factors involved in analysis of 153 crashes**

### Crash types

Table 4 summarises the number of crashes by crash type. The predominant crash types were Right Near, Right Through and Rear End which account for 45%, 27% and 14% respectively. Right Near and Right Through movements were more severe with 48% and 31% of the crashes being casualty crashes. Rear End crashes were less severe, with only 7% resulting in casualties.

A majority of the crashes (121) occurred as a result of poor gap selection by the driver in the key vehicle, which means that the driver was unable to select a safe gap to clear the intersection. Of the crashes, Right Far (RUM 11), Right Near (RUM 13), Two R Turning (RUM 14), Left Near (RUM 16), Right Through
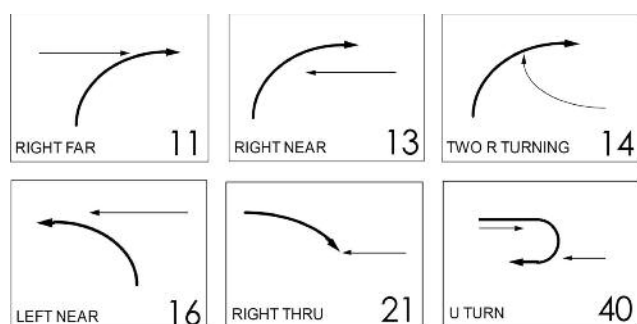


**Figure 3. Vehicle path diagrams for poor gap selection crashes**

| Road User Movement (RUM code) | Fatal | Injury | Tow away | Total | % Total | % of casualty crashes |
|---|---|---|---|---|---|---|
| **Adjacent - Right Near (13)** | 3 | 38 | 28 | 69 | 45% | 48% |
| **Right Through (21)** | 1 | 26 | 14 | 41 | 27% | 31% |
| **Rear End (30-32)** | 0 | 6 | 15 | 21 | 14% | 7% |
| **Adjacent - Other (11; 12; 14 - 19)** | 0 | 4 | 7 | 11 | 7% | 5% |
| **Lane Change (33-35)** | 0 | 3 | 2 | 5 | 3% | 3% |
| **Off End of T-Junction (75)** | 0 | 2 | 1 | 3 | 2% | 2% |
| **U-Turn (40)** | 0 | 1 | 0 | 1 | 1% | 1% |
| **Parallel Lanes Turning (36 - 37)** | 0 | 1 | 0 | 1 | 1% | 1% |
| **Vehicle Accessing Road (42; 47 - 49)** | 0 | 1 | 0 | 1 | 1% | 1% |
| **TOTAL** | **4** | **82** | **67** | **153** | | |

**Table 4. Crashes by Road User Movement (RUM) groups**

(RUM 21) and U-turn (RUM 40) were considered to be related to poor gap selection. They account for 79% of the total number of crashes.

The crash type diagrams detailing vehicle travel paths of the key and second vehicles for each of these crashes are shown in Figure 3.

### Vehicle type

Further analysis was carried out to identify the vehicle type of the deemed to be at fault vehicle[2], and the second vehicle, for the 121 crashes that were a result of poor gap selection. As shown in Figure 4 below, the distribution of vehicle types for the key and the second vehicle is almost identical, with a majority of the traffic units being motor cars.

