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TITLE

A comparison of uncontrolled, give way sign controlled and stop sign controlled intersections in South Australia

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ABSTRACT

The Centre for Automotive Safety Research (CASR) has undertaken study to compare uncontrolled, give way and stop sign controlled intersections as used in South Australia. The answers to two basic questions are desired: is more control justified if safety is impaired; and do road users differentiate by the type of control employed? The use of different levels of control was investigated through a literature review, analysis of in-depth crash investigation files and a survey of road users in South Australia. There appears to be some benefit to the use of greater control but the reasons behind this are unknown. The survey results also suggest a residual of road users are confused and prone to error at controlled and uncontrolled intersections. Recommendations to help remedy this issue include adding redundancy at intersections through the use of Safe System design principles, controlling all uncontrolled T-junctions and upgrading superseded intersection advanced warning signs.

KEYWORDS

Intersection, uncontrolled, stop sign, give way sign, safety

Summary

In Australia, the use of stop and give way controls and their associated signage is controlled by Australian Standards and the Austroads Guidelines (Austroads, 2013; Standards Australia, 2009). The warrants for employing stop sign control generally extend to intersections with limited sight distances from the minor road.

The Centre for Automotive Safety Research (CASR) has undertaken study to compare uncontrolled, give way and stop sign controlled intersections as used in South Australia. Beyond a broad categorisation of "improved/reinforced priority" being given a crash reduction factor of 30% for adjacent approach crashes, there is little consideration of the safety benefits of employing greater control, such as replacing give way with stop control, at non-signalised intersections. Given the safety biased nature of the warrants for implementing greater control, it is necessary to understand whether there is a perceivable benefit to having such levels of control. Moreover, there remains a need to understand why such a benefit may exist and whether this benefit is aligned or counter to road user expectations.

The answers to two basic questions are desired: is more control justified if safety is impaired; and do road users differentiate by the type of control employed? The aims of this study are to:

- Review and compare safety of intersections with each form of control
- Identify the mechanisms for crashes that occur at intersections with each form of control
- Identify the mechanisms related to a difference in the level of safety, if any, at intersections with each form of control
- Identify road user perceptions of personal risk and expectations surrounding the use of intersections with each form of control.

Literature review

Overall, there appears to be some evidence supporting reduced crash risk associated with the use of stop control over give way control, though it is not understood what the underlying mechanisms behind this benefit are. There is also evidence to support a reduction in control leading to increased crash risk. The benefits of increased control at three-way intersections are not as evidential.

Many of the crashes resulting at four-way controlled intersections appear to be adjacent approach, right-angle crashes. The few studies that have looked into the mechanisms of such crashes commonly attribute non-compliance of the control as a leading mechanism (i.e. a driver on the minor road failing to give way to adjacent traffic).

In the case of stop sign controlled intersections, it is suggested that traversing stop signs without stopping can be a substantial issue but that doing so is not over-proportionally observed in crashes at such intersections.

In-depth crash investigation

A range of mechanisms were identified for crashes at both intersection types. Visual obstructions were no more of an obvious issue at the crashes occurring at stop controlled intersections, compared to those occurring at give way controlled intersections. A higher proportion of cases occurred at stop controlled intersections where the minor road driver stopped before proceeding, compared to give way controlled intersections. At both give way and stop controlled intersections, a number of crashes occurred when the minor road driver did not appear to recognise the presence of either any control or the intersection itself. All crashes at uncontrolled intersections occurred at T-junctions. While there were some notable

differences in the crash mechanisms at these intersections, the preclusion of any cross road intersection cases makes comparison with the other cases difficult.

RAA survey

A survey was undertaken to identify the perception of risk that road users associate with varying levels of control at intersections. A number of questions were asked during the survey, some aimed at identifying differences in perception between control types and others aimed at identifying perceptions of related issues.

Importantly, the survey responses suggest a residual of road users (approximately 4-10% of survey respondents) do not correctly identify an expectation of the need to give way to other vehicles at intersections. This was particularly evident with uncontrolled T-junction intersections.

There was little difference between perceived risk at stop or give way controlled four-way intersections in the metro scenarios. Stop controlled intersections were perceived to be marginally safer for rural scenarios. Safe system scenarios were also tested. On average, roundabouts (metro and rural) were perceived to be moderately safer by all respondents. On average, raised plateaus (tested for the metro scenario only) were perceived to be less safe than other control types, particularly by motorcyclists.

Overall conclusions

Regarding the main topic of this report (a comparison of uncontrolled, give way and stop controlled intersections), there appears to be some benefit to the use of greater control (e.g. stop control instead of give way control) at four-way intersections. This finding was reflected in the literature review, with a general consensus regarding reduced crash risk when greater control was used to replace lesser control.

Recommendations

Results of this study, particularly the survey, highlighted important issues of road user perception and awareness at intersections. In order to help rectify these issues, the following recommendations are made.

- A residual of road users do not correctly identify expecting the need to give way at non-signalised intersections (approximately 4-10% of survey respondents). It is therefore recommended that redundancy be introduced at intersections where such confusion and therefore error could lead to severe outcomes. Redundancy could come from treatments that reduce outcome severity or likelihood of error. Safe System intersection designs, which are focussed on eliminating the potential for severe outcomes should an error occur, are recommended as a priority treatment for introducing redundancy.
- Uncontrolled T-junctions appear to elicit confusion in a proportion of road users (Approximately 7% of survey respondents). It is recommended that all uncontrolled T-junctions be treated with, at a minimum, give way control.
- A substantial proportion of road users appear to be more confused about expecting the need to give way at upcoming intersections where a superseded (without directional arrow) side-road or cross road ahead sign is present. It is recommended that these superseded signs be identified and replaced with updated signs as a priority action.

- While there appears to be some benefit to the use of greater control (e.g. stop control instead of give way control) at four-way intersections, the reasons behind this are unknown. It is recommended that further research be undertaken to gain a better understanding of these reasons.

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

Contents

1 Introduction

In Australia, the use of stop and give way control and their associated signage is controlled by Australian Standards and the Austroads Guidelines (Austroads, 2013; Standards Australia, 2009). The warrants for employing stop sign control generally extend to intersections with limited sight distances from the minor road, though anecdotal evidence suggest other reasons such as community requests extending from safety concerns are also used.

The Centre for Automotive Safety Research (CASR) has undertaken study to compare uncontrolled, give way and stop sign controlled intersections as used in South Australia. Beyond a broad categorisation of “improved/reinforced priority” being given a crash reduction factor of 30% for adjacent approach crashes, there is little consideration of the safety benefits of employing greater control, such as replacing give way with stop control, at non-signalised intersections. Given the safety biased nature of the warrants for implementing greater control, it is necessary to understand whether there is a perceivable benefit to having such levels of control. Moreover, there remains a need to understand why such a benefit may exist and whether this benefit is in-line or counter to road user expectations.

The answers to two basic questions are desired: is more control justified if safety is impaired; and do road users differentiate by the type of control employed? To answer these questions, the aims of this study are to:

- Review and compare safety of intersections with each form of control
- Identify the mechanisms for crashes that occur at intersections with each form of control
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- Identify road user perceptions of personal risk and expectations surrounding the use of intersections with each form of control.

The methods employed in the study include a review of Australian and international literature, a review of in-depth crash investigation cases and an online survey. The second method employed in-depth crash investigation cases amassed by CASR through its in-depth crash investigation work. The final method employed an online survey undertaken by the Royal Automobile Association of South Australia (RAA) on behalf of CASR.

2 Literature review

There are a number of publications devoted to the study of non-signalised intersections. Much of the recent safety oriented literature has focussed on the development of infrastructure treatments to existing intersections, such as the use of advanced warning signs and increasing the conspicuity of control signs themselves. A sample of this literature is reviewed in more detail below. This may indicate that the prevailing problem is a lack of driver awareness of the possible need to give way to other traffic at the intersection. However, as detailed below, the older literature seems to suggest that this is not the most significant safety issue at non-signalised intersections. Instead, the prevailing problem seems to be a driver's awareness of other traffic on the cross-road – the issue of "looked but did not see".

A number of publications have directly compared the safety effects of uncontrolled, give way sign controlled and stop sign controlled intersections (Elvik & Vaa, 2004). However, the number of these that have been published in English is limited, with many being published in only Scandinavian languages. Elvik, Hoye, Vaa, and Sorensen (2009) provide a review of these Scandinavian publications.

While not used in South Australia and not commonly used anywhere in Australia, all-way stop sign (AWSS) controlled intersections (i.e. a stop control on each leg of the intersection) have been widely studied. Much of this literature is devoted to the comparison with two-way stop sign (TWSS) controlled intersections. Unlike with TWSS control, the purpose of an AWSS controlled intersection is not to assign priority to certain legs. Instead, the purpose of this control type is merely to mandate the stopping of every vehicle that approaches the intersections before they proceed through. The right-of-way rules of an all-way stop sign controlled intersection work in much the same way as an uncontrolled intersection. When two or more vehicles approach the intersection at similar times, each driver must give way to the right. As its use in Australia is limited, AWSS controlled intersections are discussed separately from other control types.

2.1 Crash types

Five publications were found that reported on the types of crashes that occurred at non-signalised intersections. All reported information for stop sign controlled intersections while one reported information for uncontrolled intersections. No information was found for give way sign controlled intersections.

Within these five publications, there is consensus that lateral direction crashes are the most commonly occurring types of crashes at TWSS controlled intersections. A lateral direction crash refers to the collision between two (or more) vehicles approaching the intersection on adjacent legs. Retting, Weinstein, and Solomon (2003) analysed urban intersection crashes in four US states, reporting that stop sign violations account for 78% of crashes at four-way intersections and 59% of crashes at three-way intersections. Stokes, Rys, Russell, Robinson, and Budke (2000) reported that between 76% and 88% of crashes that occurred at a number of high-crash frequency intersections in rural Kansas State were between vehicles traveling along the minor and major roads, respectively. A United States-wide study by Ragland and Zabyshny (2003) analysed over 1.5 million intersection crashes and found that over 82% were lateral direction type crashes.

Lateral direction crashes most commonly result in a right-angle crash configuration. The high impact angle of these crashes lends them to often resulting in injuries. This is especially true at rural intersections where high through speeds ultimately lead to high impact speeds and crash severities. Preston and Storm (2003) reported that 33% of rural TWSS controlled intersection crashes in their US-based study were the result of right-angle configurations. They also reported that 62% of serious injury and 71% of fatal crashes were of right-angle configurations. Souleyrette, Tenges, McDonald, and Maze

(2005) also looked at rural intersection crashes in the US (Iowa). They found that 57% of crashes at uncontrolled intersections and 82% of crashes at stop sign controlled intersections were of right-angle configuration. Ragland and Zabyshny (2003) reported that 70% of crashes at TWSS controlled intersections were of right-angle configuration and that 45% of crashes resulted when both vehicles on the major and minor road attempted to travel straight through the intersection. Between 25% and 60% of crashes at TWSS controlled intersections have been reported as resulting from a vehicle attempting to turn from the minor road across major road traffic (Ragland & Zabyshny, 2003; Stokes et al., 2000). It was also reported that crashes involving a vehicle turning across oncoming traffic account for few crashes at TWSS controlled intersections (Ragland & Zabyshny, 2003; Retting et al., 2003).

- *A large proportion of crashes at rural 4-leg stop sign controlled intersections are adjacent direction configuration*
- *The majority of these are of right-angle configuration*
- *Few crashes result from right turns from the major road*
- *One study found much higher rates of right-angle crashes at stop sign controlled compared to uncontrolled intersections*
- *One study found a higher proportion of crashes at 4-leg intersections are due to stop sign violations compared to 3-leg intersections*
- *One study found nearly half of all crashes at 4-leg stop sign controlled intersections being between adjacent through-direction vehicles*
- *One study found a very large proportion of SI and fatal crashes were the result of right-angle crashes*

2.2 Comparison of crash frequency

Seven publications were found that made comparisons between the crash rates at uncontrolled, two-way give way sign (TWGWS) controlled and two-way stop sign (TWSS) controlled intersections (Table 2.1). Most of these are now more than twenty years old.