### Time of day

The incident time of the 121 poor gap selection crashes were also analysed. Of the crashes, 105 occurred between 8am and 6pm, which accounts for 87% of the poor gap selection crashes. The crashes that occurring in the two-hour time groups of 8am-10am, 10am-12pm, and 12pm-2pm were consistently at 12-13%. However, the number of crashes that occurred in the afternoon periods of 2pm-4pm and 4pm 6pm come to 24%, which is double the number of crashes during the morning and mid-day periods.
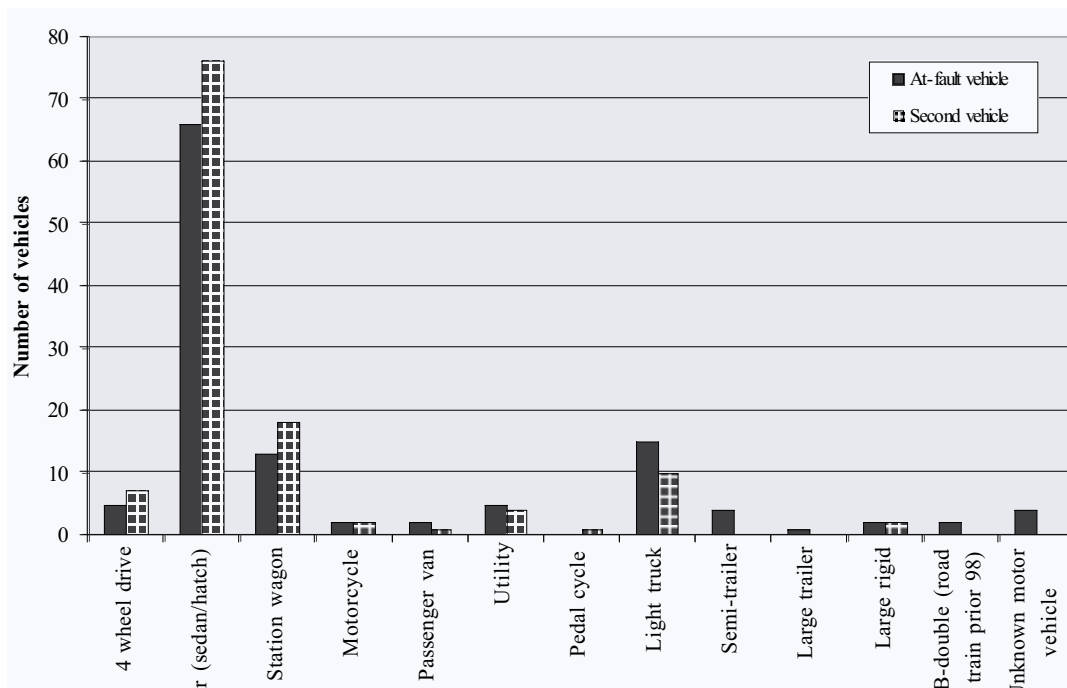


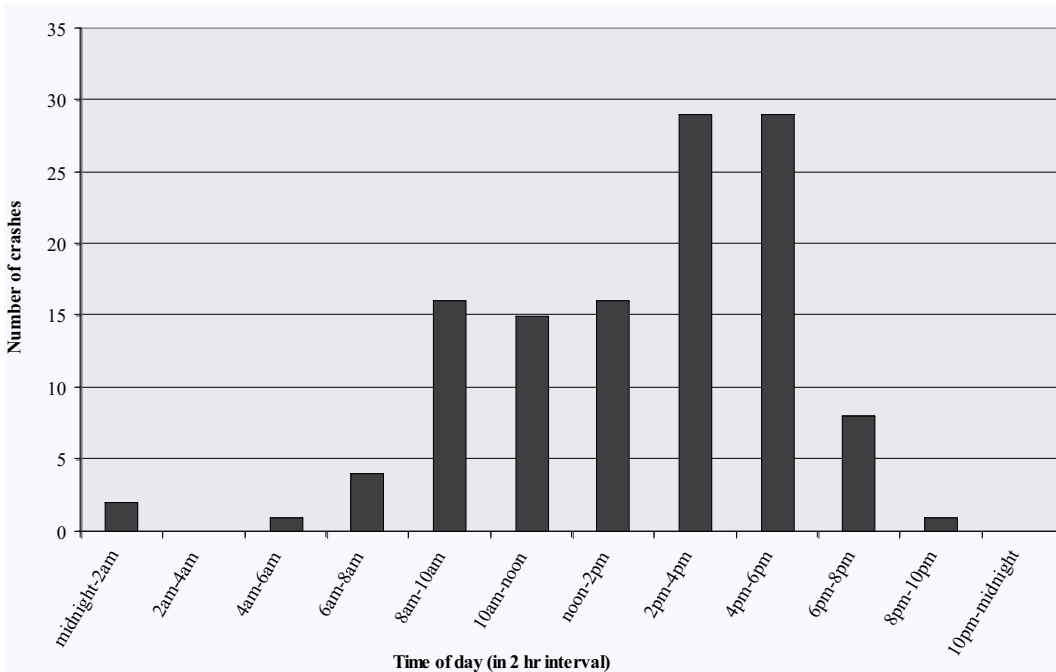**Figure 4. Vehicle types of key and second vehicle involved in poor gap selection crashes**