Table 2.1
Publications reporting on the crash rate effects of changing control type. Bold values represent changes in casualty crashes

<table>
<tr><th></th><th colspan="5">4-leg or unstated</th><th>3-leg</th></tr>
<tr><th>Before control type
After control type</th><th>Uncontrolled
GWS</th><th>Uncontrolled
SS</th><th>GWS
SS</th><th>SS
GWS</th><th>AWSS
SS</th><th>Uncontrolled
GWS/SS</th></tr>
<tr><td>Andersson (1982)</td><td></td><td></td><td>-44% (ALL)
-65% (RA)</td><td></td><td></td><td></td></tr>
<tr><td>Elvik et al. (2009)</td><td>No change</td><td>-35%</td><td></td><td>+40%</td><td></td><td>-20% (ALL)</td></tr>
<tr><td>Frith and Harte (1986)</td><td colspan="2">Stat. sig. reduction</td><td></td><td></td><td></td><td>No change</td></tr>
<tr><td>Ligon, Carter, and McGee (1985)</td><td></td><td></td><td></td><td></td><td>Increase</td><td></td></tr>
<tr><td>McGee and Blankenship (1989)</td><td></td><td></td><td></td><td>Increase</td><td></td><td></td></tr>
<tr><td>Pegrum, Lloyd, and Willett (1972)</td><td>-19% (RA)
-34% (AD)</td><td></td><td></td><td>+11% (ALL)
+31% (RA)
+42% (AD)</td><td></td><td></td></tr>
<tr><td>Polus (1985)</td><td colspan="3">Non-stat. sig. increase</td><td></td><td></td><td></td></tr>
</table>

RA = right angle crashes, AD = adjacent direction crashes, ALL = all crashes

2.2.1 Increased control

Seven publications reported on conversions resulting in an increase in control, such as from uncontrolled to controlled or from give way to stop control.

Uncontrolled to give way control

Elvik et al. (2009) reviewed a number of publications from mostly Scandinavia and also from Australia, New Zealand and North America. They concluded that the evidence reflects little perceivable change in crash rate when uncontrolled intersections are converted to give way control. Frith and Harte (1986) came to the same conclusion for three-leg intersections, but concluded a statistically significant reduction in total and adjacent direction crashes at four-leg intersections converted to TWGWS control in a study of 53 intersections in New Zealand. Pegrum et al. (1972) concluded a 19% reduction in right-angle crashes and a 34% reduction in adjacent direction crashes after conversion in a study of 566 Perth metropolitan intersections converted to TWGWS control after the introduction of priority control in 1970. Polus (1985) in a study of 65 intersections in Israel concluded that the crash rate after conversion tended to increase. However, the author noted that most results were not statistically significant at a 95% confidence level.

Uncontrolled/give way control to stop control

Andersson (1982) reviewed crash results from a number of Nordic countries where a total of 124 give way controlled intersections were converted to stop control. After conversion, the rate of total crashes reduced by 44% while adjacent direction crashes reduced by 65%. Crash reductions were found to be greater at intersections where vision was at least average, where minor road volumes were greater and where the major road speed limit was 60 km/h or below. It was noted by the author that regression to the mean could not be controlled and thus the stated results were possibly an over-estimate compared to the true reductions in crash rates.

Elvik et al. (2009) reviewed a number of publications from mostly Scandinavia and from Australia, New Zealand and North America. They concluded that converting either uncontrolled or give way control to stop control at three-leg intersection and four-leg intersections led to best estimate reductions in injury crash rates of 20% and 35%, respectively. Frith and Harte (1986), in a study of 71 uncontrolled four-leg intersections converted to stop control in New Zealand, also concluded a statistically significant reduction in crashes. However, they also concluded no change in crash rates at three-leg intersections where the same conversion was undertaken.

Polus (1985) reviewed crashes at 65 uncontrolled and 23 give way controlled intersections in Israel converted to stop control. It was concluded that the crash rate after conversion increased, though most results were not statistically significant at a 95% confidence level.

- *A very limited number of studies were available, though a review of several mostly Scandinavian studies by Elvik et al. (2009) provided results for a meta-analysis of the reviewed publications*
- *Suggestions that conversion of 3-leg uncontrolled intersections to give way control does not reduce crash risk*
- *Conflicting evidence as to whether conversion of 4-leg uncontrolled intersections to give way control does or does not reduce crash risk*
- *Suggestions that a reduction in crashes of up to 44% at four-leg uncontrolled or give way controlled intersections converted to stop control*
- *Conflicting evidence as to whether increasing control to stop control at three-leg intersection does or does not reduce crash risk; reductions, if any, are likely to be less than at four-leg intersections*
- *One study suggested conversion from give way to stop control likely to be most effective at reducing crashes at intersections with average or above vision, with higher minor road volumes and with a major road speed limit of 60 km/h or less*

2.2.2 Reduced control

Three studies reported on reduced control conversions, such as from TWSS to TWGWS control or AWSS to TWSS control.

McGee and Blankenship (1989) studied crashes before and after the conversion from TWSS control to TWGWS control at 141 intersections in three United States cities. In two cities, there was an increase in crashes at 47% and 37% of intersections, respectively. A statistically significant increase in crashes after conversion was seen in one of the three cities. The second city had a non-statistically significant increase in crashes while not enough data was collected for the third city.

Ligon et al. (1985) studied the effect of conversion from AWSS to TWSS control. They found a significant increase in the aggregated number of accidents after conversion (based on all 172 intersections studied). However, an actual increase occurred at 16% of sites with 9% of sites showing a decrease. The authors concluded that specific geometric features may have contributed to the increase in crashes at specific sites. The increase in crashes was significantly higher where no supplementary signs advising motorists of upcoming stop sign removal were used.

Elvik et al. (2009) reviewed a number of publications and reported that conversion from TWSS to TWGWS control increased injury crashes by about 40% and PDO crashes by about 15%.

- *Only three studies were available, including a review of some mostly Scandinavian publications by Elvik et al. (2009)*
- *Limited evidence suggests that conversion from TWSS to TWGWS control may result in an increase in crashes*
- *One study provided evidence that conversion from AWSS to TWSS control may result in an increase in crashes, with appropriate signal warning motorists of the changes being important to reduce this effect*

2.3 Crash mechanisms

Reporting of crash mechanisms in the literature has been limited to control violations. This is not surprising, as the majority of crashes, particularly those resulting in injuries, have been attributed to vehicles approaching one-another for lateral directions (Preston & Storm, 2003; Ragland & Zabyshny, 2003).

Of the near 530 right-angle crashes observed at four-legged TWSS controlled intersections by Preston and Storm (2003), 57% involved a vehicle that had stopped at the stop sign before entering the intersection. Crashes that involved a vehicle travelling through the intersection without stopping comprised 26% of right-angle crashes and the mechanism for 17% of crashes could not be identified.

A study by Retting et al. (2003) found that at 1,788 three- and four- legged stop sign controlled intersections, the majority of crashes were due to non-compliance of the stop sign control. At the four-legged intersections, non-compliance led to 78% of all crashes. Of these, 63% involved a vehicle stopping before entering the intersection and 24% involved a vehicle that failed to stop at the stop sign. At the three-legged intersections, a smaller proportion of crashes (59%) involved non-compliance. Of these, 76% involved a vehicle stopping before entering the intersection and 7% involved a vehicle failing to stop at the stop sign.

Stokes et al. (2000) reviewed 84 crashes at high crash frequency TWSS controlled intersections that occurred on rural state highways in Kansas. Of the 87% of crashes attributed to a driver “failing to yield the right-of-way”, 13% were reported as a driver failing to stop at the stop sign before entering the intersection.

- *Only three studies were available for review that considered crash mechanisms*
- *Evidence from two studies suggests that a majority of crashes at four-leg TWSS controlled intersections can be attributed to non-compliance of the stop control*
- *Evidence from one study suggests that fewer crashes at three-leg stop sign controlled intersections, though still in majority, result from non-compliance*
- *Evidence from three studies to suggest that most non-compliance related crashes occur after a driver has stopped at the stop control point, with the minority involving drivers that do not stop for the stop control*

2.4 Driver behaviour

Polus (1985) observed driver behaviour at two geometrically similar two-way controlled intersections. The only substantial difference between the two intersections was the control type; one was controlled by stop signs and the other by give way signs. Critical gap acceptance was found to be higher at the stop sign controlled intersection (about 7.5 seconds) compared to the give way controlled intersection (about 5.1 seconds). It is however difficult to draw any conclusions from this study as only one intersection for each control type was studied, meaning that the observed differences could be due to a factor other than the control type.

Pietrucha, Opiela, Knoblauch, and Crigler (1989) conducted interviews with 240 typical drivers and chronic traffic law offenders about their behaviour at certain traffic control devices. Low cross-road traffic and/or the absence of sight line obstructions were cited as reasons for not completing a full stop at stop signs for 51% of typical and 62% of chronic offender drivers. Impatience was cited as a reason by 18% and 11%, respectively. Site observations were also conducted at 142 stop sign controlled intersections in four US states. A total of 31,212 vehicle movements were observed. Of these, it was reported that over 67% of drivers failed to come to a complete stop, while 1.3% of these resulted in a conflict with cross-road traffic or a pedestrian.

Mounce (1981) conducted an observational study at 66 low-volume, rural TWSS controlled intersections in the US. The results of 2,830 observations showed statistically significant relationships between increased traffic volume and decreased stop sign violation, and increased minor road sight distance and increased stop sign violation.

Trinkaus (1997) looked at driver compliance at four TWSS controlled intersection in Queens, New York. The study was conducted over a 17 year period from 1979 to 1996. It was found that the proportion of drivers performing a full stop or a rolling stop fell from 37% and 34% to 1% and 2%, respectively. By 1996, 97% of drivers were reported to be driving through the intersections without substantially slowing. The intersections in question had stop signs installed under the warrant of decreasing local road traffic.

2.5 All-way stop sign controlled intersections

Post World War II, the use of all-way stop sign (AWSS) controlled intersections increased throughout the United States and Canada. However, their use in other countries is less common due in part to the development of formal warrants that restrict the use of stop sign controls to intersections with higher numbers of crashes associated with inadequate road user observation (Elvik & Vaa, 2004). While many officials believed AWSS controlled intersections to be a solve-all solution due to their promotion of speed control, their increased popularity has often been attributed political and social warrants rather than tangible safety effects (Ligon et al., 1985). There have, however, been a large number of publications from the United States reporting on the safety effects of AWSS controlled intersections.

The safety benefit of AWSS controlled intersections may be attributed to an overall reduction in crashes. Lovell and Hauer (1986) studied crashes at 350 urban intersections in Philadelphia, San Francisco and Toronto and 10 rural intersections in Michigan from before and after the conversions from TWSS to AWSS controlled intersections. Crash reductions were reported to be in the range of 37% to 62% with an average of 47%. Injury crash reductions were even greater, ranging from 62% to 74% with an average of 71%. The most substantial effect was observed to be a reduction in the number of right-angle and pedestrian crashes. Rear-end crashes were reported to have increased substantially in San Francisco after the conversion to AWSS controlled intersections, though minor reductions in rear-end crashes were reported in the other cities. Fixed object crashes were only reported for Philadelphia, where they were reported to have risen by 30% after the conversion to AWSS controlled intersections.

Another study by Persaud, Hauer, Retting, Vallurupalli, and Mucsi (1997) studied the effect of the conversion of signalised intersections of 199 one-way streets in Philadelphia. These were converted from traffic signal control to AWSS controlled intersections and were typically low volume intersections where the signals had tended to be pre-timed and on short cycle lengths of about 45 seconds. Most of the intersections also had single lane approaches with parking allowed on both sides of the roads. After the conversion to AWSS controlled intersections, minor injury crashes reduced by 37.7% and severe injury crashes reduced by 62.5%. The greatest reduction by crash type were found to be for fixed object crashes (90.1%), severe injury rear-end crashes (66.3%), pedestrian crashes (54.5%) and right-angle and turning crashes (46.3%). The authors speculated that the reduction in crashes may have been due to a diversion of traffic to other routes, reduced speeds between intersections and a reduction in the tendency to speed up before intersections in order to “beat the red” (at signalised intersections).

A number of other studies have also reported that AWSS controlled intersections have a propensity for an increased proportion of rear-end crashes and a decreased proportion of right-angle crashes compared to TWSS controlled intersections. Ragland and Zabyshny (2003) found that rear-end crashes made up nearly 38% of all crashes at AWSS controlled intersections, whereas right-angle crashes accounted for 25% of crashes. In comparison, over 70% of crashes at TWSS controlled intersections were right-angle crashes. For intersections from three of the four cities studied by Lovell and Hauer (1986), rear-end crashes increased in proportion to other crash types, while all four cities right-angle crashes reduced in proportion. Persaud et al. (1997) reported a minor reduction in the proportion of right-angle crashes, however also found a reduction in the proportion of rear-end crashes.

AWSS controlled intersections have also been trialled in Newcastle, Australia. Guyano-Cardona, Sylvester, and Jenkins (2002) reported on the 42 intersections converted to AWSS control from 1989 to 2001. AWSS controls were installed at high crash rate intersections where roundabouts were not geometrically or economically feasible and traffic flows were not enough to warrant the use of traffic signals. An average crash rate reduction of 83% was reported for the 42 intersections after the installation of AWSS control (the “before” control types were not stated). Compliance was also reported on for all intersections converted to AWSS control prior to 1998. It was found that 72% of vehicles came to a complete stop and 18% performed a rolling stop. The majority of the 10% that slowed but did not stop were performing left turns. Less than 1% of vehicles drove through the intersections without slowing.

The behaviour of drivers at AWSS controlled intersections was reported on by Eck and Biega (1988). Observations were made at three intersections in West Virginia that were converted from TWSS to AWSS controlled for periods of four weeks both before and after the conversions. It was reported that traffic flows did not vary by more than 10% for all but one road at one intersection, where the traffic flow reduced by 23%. It was speculated that this differing result may be due to drivers diverting to another route in order to avoid the intersection. Spot speeds were recorded along the mid-length of each approach road (i.e. midway between the subject intersections and the adjacent intersections). While the 85th percentile speeds did not change along the minor approach roads, there was an average 2.3 mph decrease in 85th percentile speed along the major approach roads.

Eck and Biega (1988) also collected delay and compliance data for each intersection before and after the conversions to AWSS controlled intersections. As would be expected, the average individual delay on the major road legs (i.e. those without stop signs before the conversion to AWSSs) increased substantially, from 0.4 to 5.0 seconds. On the minor road legs, the average individual delay reduced from 5.1 to 4.5 seconds. The total daily cumulative delay for each intersection (including all legs) increased from 14.0 to 36.3 minutes. A substantial proportion of this was due to delays along the major road legs. Control non-compliance (i.e. a vehicle not stopping before entering the intersection) was observed to be on average 14.1% on the minor road legs before the conversions. After conversion to AWSSs, non-compliance increased 23.8% on the minor road legs and was 26.4% on the major road legs. The proportion of vehicles performing rolling stops (i.e. 0-3 mph through the control point) decreased from 65.7% to 55.8% while the proportion of vehicles performing a voluntary stop did not substantially change (about 15%). Only a small proportion of vehicles were required to stop because of other traffic at the intersection (about 4% before and after conversion on the minor legs and 1.3% on the major legs).

2.6 Literature review summary

Safety effects and issues at non-signalised intersections have been reported on in a number of publications, with the majority using data from crash analyses and observational studies. The majority of publications looked at stop-sign controlled intersections, with a large proportion focussing on AWSS controlled intersections. Only a small number of publications could be found that reported on uncontrolled and give-way sign controlled intersections; most of these were comparison studies with stop sign controlled intersections.

Results from the published crash analyses suggest that the frequency and types of crashes occurring at non-signalised intersections are linked to the type of control employed and the intersection geometry. The following key points were noted:

- Most crashes at TWSS controlled intersections are adjacent direction crashes and these are more common at four-legged intersections than three-legged intersections (with stop control on the terminating road)
- Right-angle crashes make up the majority of adjacent direction crashes at TWSS controlled intersections and these are mainly the result of straight through and turn in front of cross traffic (from the minor road) movements
- The evidence generally points to a substantial reduction in right angle and adjacent direction crashes (19-65% reduction) when converting 4-leg intersections from uncontrolled to controlled or give way to stop controlled. This evidence is, however, based on a limited number of studies
- There is limited evidence about change in control type at 3-legged intersections; the available research suggests conversion from uncontrolled to controlled may reduce the rate of crashes
- There is evidence showing that conversion to reduced control, such as AWSS to TWSS control and TWSS to TWGWS control, leads to increased crash rates. At intersections converted from AWSS to TWSS control, there is evidence to suggest that this effect is reduced when signs are installed to advise of upcoming stop sign removal

- There is strong evidence that conversion from TWSS control to AWSS control can lead to substantial crash reductions, especially for more severe crashes
- While there is some evidence that the proportion of right-angle crashes is reduced, there is conflicting evidence about whether conversion from TWSS to AWSS control can result in an increased or decreased proportion of rear-end and fixed object crashes.
- Analysis of crashes at stop sign controlled intersections suggests that substantially more crashes result from vehicles entering the intersection after stopping at the stop sign than from vehicles entering the intersection without stopping at the stop sign. It should be noted that the degree to which a vehicle stops or slows was not reported.

The results from the published observational studies and behavioural surveys suggest that there exists a substantial rate of non-compliance at stop sign controls, much of which has been collected at AWSS controlled intersections. The following key points were noted:

- A substantial proportion of vehicles (reported to be about 10-25%) slow but do not stop at stop sign controlled intersections. The proportion of vehicles performing a rolling stop is reported to be larger (about 18-65%)
- There is some evidence to suggest that non-compliance is higher after conversion from TWSS to AWSS control
- Higher rates of non-compliance have been linked to lower major road traffic volumes and greater sight distances from the minor road. This has been substantiated by driver surveys.

3 In-depth crash investigation

CASR performs in-depth crash investigations of crashes that occur on South Australian metropolitan and inner rural (within 100 km of Adelaide) roads. This activity is used to collect specific data related to the participants, vehicles, road and infrastructure, circumstances and mechanisms of the investigated crashes. Specific selection criteria are used to select which crashes are attended. For most of the investigation duration, crashes must have included a motorised vehicle, result in at least one participant being transported to hospital by emergency ambulance and occur during the “on-call” period, which is generally during daylight hours. The method of data collection lends in-depth crash investigation to inform the structural failures of and potential corrective measures to crashes, rather than the statistical analysis of likelihood associated with certain crash features.

Three types of crashes contained in the in-depth investigation case register were reviewed; crashes occurring at stop sign controlled, give way sign controlled and uncontrolled intersections. Most crashes at stop and give way sign controlled intersections occurred in rural areas. More uncontrolled intersection crashes occurred in metro areas than rural areas. Only crashes that included vehicle movements along adjacent approach legs to the intersection with at least one vehicle movement along a minor road approach (i.e. either the controlled approach or terminating approach for a T-junction type intersection layout) were included.

A total of 53 cases were reviewed for crashes that occurred between 2006 and 2012 (the in-depth crash investigation study period). These included 17 at stop sign controlled intersections, 28 at give way sign controlled intersections and 18 at uncontrolled intersections. There were 11 fatal crashes, 28 crashes resulting in admittance to hospital, 22 crashes resulting in treatment at hospital, one crash that resulted in property damage only and one of unknown severity. In all but one case, there were only two involved vehicles (i.e. those directly involved in the crash); one on the minor road and one on the major road. In some cases, a non-involved vehicle may have contributed by obscuring the minor road driver’s vision.

3.1 Stop sign controlled intersection crashes

Two broad crash mechanisms were evident; crashes where the minor road driver reacted to the intersection by stopping or substantially slowing before entering the intersection but failed to see and give way to the major road vehicle, and crashes where the minor road driver did not slow for the intersection (Table 3.1).

The majority of crashes were associated with the former mechanism. Eight of these crashes occurred at an intersection without visual obstructions from the minor road along the major road at the control point. In five of these cases, it was reported that the minor road driver was in some way distracted or unfamiliar with the road and did not notice or misjudged the distance to the major road vehicle. In one case, the driver reacted to the stop sign too late and skidded into the intersection. Three crashes occurred at intersections where another non-involved vehicle in the major road’s left turn slip lane obscured the minor road driver’s sight of the major road vehicle, and one where vehicles stopped on the major road obscured the minor road driver’s sight of the major road vehicle. Two crashes occurred at intersections with visual obstructions along the major road from the minor road, with one also having visual obstructions of the intersection from the major road approach.

Three of the crashes were associated with the minor road vehicle not slowing for the intersection. These all occurred at four-way (cross road) intersections in rural areas. In one case, the minor road driver was somewhat familiar with the road but reported being distracted by thought and was not paying attention to the driving task. In another case, the driver was unfamiliar with the road (international visitor) and items in the car suggested the driver may have been distracted. Both of these cases, occurred at the same intersection where the cross road or control signage was not easily visible from the minor road prior to the intersection, though advanced warning signs (AWSs) showing priority control were installed. In the last case, the minor road driver reported being aware of the intersection but was "following the GPS" and thought they had right of way.

Table 3.1
Investigated crashes occurring at stop sign controlled intersections

				Speed limit (km/h)		Movement				
No.	Region	Severity	Layout	Major	Minor	Major	Minor	Response	Signage*	Visibility**
S1	Metro	Treated	Cross road	60	60	Straight	R/turn	Rolling stop	1, Y, N	Good
S2	Metro	Treated	Cross road	60	40	Straight	Straight	U/k	1,F, N	Vehicle
S3	Metro	U/k	T-junction	50	50	Straight	R/turn	Stopped	1,F, U/k	Vehicle
S4	Metro	Treated	T-junction	60	50	Straight	R/turn	Stopped	1, Y, U/k	Good
S5	Rural	Treated	Cross road	100	80	Straight	Straight	Did not stop	2, VF, 2	Approach
S6	Rural	Treated	Cross road	100	100	Straight	R/turn	Stopped	1, VF, U/k	Vehicle
S7	Rural	Treated	Cross road	100	100	Straight	R/turn	Stopped	2, Y, 1	Good
S8	Rural	Admitted	Cross road	50	80	Straight	Straight	Slowed	1, Y, 1	Good
S9	Rural	Admitted	Cross road	100	80	Straight	Straight	Stopped	2, F, 2	Intersection
S10	Rural	Admitted	Cross road	100	80	Straight	Straight	Did not stop	2, Y, 2	Approach
S11	Rural	Admitted	Cross road	100	80	Straight	R/turn	Rolling stop	2, Y, U/k	Good
S12	Rural	Fatal	Cross road	100	100	Straight	Straight	Did not stop	1, F, 2	Good
S13	Rural	Fatal	Cross road	110	110	Straight	U/k	Stopped	1, N, 2	Good
S14	Rural	Admitted	T-junction	80	80	Straight	R/turn	Stopped	1, Y, U/k	Intersection
S15	Rural	Admitted	T-junction	80	60	Straight	R/turn	U/k	2, F, 1	Good
S16	Rural	Fatal	T-junction	80	50	Straight	R/turn	Rolling stop	1, Y, N	Good
S17	Rural	Fatal	T-junction	100	60	Straight	R/turn	Stopped	2, F, 1	Vehicle

U/k = Unknown

*Signage [number of control signs, presence and condition of control line (yes/no/faded/very faded), number of advanced warning signs]

**Vehicle = obscured by non-involved vehicle, approach = poor visibility of intersection on approach, intersection = poor visibility along intersecting road at or approaching intersection

3.2 Give way sign controlled intersection crashes

Two broad crash mechanisms were evident at give way sign controlled intersections and are very similar to those occurring at stop sign controlled intersections (Table 3.2). The first crash mechanism was where the minor road driver stopped or substantially slowed before entering the intersection but failed to give way to the major road vehicle. For five of these crashes, the minor road driver was reported to have stopped or nearly stopped before entering the intersection. For 16 of these crashes, the minor road driver was reported to have slowed well below the speed limit but still have traversed the control point at approximately 10 km/h or above. For three crashes, the speed of the minor road vehicle before entering the intersection was not reported but it was considered that the driver had stopped before entering the intersection. For 16 of the crashes, the visibility at the control point was good for the minor road driver. For five of the crashes, visual obstructions at the control point from the minor road looking along the major road were considered to be contributing factors (subjective judgement of CASR crash investigators). Two involved the minor road driver stopping before entering the intersection and two involved the minor road vehicle slowing but not stopping.

The second crash mechanism was where the minor road driver failed to slow before entering the intersection; this involved four crashes. All four crashes occurred at four-way (cross road) intersections in rural areas. At none of the associated intersections was visibility of the major road or the control signage obscured for the approaching minor road driver. AWSs showing priority control were also employed at three of the four intersections. At one intersection, a single give way sign was employed with no AWS or control line. In one crash, the driver reported being aware of the intersection but not seeing the give way signs or AWSs and thought he had right of way (driver had been in Australia for a short time and was likely inexperienced at driving on Australian roads). In another crash, the driver was reportedly drunk with a blood alcohol content more than twice the legal limit.