**Figure 5. Crashes related to poor gap selection in 2-hour intervals**

### Age group, gender and time of day

The gender and age groups of the deemed to be at-fault drivers[3] (those unable to select a sufficient safe gap) of the 121 poor gap selection crashes were identified. The two most severe crash types (Right Near and Right Through) were analysed separately.

Right Near crashes are those that occurred as a vehicle turned right out of the minor road and collided with the vehicle from the right. The at-fault driver who is performing the right turn manoeuvre is only required to observe the safe gap from the adjacent vehicles, as a fully protected acceleration lane is available once the right turning vehicle is on the 'wing' of the Seagull junction.

There were 69 Right Near crashes, with almost an equal split on the total number of female (34) and male (35) key vehicle at-fault drivers, as shown in Figure 6. The distribution of female at-fault drivers is consistent across all ages, with the number of

crashes fluctuating between 4 and 6. Male drivers appear to perform relatively better than female drivers in Right Near crashes at or under the age of 66. However, in the age group from 67 to 96, the proportion of male at-fault drivers increases substantially. Approximately 60% of male at-fault Right Near crashes are within this group.

From Figure 7, the distribution of male at-fault drivers shows a steady increase with time of the day, with the peak at 2pm-4pm followed by a gradual decrease after the peak. In contrast, the distribution of crashes with female at-fault drivers has two peaks, one at 8am-10am and a second peak at 4pm-6pm.

Right Through crashes occurred when the driver travelling from the main through road performed a right turn into the minor road and collided with an opposing vehicle. The at-fault driver performing the right turn is required to observe the safe gap from an oncoming vehicle.
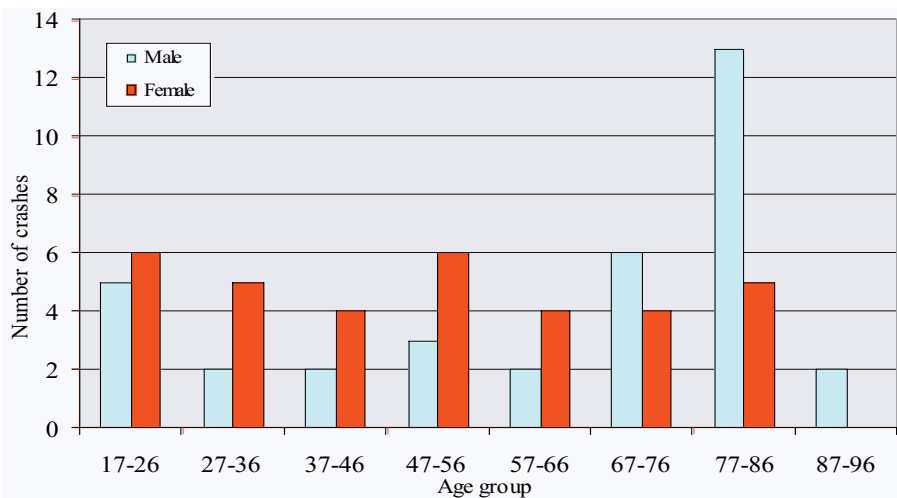