Table 3.2
Investigated crashes occurring at give way sign controlled intersections

				Speed limit (km/h)		Movement				
No.	Region	Severity	Layout	Major	Minor	Major	Minor	Response	Signage*	Visibility**
GW1	Metro	Treated	Cross road	50	50	Straight	Straight	U/k	1, Y, N	Good
GW2	Metro	Treated	Cross road	60	60	Straight	Straight	Stopped	1, Y, N	Intersection
GW3	Metro	Admitted	Cross road	50	50	Straight	Straight	U/k	1, Y, N	Good
GW4	Metro	Admitted	Cross road	50	50	Straight	Straight	Slowed	1, Y, N	Good
GW5	Metro	Admitted	Cross road	60	50	Straight	Straight	Slowed	1, Y, N	Good
GW6	Metro	Fatal	Cross road	60	50	Straight	R/turn	Stopped	1, Y, N	Intersection
GW7	Metro	Treated	T-junction	60	50	Straight	R/turn	Slowed	2, Y, N	Good
GW8	Rural	PDO	Cross road	110	100	Straight	Straight	Slowed	1, N, N	Approach
GW9	Rural	Treated	Cross road	60	80	Straight	Straight	Slowed	1, Y, 1	Own mirror
GW10	Rural	Treated	Cross road	80	U/k	Straight	Straight	U/k	1, F, U	Intersection
GW11	Rural	Treated	Cross road	100	60	Straight	Straight	Slowed	1, Y, 1	Good
GW12	Rural	Treated	Cross road	100	100	Straight	Straight	Did not stop	1, Y, 1	Good
GW13	Rural	Treated	Cross road	100	100	Straight	Straight	Slowed	1, F, 1	Good
GW14	Rural	Treated	Cross road	100	100	Straight	Straight	Did not stop	1, N, N	Good
GW15	Rural	Admitted	Cross road	80	80	Straight	L/turn	Slowed	1, F, U	Intersection
GW16	Rural	Admitted	Cross road	80	100	Straight	Straight	Rolling stop	1, F, 1	Good
GW17	Rural	Admitted	Cross road	80	100	Straight	Straight	Slowed	1, VF,1	Good
GW18	Rural	Admitted	Cross road	80	80	Straight	Straight	Stopped	1, F, 2	Good
GW19	Rural	Admitted	Cross road	100	100	Straight	Straight	Slowed	1, F, 1	Intersection
GW20	Rural	Admitted	Cross road	100	80	Straight	Straight	Did not stop	2, F, 2	Intersection
GW21	Rural	Admitted	Cross road	110	100	Straight	Straight	Slowed	1, VF,1	Good
GW22	Rural	Fatal	Cross road	80	80	Straight	Straight	Did not stop	2, VF, 2	Good
GW23	Rural	Fatal	Cross road	80	100	Straight	Straight	Slowed	1, VF, 1	Approach
GW24	Rural	Fatal	Cross road	100	100	Straight	Straight	Did not stop	1, F, 1	Intersection
GW25	Rural	Fatal	Cross road	110	100	Straight	Straight	Slowed	1, F, 1	Good
GW26	Rural	Treated	T-junction	80	80	Straight	R/turn	Slowed	1, F, 1	Approach
GW27	Rural	Admitted	T-junction	80	80	Straight	R/turn	Slowed	1, VF,1	Approach
GW28	Rural	Admitted	T-junction	100	80	Straight	R/turn	Rolling stop	1, VF, N	Good

U/k = Unknown, PDO = property damage only

*Signage [number of control signs, presence and condition of control line (yes/no/faded/very faded), number of advanced warning signs]

** Vehicle = obscured by non-involved vehicle, approach = poor visibility of intersection on approach, intersection = poor visibility along intersecting road at or approaching intersection, own mirror = obscured by minor road vehicle's own side mirror (heavy vehicle)

3.3 Uncontrolled intersection crashes

Crash mechanisms at uncontrolled intersections were different to those evident with crashes occurring at controlled intersections (Table 3.3). All 18 crashes occurred at T-junctions, though this is a function of where uncontrolled intersections are placed. In almost all cases where the minor road driver's speed was reported, the driver stopped at the intersection before entering. Nine crashes were associated with the minor road driver's view of the major road vehicle being obstructed by another non-involved vehicle (moving or parked) on the major road. Eight of these crashes occurred in the metro area. In four of these cases, the minor road driver was reported as waiting a considerable amount of time for a suitable gap and it is likely that impatience played a role in the crash.

Seven crashes occurred at rural intersections. In four cases, visibility from the minor road along the major road was good, with little recorded evidence for why the driver did not give way. In two cases, visibility from the minor road along the major road was poor. In one case, a non-involved vehicle turning left from the minor road obscured the minor road driver's view of the major road vehicle.

Table 3.3
Investigated crashes occurring at uncontrolled intersections

				Speed limit (km/h)		Movement				
No.	Region	Severity	Layout	Major	Minor	Major	Minor	Response	Signage*	Visibility**
U1	Metro	Treated	T-junction	60	50	Straight	R/turn	Stopped	F, N	Vehicle
U2	Metro	Treated	T-junction	60	50	Straight	R/turn	Stopped	N, N	Vehicle
U3	Metro	Treated	T-junction	60	50	Straight	R/turn	Stopped	N, 1	Vehicle
U4	Metro	Treated	T-junction	60	60	Straight	R/turn	Stopped	N, N	Vehicle
U5	Metro	Admitted	T-junction	50	50	Straight	R/turn	U/k	N, N	Vehicle
U6	Metro	Admitted	T-junction	50	50	Straight	R/turn	U/k	N, N	Intersection
U7	Metro	Admitted	T-junction	60	50	Straight	R/turn	Stopped	F, N	Vehicle
U8	Metro	Admitted	T-junction	60	50	Straight	R/turn	Stopped	F, N	Vehicle
U9	Metro	Admitted	T-junction	60	50	Straight	R/turn	Stopped	N, N	Vehicle
U10	Metro	Admitted	T-junction	70	50	Straight	R/turn	Slowed	F, N	Good
U11	Metro	Admitted	T-junction	80	50	Straight	R/turn	Stopped	N, N	Good
U12	Rural	Treated	T-junction	100	100	Straight	R/turn	U/k	N, 1	Good
U13	Rural	Treated	T-junction	100	80	Straight	R/turn	Stopped	F, 1	Intersection
U14	Rural	Admitted	T-junction	80	100	Straight	R/turn	Stopped	N, N	Intersection
U15	Rural	Admitted	T-junction	110	110	Straight	R/turn	Stopped	N, 1	Good
U16	Rural	Admitted	T-junction	110	110	Straight	R/turn	Stopped	N, Route sign	Good
U17	Rural	Fatal	T-junction	100	100	Straight	L/turn	Stopped	F, 1	Vehicle
U18	Rural	Fatal	T-junction	110	80	Straight	R/turn	U/k	N, 1	Good

U/k = Unknown

*Signage [presence and condition of control line (yes/no/faded/very faded), number of advanced warning signs]

**Vehicle = obscured by non-involved vehicle, intersection = poor visibility along intersecting road at or approaching intersection

3.4 Summary of in-depth crash investigation findings

The most notable circumstances and mechanisms of crashes occurring at stop and give way sign controlled intersections and uncontrolled T-junction intersections are outlined below.

Stop sign controlled intersection crashes

- Many involved right turns from the minor road at either four-way (cross road) or three-way (T-junction) intersections
- Most involved the minor road driver stopping or nearly stopping at the control point before entering the intersection
- Generally, not associated with visual obstructions at the intersection, though two cases were an exception
- Driver distraction and visual obstruction by non-involved vehicles were commonly reported as associated factors leading to a crash

- Crashes that involved minor road drivers failing to slow down for the intersection were associated with distraction, unfamiliarity with the road, poor visibility of the intersection or signage from the minor road approach, or a combination of these.
- A number of rural road crashes occurred where sight obstructions (static or dynamic) were not identified as issues and the minor road driver's behaviour (based on driver or witness interviews) was consistent with the minor road driver being unaware of the major road vehicle before entering the intersection

Give way sign controlled intersection crashes

- Most involved a straight through manoeuvre from the minor road
- Most involved the minor road driver slowing to a speed of approximately 10 km/h or more before entering the intersection. Very few were associated with a minor road vehicle that stopped or slowed to very low speed before the crash
- A number of crashes involved minor road vehicles that proceeded through the intersection while slowing to no less than about 20 km/h, even though visual obstruction at the intersection was reported to be an issue
- Crashes that involved minor road drivers failing to slow down for the intersection were associated with distraction, impairment and unfamiliarity with the road. However, poor visibility of the intersection or signage from the minor road approach was not associated with these crashes.

Uncontrolled intersection crashes

- All uncontrolled intersection crashes occurred at T-junctions
- Most involved a right turn from the minor road at a three-way (T-junction) intersection
- Most involved a minor road driver that had stopped before entering the intersection
- Most crashes in metro areas involved the minor road driver's view being obstructed by a non-involved vehicle either driving or parked on the major road
- Considerable waiting time at the intersection was associated with some crashes, possibly leading to impatience by the minor road driver
- Rural crashes showed little evidence for why the minor road driver had failed to give way.

4 Survey

A survey was undertaken to identify the perception of risk that road users associate with varying levels of control at intersections, and whether road users could correctly identify the need to give way to other vehicles at an intersection. The survey was focused specifically towards the last aim of the study: to identify road user perceptions of personal risk and expectations surrounding the use of intersections with each form of control.

The survey was undertaken with assistance from the Royal Automobile Association of South Australia (RAA). The survey was used to assist work undertaken by the RAA and DPTI, as well as this study for which the survey was undertaken. The survey contained four general themes of inquiry: general profile, perception of risk at intersections, giving way at rural T-junctions and understanding of intersection warning signs. The survey was released to invited respondents on 10 August 2017. A total of 696 completed responses were received.

4.1 Method

4.1.1 Survey distribution

The survey was distributed by the Royal Automobile Association of South Australia (RAA). This method was chosen as:

- A greater number of responses were likely compared to other feasible methods (e.g. recruitment through the CASR website, recruitment of university students).
- CASR has a longstanding relationship with the RAA and they were receptive to the idea of collaboration.
- All other methods displayed bias that may be equal to or greater than that of the selected method.

The RAA elected to recruit respondents through their Members Panel. The Members Panel consists of subscripted RAA members who elect to respond to regular surveys. A number of limitations are associated with this method of recruitment, namely:

- The recruitment process was not randomised and was selective of a specific cohort.
- The wider population outside of RAA members were not recruited.
- The Member Panel demographic does not generally reflect the demographic of the wider population of South Australian road users.

In general, these limitations mean that systematic bias was introduced by recruiting RAA Member Panel members and that this may be reflected by results that are not an accurate representation of the overall population of South Australian road users.

4.1.2 Questions

The survey consisted of four general themes of inquiry contained in four sections. The specific questions presented to respondents are given in Appendix A. Note that the term “regional” instead of “rural” was used in all survey questions at the request of the RAA.

General profile questions

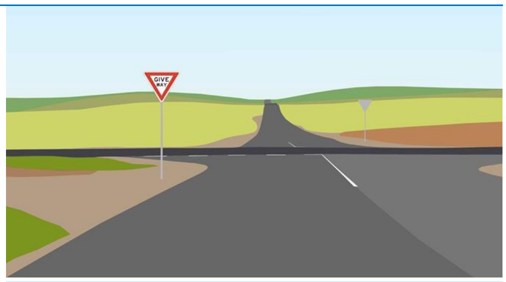
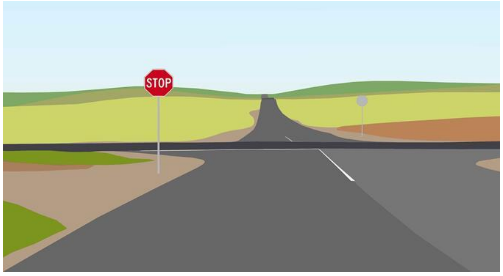
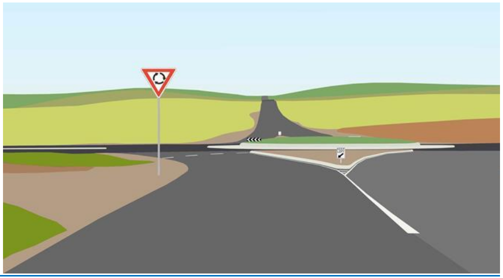
This consisted of questions regarding demographic, driving practices and behaviour and general perception of risk. The purposes of these questions were to establish the profile of respondents, their general driving practices and behaviour, as well as establishing the respondents' perception of personal safety in terms of the general task of driving and where this risk comes from.

For Question 9 (rating one's own perception of safety for the general task of driving), respondents were asked to select an answer from a rating scale (very safe; moderately safe; neither safe nor dangerous; moderately dangerous; very dangerous). This same rating scale was used for the "perception of personal safety" questions (below).

Perception of personal safety at intersections questions

These questions were related to the core objective of the project. This consisted of questions regarding the respondents' perception of risk when faced with a specific scenario of turning right at a two-lane/two-way cross road intersection. The respondents were presented with an image from a driver's point of view on the approach to the intersection along the minor road (Table 4.1).

Table 4.1
Images presented to respondents for each scenario of the perception of personal safety at intersections questions. Note that size of these images as shown to respondents was dependent on the size of the screen on which the respondent was viewing the survey.

Scenario	Image presented to respondents	
	Metro scenarios	Rural scenarios
Give way control		
Stop control		
Plateau		Not presented
Roundabout		

Seven scenarios were presented: four at a metro intersection and three at a rural intersection. Each scenario differed by the type of control used to control the movements of minor road vehicles. Four types of control were presented: give way (single sign, control line), stop (single sign, control line), raised plateau (raised intersection footprint, single give way sign, control line) and roundabout (roundabout intersection footprint, single roundabout sign, control line). All four scenarios were presented for both metro and rural locations, with the exception of no raised plateau scenario for the rural location due to the treatment's relative scarcity in rural areas. Both the roundabout and raised plateau intersections are considered Safe System compliant due to their ability to reduce vehicle speeds to safe levels when negotiating the intersection (Austroads, 2017). The intention behind including these intersections was to assess road user perception of safety at intersections that are objectively safer than that of traditional cross road designs.

The respondents were asked to rate their perception of personal safety to themselves when undertaking a right turn. Respondents were asked to select an answer from a rating scale (very safe; moderately safe; neither safe nor dangerous; moderately dangerous; very dangerous).

The purpose of these questions was to establish whether respondents perceived a difference in risk with the different scenarios where the only change to the presented image was a difference in intersection control.

Negotiating rural T-junction intersections questions

This section consisted of two questions presenting two scenarios. In each scenario an image of a rural T-junction intersection was presented (Figure 4.1). The image was from the point of view of a driver approaching the intersection along the terminating road. In the first scenario the respondents were presented with a T-junction that contained no control devices. A hazard board was presented opposite to the terminating road. In the second scenario, the same T-junction but with a single give way sign and control line was presented to the respondents.

Figure 4.1
Scenario 1: hazard board only (left) and Scenario 2: give way control and hazard board (right). Note that size of these images as shown to respondents was dependent on the size of the screen on which the respondent was viewing the survey.

The respondents were asked whether they would be required to give way to traffic on the intersecting (continuous) road. The respondents were asked to select one of four answers (yes, to all other traffic; yes, but only to traffic on my right; No, I am not required to give way to other traffic; I don't know).

The purpose of these questions was to establish whether respondents could identify their requirement to give way to traffic on the intersecting road and whether the implementation of give way control would improve this identification.

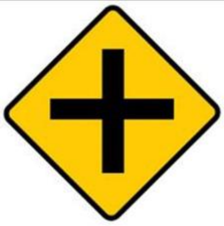
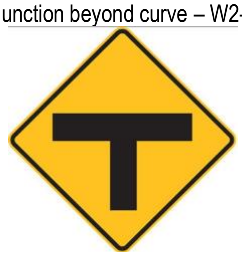
Understanding of intersection warning signs questions

This section consisted of eight questions. In each question, an intersection warning sign was presented to the respondent. Eight warning signs were presented (Table 4.2), each either indicating the need to give way to other traffic at an upcoming intersection or indicating the presence of an upcoming intersection but not indicating the need to give way.

The respondents were asked whether they would expect to be required to give way to other traffic at an upcoming intersection. The respondents were asked to select one of four answers (yes; sometimes; no; I don't know).

The purpose of these questions was to establish whether respondents understood when a warning sign was indicating the need to give way to other traffic at an upcoming intersection and when a warning sign was indicating the presence of an upcoming intersection without specifying the need to give way. All signs indicating the former are used on minor road approaches (those being controlled or requiring the driver to give way at an upcoming intersection). All signs indicating the latter are used on major road approaches (those not being controlled at an upcoming intersection). There is some perception within the traffic engineering profession that the latter signs have also been installed along minor roads and that this may confuse their meaning. However, this has not been established and current Australian Standards requirements (Standards Australia, 2009) specify that these signs shall not be used on any approach controlled by stop or give way signs.

Table 4.2
Images presented to respondents for each scenario of the understanding of intersection warning signs questions. Note that size of these images as shown to respondents was dependent on the size of the screen on which the respondent was viewing the survey. The warning sign descriptions and sign number (Standards Australia, 2014) are shown below each image.

Image presented to respondents	
Major road signs	Minor road signs
 Cross road ahead (with arrow) – W2-1	 Stop sign ahead – W3-1
 Cross road ahead – W2-1 (superseded)	 Give way sign ahead – W3-2
 Side road ahead (with arrow) – W2-4	 T-junction beyond curve – W2-14
 Side road ahead – W2-4 (superseded)	 T-junction ahead – W2-3

4.2 Results

4.2.1 General profile

Each respondent was asked a number of general profiling questions, including those used to derive demographic, road use and general road safety perception information.

Most respondents (78.9%) reside in the Adelaide metro area (Figure 4.2). A further 17.5% reside in the Adelaide Hills, inner regional and regional south-east areas of South Australia (inner regional). A small proportion of respondents reside in the outer regional areas of South Australia (3.6%), including one respondent from the Broken Hill area of New South Wales (postcode 2880). While some results were able to be derived from the responses of those respondents living in outer rural areas, the low response numbers reduced the statistical value of these results.

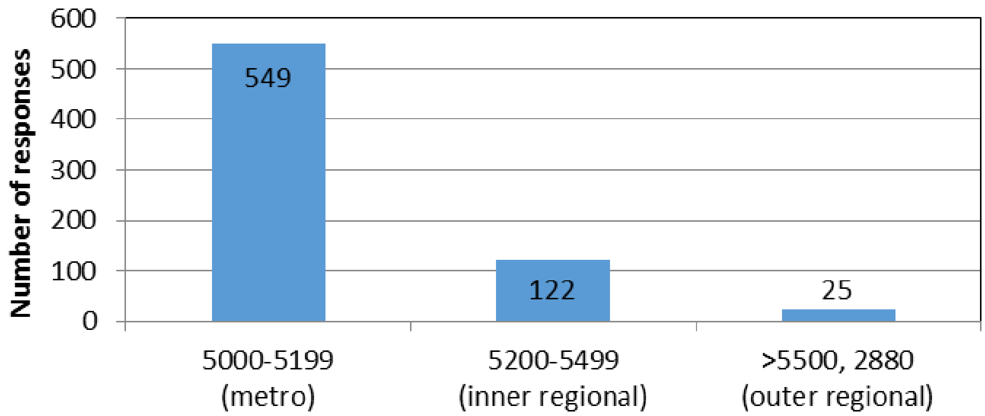


Figure 4.2
Responses to question "What is your residential postcode?"

The age distribution of respondents is skewed to an older demographic (Figure 4.3). 9.1% of respondents are aged under 45 years. The majority of respondents are between 45 and 74 years of age (79.7%), with a further 11.2% above 75 years of age. The skewed age distribution means that there was limited statistical value in deriving results for the younger age groups. However, some differences were seen between the younger (below 45) cohort and the rest of the respondents, and are discussed later.

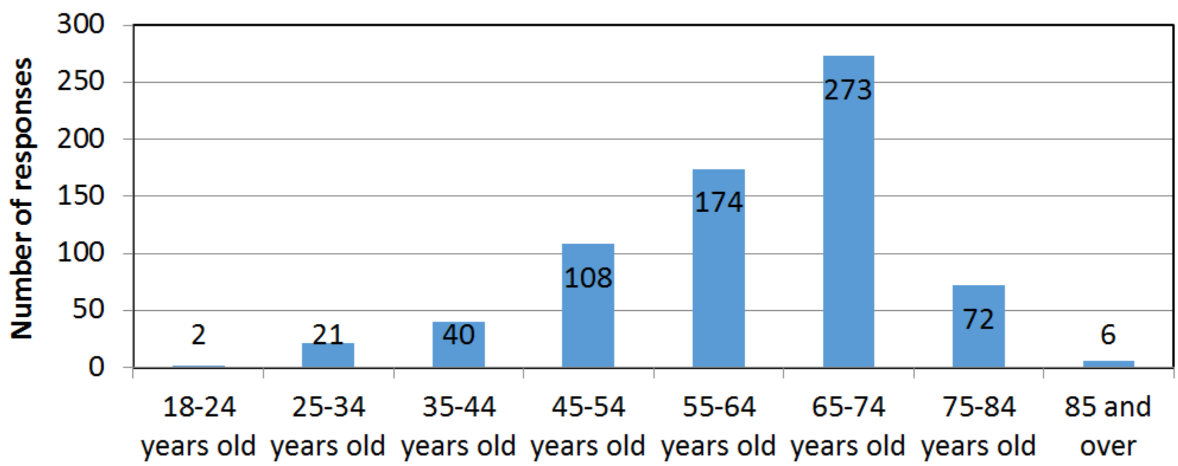


Figure 4.3
Responses to question "what age range are you within?"

The vast majority of respondents (93.7%) have held an unrestricted driver's licence for 20 or more years (Figure 4.4). This suggests that the sample cohort is on average older than the general population of

South Australia and have held a driver's licence for a longer period of time. As such, results from the survey are likely to be biased towards this specific cohort and less representative of the overall population of South Australia.

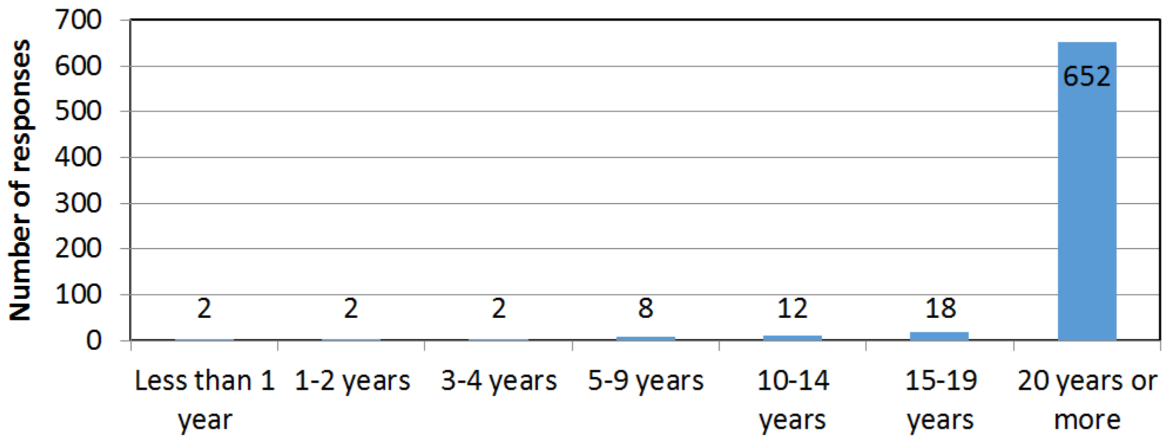


Figure 4.4
Responses to question "For how long have you held an unrestricted (i.e. no "L" or "P" plate required) driver's license?"

Almost all respondents (99.3%) had driven/ridden a vehicle (of those listed) in the past six months (Figure 4.5). The vast majority of respondents had driven a passenger vehicle (99.0%), with less having ridden a bicycle (26.6%), driven a heavy vehicle (14.8%) or having ridden a motorcycle (11.5%). More than half of all respondents had driven only a passenger vehicle in the past six months (59.3%).

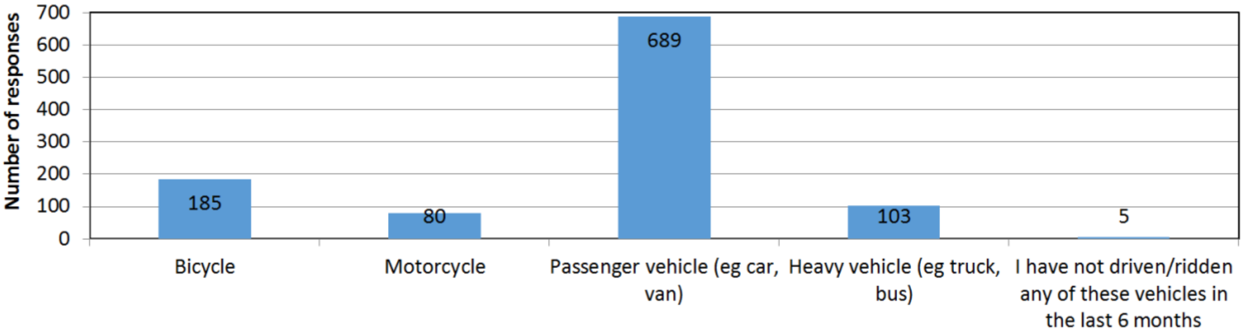


Figure 4.5
Responses to question "Which of the following vehicle(s) have you driven/ridden in the last 6 months?"

Most respondents had perceived themselves to have driven/ridden frequently on metro roads in the past six months (Figure 4.6): 83.5% responded as having driven/ridden often or most days. Few respondents perceived themselves as having rarely or not driven/ridden on metro roads in the past six months (3.9%).