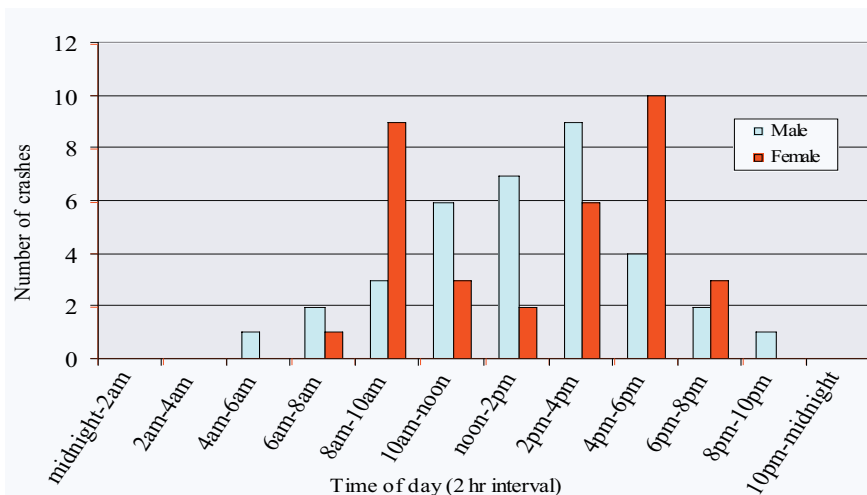**Figure 6. Distribution of Right Near Crashes (RUM 13) in age and gender group**

**Figure 7. Distribution of Right Near crashes (RUM 13) in 2-hour intervals and gender group**

*(Note: Time of day may reflect traffic volume and should not be interpreted to indicate more problem behaviour.)*

There were 41 Right Through crashes involving 20 female and 21 male at-fault drivers. The dataset may not be large enough to show a significant difference in different age groups and time intervals for this crash type, as indicated in Figures 8 and 9, respectively. However, it gives an indication that a majority of the at-fault drivers for Right Through crashes were in the lower age groups. Unlike the case of Right Near crashes, older male drivers are not so significant in terms of crash frequencies. Similarly, a majority of the crashes occur at the afternoon hours between 2pm-4pm and 4pm-6pm.

## Discussion

There were 153 reported crashes at the 23 Seagull T-junction sites, of which 57% of the crashes were casualty crashes. A majority of the crashes occurred with dry surface conditions and during daylight hours and in light motor vehicles. Although 18% of the crashes occurred with wet surface conditions, this is not considered to be a significant factor as only 4% of the vehicles involved in a crash had skidding or sliding as an error factor.

This is consistent with studies by Arndt [2] that found that the majority of the high frequency intersection crashes occurred during clear conditions and in daylight. The study also suggested that it is possible that, because traffic volumes and delays are greater during the hours of daylight, drivers accept smaller traffic gaps, thereby taking greater risk and increasing their likelihood of being involved in a crash.

The predominant crash types are Right Near (45%), Right Through (27%) and Rear End (14%). Right Near and Right Through crashes contribute 48% and 31% of the casualty crashes. Rear End account for only 4% of the casualty crashes. Of the total crashes, 87% were due to the result of poor gap selection by the deemed to be at-fault driver.

The crash frequencies of older male drivers in Right Near crashes were substantially higher than younger age groups. Approximately 60% of the male deemed to be at-fault drivers involved in Right Near crashes were at or above the age of 67. In general, the crash occurrences of Right Near (adjacent traffic gap) crashes of female drivers at or under the age of 66 were higher than male drivers in the equivalent age group. With the 56% of female driver deemed to be at-fault Right Near crashes occurring at 8am-10am and 4pm-6pm, 73% of these female drivers were at or under the age of 66.
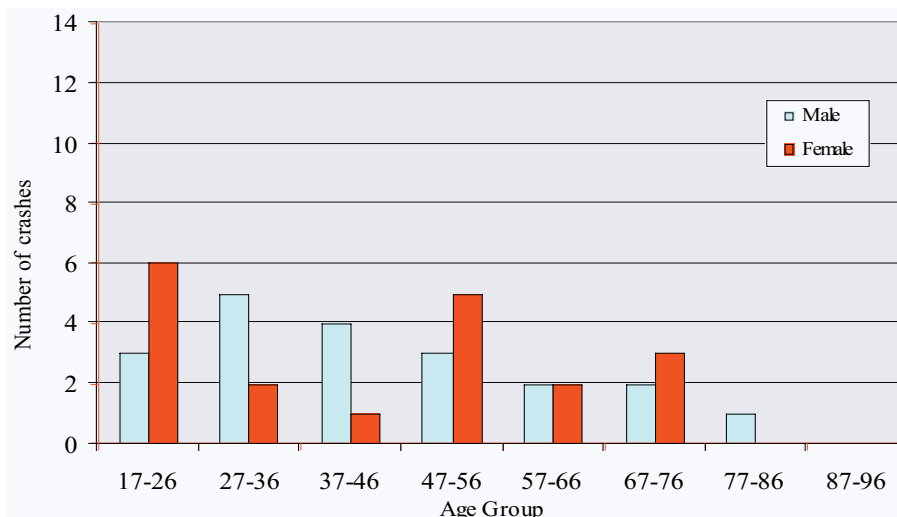