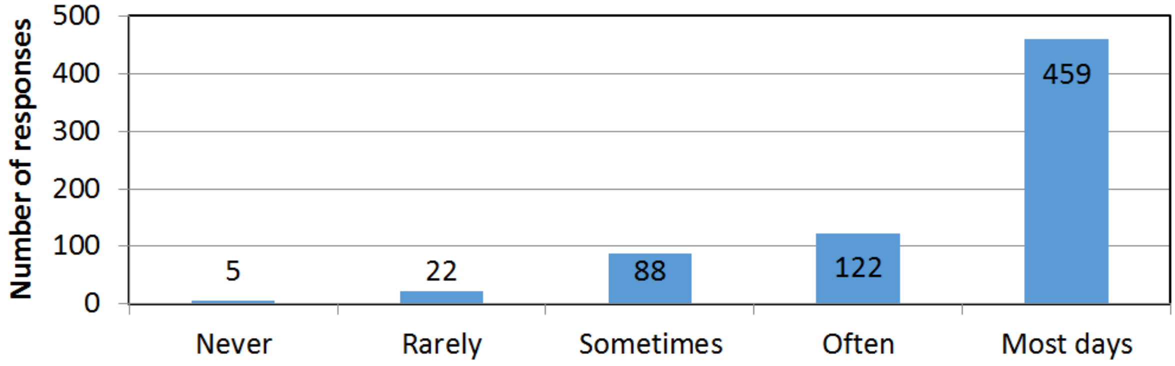


Figure 4.6
Responses to question "In the past 6 months, how frequently have you driven on metro roads?"

More respondents perceived themselves as recently driving/riding less often on rural roads than metro roads (Figure 4.7). Nonetheless, more than half of all respondents still perceived themselves as having driven/ridden often or most days on rural roads in the past six months (51.1%). 12.6% of respondents perceived themselves as having driven/ridden on rural roads either rarely or not at all.

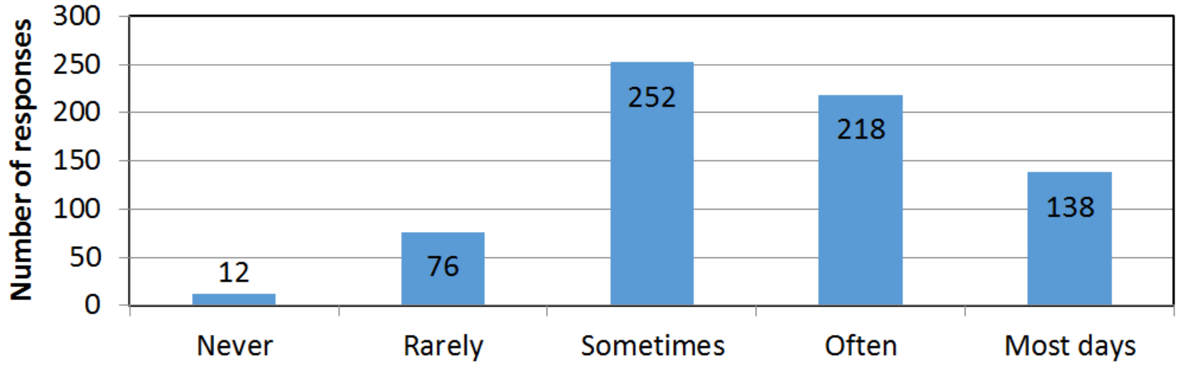


Figure 4.7
Responses to question "In the past 6 months, how frequently have you driven on rural roads/highways?"

The majority of respondents (87.1%) stated that they had driven/ridden an average of two or less hours per day in the past six months (Figure 4.8). A further 10.1% stated having driven/ridden for 3-4 hours per day, while only 2.9% stated having driven/ridden for five or more hours per day.

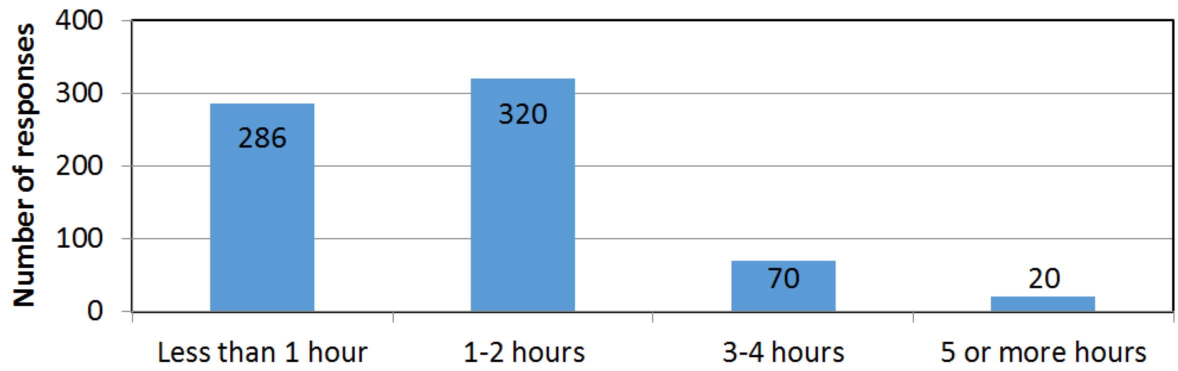


Figure 4.8
Responses to question "On average, how many hours per day do you spend driving?"

Most respondents (80.5%) stated that they drive at about the same speed as other vehicles around them (Figure 4.9). More respondents said they drove at a slower speed than most other vehicles (11.9%) than at a faster speed than most other vehicles (7.6%).

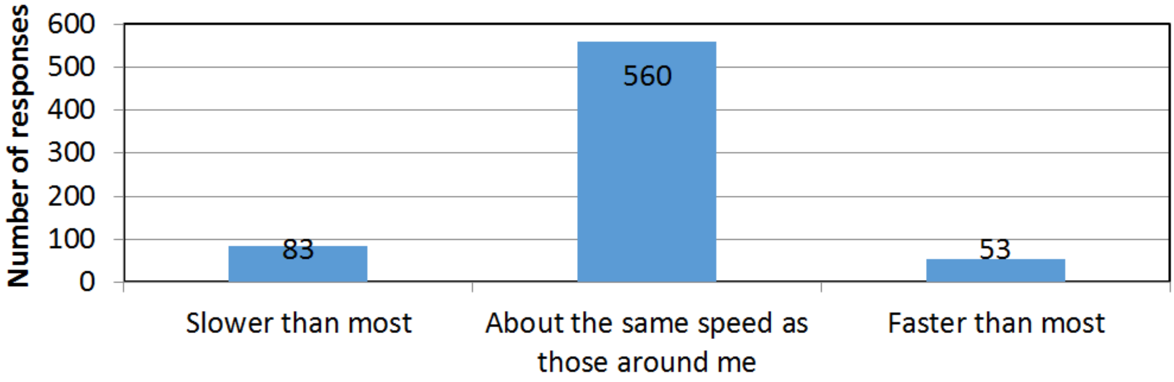


Figure 4.9
Responses to question "How would you rate the speed that you generally drive at compared to most other drivers on the road?"

Most respondents perceived the task of driving to be safe (Figure 4.10), with 65.2% perceiving it to be moderately safe or very safe. Far fewer respondents perceived the task of driving to be neither safe nor dangerous (13.8%) or (moderately or very) dangerous (21.0%).

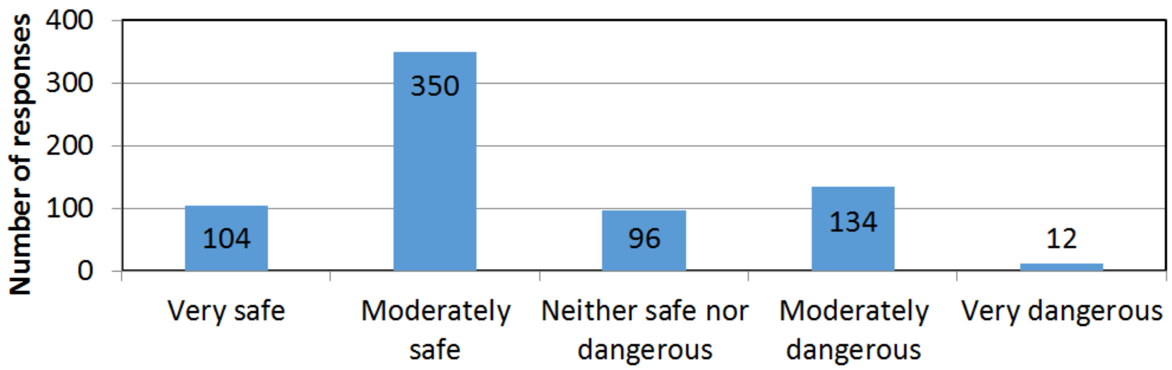


Figure 4.10
Responses to question "Considering all factors (e.g. the road environment, other drivers, your own driving ability), how safe do you perceive the task of driving to be?"

As shown in Figure 4.11, most respondents perceived the greatest risk to their own safety on the road to come from the actions of other road users (82.2%), rather than from their own actions (7.8%) or the road environment (10.1%).

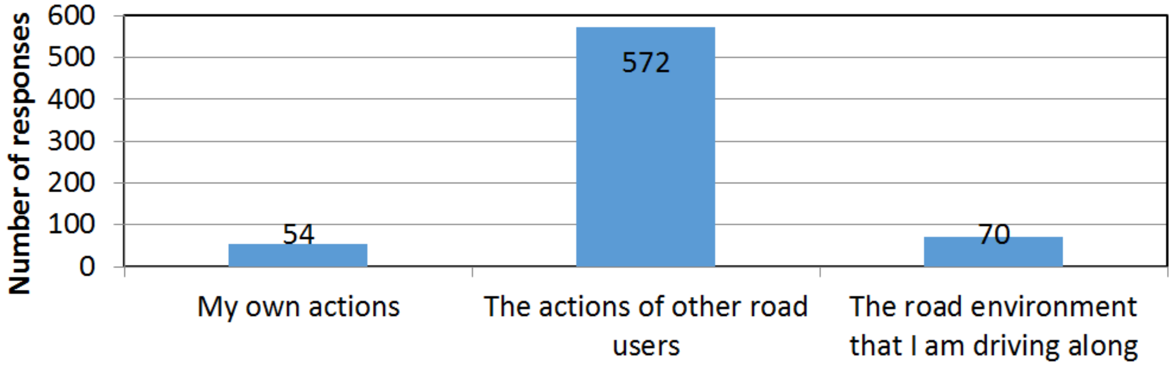


Figure 4.11
Responses to question "What do you perceive to be the source of greatest risk to your own safety as a road user?"

The final general profiling question was requested by the RAA and the results are shown in Figure 4.12. The top three driver behaviour issues that most concerned respondents were inattention (18.3%), mobile phone usage/texting (16.5%) and reckless driving (14.2%).

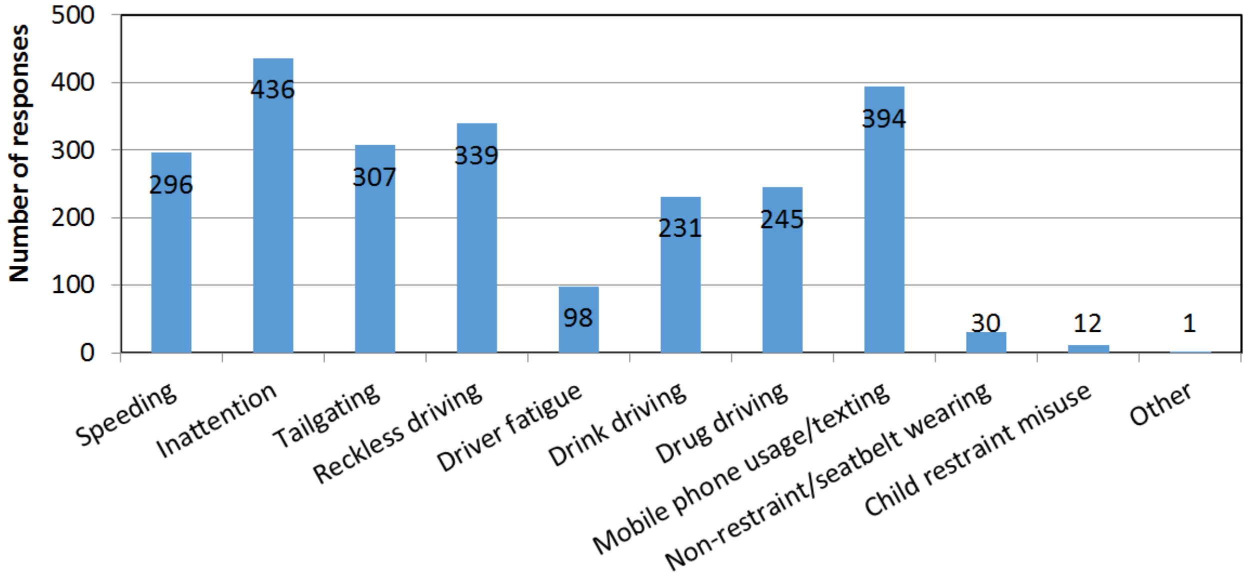


Figure 4.12
Responses to question "What are the top three (3) driver behaviour issues that most concern you? (please select your top 3)?"