**Figure 8. Distribution of Right Through Crashes (RUM 21) in age and gender group**
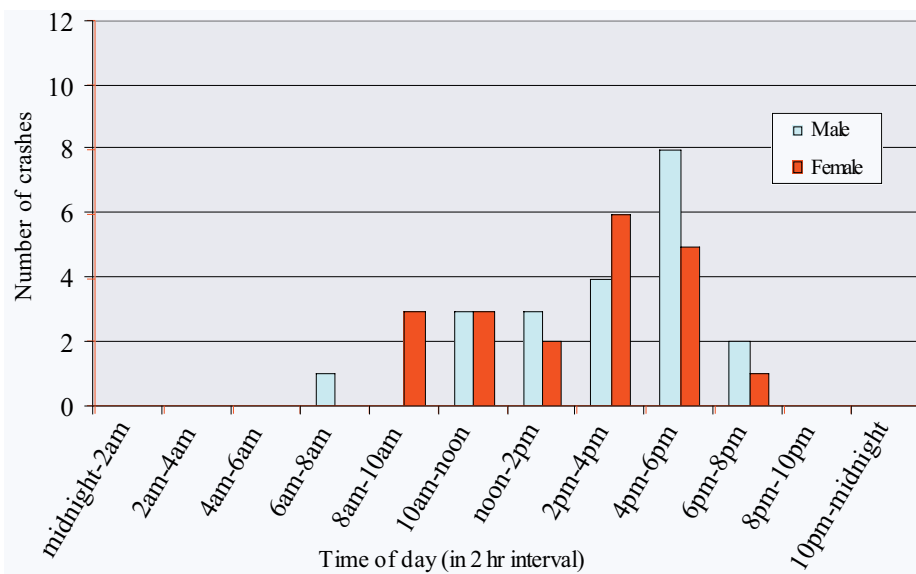
**Figure 9. Distribution of Right Through Crashes (RUM 21) in 2-hour interval and gender group**

A study by King [3] found that older drivers were more likely to be involved and responsible for intersection crashes. Similarly, Ryan, Legge and Rosman [4] also found that older drivers over the age of 60 had more direct and indirect right angle crashes. Another study by Oxley, Fildes, Corben and Langford [5] found that older drivers had problems in determining safe gaps and turning across oncoming traffic. Job [6] also found that older males are more overconfident about their driving ability.

Yan, Radwan and Guo [7] suggested older drivers rely primarily on perceived distance to perform gap selection judgements. There is also work suggesting that older drivers may have difficulty selecting safe gaps in traffic while the principles of gap identification and ability to judge speed and safe distance can apply to drivers as well. For example, an experimental study by Oxley, Ihsen, Fildes, Charlton and Day [8] in a simulated environment showed that a high proportion of older pedestrians selected unsafe gaps to cross the virtual road. This experiment followed an RTA-funded real world observation of the same pattern of gap acceptance and age [9].

The above studies are consistent with the findings in this study that older drivers have a higher probability of involvement in right angle crashes. It is possible that this may be due to the deterioration in their cognitive ability, resulting in a delayed reaction time and difficulty in selecting safe gaps.