4.2.2 Perception of personal safety at intersections

For each scenario, respondents were asked to rate their perception of personal safety if they were to perform a right turn at the cross road intersection shown in the image. The available responses ranged from *very safe* to *very dangerous*. For all scenarios, the most popular response was *moderately safe*, with *very dangerous* being the least popular response for all scenarios (Figure 4.13).

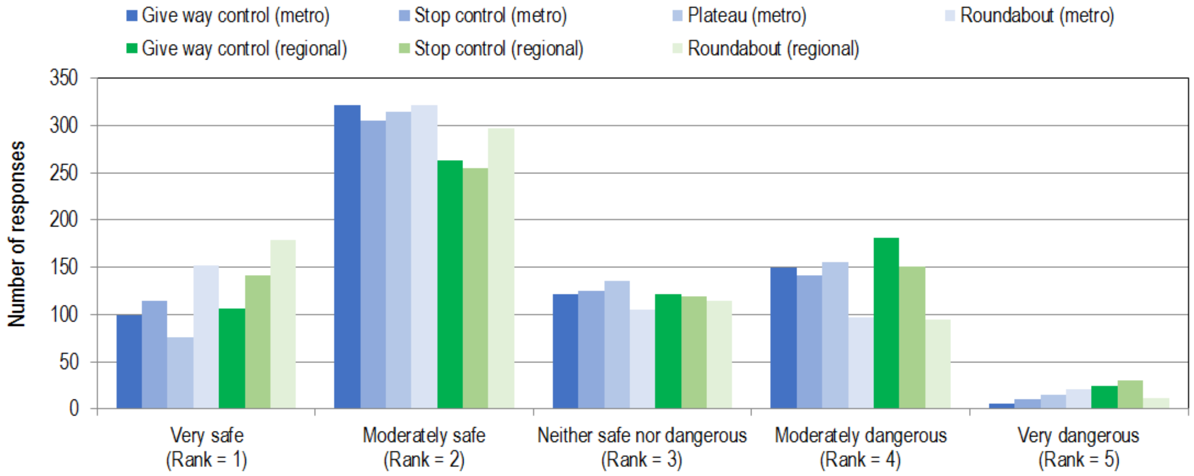


Figure 4.13
Results of personal safety at intersections scenarios shown as the response rate for each possible response.

For metro scenarios, there was no statistically significant difference (at 95% confidence) between the weighted average response rank value for give way controlled and stop controlled scenarios (Table 4.3). The plateau scenario was on average ranked as more dangerous than the give way control scenario (p<0.01). The roundabout scenario was on average ranked as less dangerous than the give way scenario (p<0.01).

Table 4.3
Results of personal safety at intersections scenarios shown as the weighted average response rank value. Statistical significance testing was performed using the "give way control" responses for the same location (metro/rural) as the expected range.

Scenario	Rank weighted average *(Chi Squared test p-value*)*
Metro intersection	
Give way control	2.49
Stop control	2.46 *(0.16)*
Plateau	2.60 *(<0.01)*
Roundabout	2.30 *(<0.01)*
Rural intersection	
Give way control	2.65
Stop control	2.53 *(<0.01)*
Roundabout	2.23 *(<0.01)*

Scenario responses were analysed for certain respondent cohorts (Table 4.4). Due to the small number of respondents aged under 45 (9% of total), this cohort was separated from the cohort of respondents aged 45 years and above. When compared to all respondents for the same scenario, there was no statistically significant difference for either cohort for any of the scenarios (at 95% confidence). However, the comparisons suggested respondents aged under 45 years on average ranked both the metro plateau scenario (p=0.08) and the roundabout scenario (p=0.07) as safer.

Cohorts categorised by the type of vehicle that was driven/ridden in the past six months were also compared to the responses from all respondents. Bicyclist, motorcyclist and heavy vehicle driver cohorts included those who had indicated driving/riding these types of vehicles in the last six months. The passenger vehicle driver cohort included those who had indicated driving only this type of vehicle in the last six months. The comparisons showed that motorcyclists on average ranked all metro scenarios with the exception of the roundabout scenario as more dangerous. The same trend was seen for rural intersections, but the comparisons were not statistically significant.

Table 4.4
Responses to personal safety at intersections scenarios shown as the weighted average rank value. Statistical significance testing for each cohort was performed using the "all respondents" cohort responses for the same scenario as the expected range.

Scenario	Rank weighted average *(Chi Squared test p-value*)*						
	All respondents	Respondents aged < 45	Respondents aged ≥ 45	Bicyclists	Motorcyclists	Passenger vehicle drivers^	Heavy vehicle drivers
Cohort size (% all respondents)	696 (100%)	63 (9%)	633 (91%)	184 (26%)	79 (11%)	413 (59%)	102 (15%)
Metro intersection							
Give way control	2.49	2.49 *(0.23)*	2.48 *(0.97)*	2.55 *(0.80)*	2.66 *(0.03)*	2.47 *(0.80)*	2.36 *(0.48)*
Stop control	2.46	2.54 *(0.63)*	2.45 *(0.99)*	2.53 *(0.69)*	2.66 *(0.01)*	2.45 *(0.93)*	2.26 *(0.24)*
Plateau	2.60	2.41 *(0.08)*	2.61 *(0.94)*	2.59 *(0.75)*	2.85 *(0.01)*	2.59 *(0.82)*	2.47 *(0.06)*
Roundabout	2.30	2.08 *(0.07)*	2.32 *(0.93)*	2.33 *(0.92)*	2.44 *(0.55)*	2.31 *(0.97)*	2.16 *(0.66)*
Rural intersection							
Give way control	2.65	2.57 *(0.87)*	2.65 *(0.99)*	2.71 *(0.37)*	2.72 *(0.83)*	2.62 *(0.59)*	2.56 *(0.42)*
Stop control	2.53	2.71 *(0.58)*	2.51 *(0.99)*	2.61 *(0.20)*	2.70 *(0.11)*	2.49 *(0.42)*	2.42 *(0.59)*
Roundabout	2.23	2.06 *(0.77)*	2.24 *(0.99)*	2.24 *(0.95)*	2.41 *(0.36)*	2.23 *(0.93)*	2.17 *(0.68)*

*Chi Squared test was performed using *all respondents'* cohort as the expected range

^Refers to respondents who have indicated driving only passenger vehicles in the past six months

The comparisons showed that heavy vehicle drivers on average ranked the metro plateau scenario to be less dangerous compared to that perceived by all respondents (p=0.06). However, the comparisons also suggested heavy vehicle drivers perceived all scenarios to be less dangerous, though these results were not statistically significant.

The results from these questions indicated that for the provided scenarios, respondents perceived give way controlled intersections to be as safe as stop controlled intersections in a metro environment but found stop controlled intersections to be less dangerous in a rural environment. This suggests that providing stop control does not indicate a heightened level of perceived danger at metro intersections. These findings also suggest that, contrary to the warrants commonly used to justify the installation of stop controls, providing stop controls indicate a lower level of danger at rural intersections. These results may be indicative that stop controlled intersections are being perceived in an "incorrect" way by the public with respect to safety when compared to the warrants being used to justify the installation of stop control over give way control.

The results indicate that a younger cohort may be more perceptive of the safety benefits of plateau treated and roundabout controlled intersections, which provide greater Safe System alignment by reducing speeds on all approaches and, in the case of roundabouts, reducing the angle at which conflicting vehicles will impact one another.

The results also indicate that motorcyclists may perceive metro intersections to be more dangerous. Interestingly, this finding did not extend to the metro roundabout scenario, suggesting that motorcyclists may not perceive these intersections as being any more dangerous than the wider population perceives.

Though the results were mostly non-significant, the findings suggest that heavy vehicle drivers may perceive intersections in general to be less dangerous when compared to the general population.

4.2.3 Negotiating rural T-junction intersections

When asked the question “do you think you are required to give way to traffic on the intersecting road?”, the majority of respondents identified the need to give way to all other traffic for both scenarios (Figure 4.14). For Scenario 1 (hazard board only), a larger proportion of respondents misidentified the need to give way to traffic on the right only (6.6% versus 2.3%) (

Table 4.5), while fewer respondents misidentified not being required to give way to other traffic (0.4% versus 0.9%). There was a statistically significant difference between the responses for Scenarios 1 and 2.

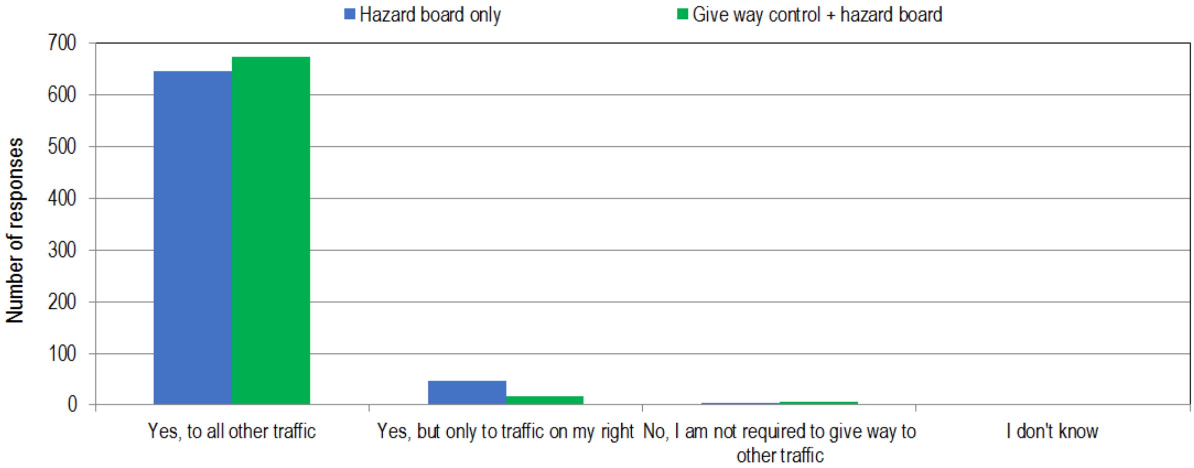


Figure 4.14
Responses by all respondents to giving way at rural T-junction intersections questions.

When cohorts were aggregated by postcode, the responses between Scenario 1 and 2 were different for those respondents from postcodes 5000-5199 (suburban Adelaide), 5200-5499 (Adelaide Hills, inner rural and rural south-east). Note the difference between Scenarios 1 and 2 for postcodes 5200-5499 was not statistically significant but followed a similar trend to that for all respondents. For postcodes 5500 and above (outer rural South Australia) and 2880 (Broken Hill area – one respondent), there was no difference between the responses for Scenarios 1 and 2. All respondents from this cohort correctly identified the need to give way to all other traffic.

The findings from these questions suggest that road users may more often correctly identify the need to give way at rural T-junctions where give way controls are implemented, compared to when road users have to rely on correctly identifying the need to use the “T-junction rule” that requires vehicles on the terminating road to give way to traffic along the continuing road.

Table 4.5
Responses by all respondents and “by postcode” cohorts to giving way at rural T-junction intersections questions.

	Number of responses *(proportion)*							
	All respondents		Postcodes 5000-5199		Postcodes 5200-5499		Postcodes >5000, 2880	
Scenario*	1	2	1	2	1	2	1	2
Cohort size (% all respondents)	696		549		122		25	
Responses								
Yes, to all other traffic	647 *(93.0%)*	674 *(96.8%)*	509 *(92.7%)*	531 *(96.7%)*	113 *(92.6%)*	118 *(96.7%)*	25 *(100.0%)*	25 *(100.0%)*
Yes, but only to traffic on my right	46 *(6.6%)*	16 *(2.3%)*	37 *(6.7%)*	13 *(2.4%)*	9 *(7.4%)*	3 *(2.5%)*	0 *(0.0%)*	0 *(0.0%)*
I am not required to give way to other traffic	3 *(0.4%)*	6 *(0.9%)*	3 *(0.6%)*	5 *(0.9%)*	0 *(0.0%)*	1 *(0.8%)*	0 *(0.0%)*	0 *(0.0%)*
I don’t know	0 *(0.0%)*	0 *(0.0%)*	0 *(0.0%)*	0 *(0.0%)*	0 *(0.0%)*	0 *(0.0%)*	0 *(0.0%)*	0 *(0.0%)*
Chi Squared test p-value^	<0.01^		<0.01		0.24		1.00	

*Scenario 1 = Hazard board only; Scenario 2 = Give way control + hazard board

^Chi Squared test was performed between Scenario 1 and Scenario 2 for relevant cohort

4.2.4 Understanding of intersection warning signs

It must be acknowledged that while the intention of these questions was to probe respondents’ perceptions of the “legal” requirement to give way to other traffic if there was other traffic present or approaching the intersection, the wording of the questions are such that respondents’ intentions could be different. In this way, the findings of these questions may be reflecting the respondents’ own personal driving/riding situations rather than knowledge of give way rules and the meanings of specific signs. In either case, the findings give a useful insight into how respondents view the expectation to need to give way in situations where they are presented with signs used on the major road approach (without control) or minor road approach (with control or reverting to the T-junction rule) to an intersection.