The reasons for the uneven gender split of deemed to be at-fault drivers in Right Near crashes in the age of 67 or above are at this stage unclear. However, in general, there are fewer older female drivers on the roads [10], and hence may be less represented in the crash statistics. Hakamies-Blomqvist [11] also found that older female drivers drive less than male drivers.

The observation that younger female drivers are over-represented in Right Near crashes could be because female drivers are more responsive to pressure from higher traffic volumes. It may also be due to other factors that are not captured in the crash database. Further research is required to identify the influencing factors.

As Right Through crashes involve substantially lower numbers of older drivers, it is conjectured that the right turn manoeuvre only requires drivers to look forward to judge the speeds and distances of opposing vehicle (apparently head on) which falls within their peripheral limit. There is no significant pattern in terms of age band and gender group to suggest possible reasons for the crash. The crash data demonstrated a vast majority of these crashes had no influence of alcohol, driver fatigue and excessive speeding. There may be a broad range of reasons why these crashes are occurring, however, no obvious ones were identified other than that of a diminishing cognitive ability to select gaps due to age.

## Conclusion

This paper provides empirical evidence of the crash frequencies and patterns of reported crashes occurring at rural Seagull T-junctions. It also produced identification of crash profiles for further analysis. The findings from this study will still be applicable even though the demographics in other locations may be different.

Future studies will place emphasis on identifying crash trends at Seagull junctions as compared with other T-junction configurations. A full report, which will assist road safety practitioners in selecting T-junction treatments, will be compiled once the other T-junction configurations have been analysed.

The crash data indicates two groups of drivers that have a higher risk of crashes at rural Seagull T-junctions, namely young female drivers and older (at or above 67 years of age) male drivers.

The Seagull treatment separates out conflict points and thereby reduces the conflict complexity. The Seagull treatment provides relatively safe positions for drivers to stop before turning as demonstrated by the relatively few rear end crashes. However, the Seagull treatment, like other rural intersection treatment, does not affect the speeds of through traffic, and other means to reduce the speeds of through traffic requires further consideration and research.

Consistent with the RTA's Safe System approach, which acknowledges the inevitability of human errors, the feasibility of reducing the entering speeds of the through traffic into the T-junction and other measures to minimise conflict points may be considered for the junctions where crashes have occurred.

## Notes

1   Gipsicam is a mobile mapping system that records photo images of RTA's State road network. It also provides accurate Geographic Positioning System (GPS) coordinates for the photo location. The roads are re-surveyed every two to three years, and the survey date is clearly marked on the image. It enables users to view images of the State road network in 10-metre intervals for both directions.

2   At-fault vehicle is defined as the key and second vehicle involved in the turning movement based on the vehicle travel directions provided in the crash data. Second vehicle is defined as the next vehicle that collided with the at-fault vehicle.

3   At-fault driver is defined as the driver controlling the at-fault vehicle who made the gap selection decision for the turning movement – that is, the driver who failed to give way.

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# Evaluation of narrow median wire rope barrier installation on Centennial Highway, New Zealand

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## Abstract

This paper reports on the performance of a wire rope barrier on a narrow median installation on Centennial Highway, New Zealand. Since the time the speed limit was reduced from 100km/h to 80km/h and the wire rope median barrier was installed, no fatalities or serious injuries have occurred. The median barrier was introduced in two stages and has been very successful in reducing road trauma. Prior to stage one the average annual social cost of crashes on Centennial Highway was $5,796,889.[1] This has since reduced to an average social cost of $65,400 per year.

Surveillance of the Centennial Highway median barrier showed that vehicles generally sustained relatively little damage when they struck the barrier and were often observed to drive away after the impact. Drivers also tended to travel more centrally within their lane with the barrier in place.

While the narrow median on Centennial Highway has resulted in an increase in maintenance costs due to impacts on the wire rope barrier, this cost has been significantly offset by reductions in trauma costs. This paper presents a number of challenges that needed to be overcome to construct the narrow median wire rope barrier and evaluates the success of the barrier in reducing road trauma along this section of state highway.

## Keywords

Head-on crashes, Wire rope, Median barriers