The majority of respondents identified the possibility of expecting a need to give way to other traffic at an upcoming intersection when faced with a cross road ahead sign without an arrow (

Table 4.6). When presented with the cross road ahead sign with an arrow, the proportion of respondents identifying no expectation of needing to give way to other traffic increased substantially. This difference was seen with all postcode cohorts, suggesting the misinterpretation of the cross road ahead sign without an arrow is not limited to just metro or rural road users.

Table 4.6
Responses by all respondents and "by postcode" cohorts to understanding of intersection warning signs questions.

	Number of responses *(proportion)*							
	All respondents		Postcodes 5000-5199		Postcodes 5200-5499		Postcodes >5000, 2880	
Sign*	1	2	1	2	1	2	1	2
Cohort size (% all respondents)	696		549		122		25	
Responses								
Yes	183 *(26.3%)*	402 *(57.8%)*	154 *(28.1%)*	327 *(59.6%)*	25 *(20.5%)*	64 *(52.5%)*	4 *(16.0%)*	11 *(44.0%)*
Sometimes	111 *(15.9%)*	242 *(34.8%)*	81 *(14.8%)*	188 *(34.2%)*	28 *(23.0%)*	46 *(37.7%)*	2 *(8.0%)*	8 *(32.0%)*
No	296 *(42.5%)*	25 *(3.6%)*	223 *(40.6%)*	12 *(2.2%)*	56 *(45.9%)*	11 *(9.0%)*	17 *(68.0%)*	2 *(8.0%)*
I don't know	106 *(15.2%)*	27 *(3.9%)*	91 *(16.6%)*	22 *(4.0%)*	13 *(10.7%)*	1 *(0.8%)*	2 *(8.0%)*	4 *(16.0%)*
Chi Squared test p-value	<0.01		0.52	0.33	0.06	<0.01	0.08	0.01

*Sign 1 = Cross road ahead (with arrow); Sign 2 = Cross road ahead (superseded)
^Chi Squared test was performed between Scenario 1 and Scenario 2 for the *all respondents* cohort
^^Chi Squared test was performed using *all respondents* cohort as the expected range

The majority of respondents identified not expecting to need to give way to other traffic at an upcoming intersection when faced with either side road ahead sign (with or without an arrow) (Table 4.7). However, the proportion of respondents misinterpreting this expectation to need to give way was somewhat higher when presented with the side road sign without an arrow.

Table 4.7
Responses by all respondents and "by postcode" cohorts to understanding of intersection warning signs questions.

	Number of responses *(proportion)*							
	All respondents		Postcodes 5000-5199		Postcodes 5200-5499		Postcodes >5000, 2880	
Sign*	3	4	3	4	3	4	3	4
Cohort size (% all respondents)	696		549		122		25	
Responses								
Yes	21 *(3.0%)*	88 *(12.6%)*	19 *(3.5%)*	72 *(13.1%)*	2 *(1.6%)*	14 *(11.5%)*	0 *(0.0%)*	2 *(8.0%)*
Sometimes	34 *(4.9%)*	92 *(13.2%)*	25 *(4.6%)*	63 *(11.5%)*	8 *(6.6%)*	22 *(18.0%)*	1 *(4.0%)*	7 *(28.0%)*
No	612 *(87.9%)*	497 *(71.4%)*	482 *(87.8%)*	397 *(72.3%)*	107 *(87.7%)*	84 *(68.9%)*	23 *(92.0%)*	16 *(64.0%)*
I don't know	29 *(4.2%)*	19 *(2.7%)*	23 *(4.2%)*	17 *(3.1%)*	5 *(4.1%)*	2 *(1.6%)*	1 *(4.0%)*	0 *(0.0%)*
Chi Squared test p-value	<0.01		0.92	0.64	0.69	0.41	0.84	0.14

*Sign 3 = Side road ahead (with arrow); Sign 4 = Side road ahead (superseded)
^Chi Squared test was performed between Scenario 1 and Scenario 2 for the *all respondents* cohort
^^Chi Squared test was performed using *all respondents* cohort as the expected range

When presented with a stop sign ahead sign, the majority of respondents identified the expectation of needing to give way to other traffic at an upcoming intersection (

Table 4.8). This proportion was lower when respondents were presented with a give way sign ahead sign. This difference was seen with all postcode cohorts.

Table 4.8
Responses by all respondents and "by postcode" cohorts to understanding of intersection warning signs questions.

	Number of responses *(proportion)*							
	All respondents		Postcodes 5000-5199		Postcodes 5200-5499		Postcodes >5000, 2880	
Sign*	5	6	5	6	5	6	5	6
Cohort size (% all respondents)	696		549		122		25	
Responses								
Yes	589 *(84.6%)*	661 *(95.0%)*	462 *(84.2%)*	522 *(95.1%)*	106 *(86.9%)*	115 *(94.3%)*	21 *(84.0%)*	24 *(96.0%)*
Sometimes	33 *(4.7%)*	9 *(1.3%)*	28 *(5.1%)*	7 *(1.3%)*	4 *(3.3%)*	2 *(1.6%)*	1 *(4.0%)*	0 *(0.0%)*
No	11 *(1.6%)*	9 *(1.3%)*	6 *(1.1%)*	5 *(0.9%)*	3 *(2.5%)*	3 *(2.5%)*	2 *(8.0%)*	1 *(4.0%)*
I don't know	63 *(9.1%)*	17 *(2.4%)*	53 *(9.7%)*	15 *(2.7%)*	9 *(7.4%)*	2 *(1.6%)*	1 *(4.0%)*	0 *(0.0%)*
Chi Squared test p-value	<0.01		0.75	0.85	0.66	0.63	0.06	0.50

*Sign 5 = Give way sign ahead; Sign 6 = Stop sign ahead
^Chi Squared test was performed between Scenario 1 and Scenario 2 for the *all respondents* cohort
^^Chi Squared test was performed using *all respondents* cohort as the expected range

When faced with either T-junction ahead or T-junction beyond curve signs, the majority of respondents identified the expectation of needing to give way to other traffic at an upcoming intersection (Table 4.9).

Table 4.9
Responses by all respondents and "by postcode" cohorts to understanding of intersection warning signs questions.

	Number of responses *(proportion)*							
	All respondents		Postcodes 5000-5199		Postcodes 5200-5499		Postcodes >5000, 2880	
Sign*	7	8	7	8	7	8	7	8
Cohort size (% all respondents)	696		549		122		25	
Responses								
Yes	663 *(95.3%)*	650 *(93.4%)*	524 *(95.4%)*	514 *(93.6%)*	114 *(93.4%)*	112 *(91.8%)*	25 *(100.0%)*	24 *(96.0%)*
Sometimes	22 *(3.2%)*	32 *(4.6%)*	15 *(2.7%)*	22 *(4.0%)*	7 *(5.7%)*	9 *(7.4%)*	0 *(0.0%)*	1 *(4.0%)*
No	4 *(0.6%)*	7 *(1.0%)*	3 *(0.5%)*	6 *(1.1%)*	1 *(0.8%)*	1 *(0.8%)*	0 *(0.0%)*	0 *(0.0%)*
I don't know	7 *(1.0%)*	7 *(1.0%)*	7 *(1.3%)*	7 *(1.3%)*	0 *(0.0%)*	0 *(0.0%)*	0 *(0.0%)*	0 *(0.0%)*
Chi Squared test p-value	0.20		0.87	0.84	0.27	0.34	0.74	0.91

*Sign 7 = T-junction beyond curve; Sign 8 = T-junction ahead
^Chi Squared test was performed between Scenario 1 and Scenario 2 for the *all respondents* cohort
^^Chi Squared test was performed using *all respondents* cohort as the expected range

The intersection warning sign questions suggest that many respondents expect the need to give way to other traffic when faced with a sign indicating their path along the major road of an upcoming intersection. This expectation was lessened when presented with side road ahead sign versus a cross road ahead sign. This expectation was also reduced when the sign showed an arrow indicating the path that the road user was on. These results suggest that the cross road ahead sign can be particularly confusing for road users and that the addition of an arrow to the sign (as is now standard practice) helps reduce this confusion.

The results suggest that there was a residual of respondents that did not correctly identify expecting the need to give way at an upcoming intersection when presented with a give way/stop sign ahead, T-junction ahead or T-junction beyond curve sign. This residual was largest when presented with a give way sign ahead sign.

5 Conclusions

5.1 Literature review

From the literature review, it is evident that a number of studies have identified a crash benefit to using stop signs in-lieu of give way signs (or no control at all) at four-way intersections; whether this be from a reduction in crashes from increased control or an increase in crashes when control is reduced. The effect of changing control at three-way intersections is less clear.

Many of the crashes resulting at four-way controlled intersections appear to be adjacent approach, right-angle crashes. The few studies that have looked into the mechanisms of such crashes commonly attribute non-compliance of the control as a leading mechanism (i.e. a driver on the minor road failing to give way to adjacent traffic).

In the case of stop sign controlled intersections, it is suggested that traversing stop signs without stopping can be a substantial issue but that doing so is not over-proportionally observed in crashes at such intersections.

Overall, there appears to be some evidence supporting a reduction in crash risk associated with the use of stop control over give way control, though it is not understood what the underlying mechanisms behind this benefit are.

5.2 In-depth crash investigation

A range of mechanisms were identified for crashes at both intersection types. Visual obstructions (based on the subjective judgement of CASR crash investigators) were no more of an obvious issue at the crashes occurring at stop controlled intersections, compared to those occurring at give way controlled intersections. A higher proportion of cases occurred at stop controlled intersections where the minor road driver stopped before proceeding, compared to give way controlled intersections. A number of crashes at stop controlled intersections involved the possibility of dynamic visual obstruction from other vehicles, a phenomenon not observed with any of the give way controlled intersection cases.

At both give way and stop controlled intersections, a number of crashes occurred when the minor road driver did not appear to recognise the presence of either any control or the intersection itself. This phenomenon was observed to occur twice at one particular stop controlled intersection, with one crash occurring after signage upgrades aimed at increasing driver awareness of the control signs.

All crashes at uncontrolled intersections occurred at T-junctions. While there were some notable differences in the crash mechanisms at these intersections, the preclusion of any cross road intersection cases makes comparison with the other cases difficult. Notably, the majority of crashes occurred in metro locations in 60 km/h or below speed zones and there was only one case where a minor road driver was identified as not having stopped before proceeding into the intersection. A substantial proportion of cases also involved the possibility of dynamic visual obstruction.

5.3 RAA survey

A survey was undertaken to identify the perception of risk that road users associate with varying levels of control at intersections, and whether road users could correctly identify the need to give way to other vehicles at an intersection.

The cohort of respondents was likely not representative of the overall population of road users in South Australia, with the majority of respondents being 45 years or older and having driven on an unrestricted driver's license for 20 or more years. This limitation was due to the survey distribution process. Other distribution methods were considered but were deemed likely to result in an even more biased sample.

Overall, the findings suggest some statistically significant, though generally small differences between the perception of personal risk related to using intersections of varying control. While there was little difference between perceived risk at stop or give way controlled four-way intersections in the metro scenarios, stop controlled intersections were perceived to be marginally safer for rural scenarios.

Safe system scenarios were also tested. On average, roundabouts (metro and rural) were perceived to be moderately safer by all respondents. On average, raised plateaus (tested for the metro scenario only) were perceived to be less safe than other control types, particularly by motorcyclists. However, this perception was reversed for the under 45 years of age cohort, who on average perceived raised plateaus to be safer.

Respondents were also asked to rate their expectation of the need to give way to other traffic under a number of scenarios. When presented with a rural T-junction scenario, there was marginally greater expectation of the need to give way to other traffic when a give way sign was present, as opposed to when no control signage was present.

There was generally good consensus between the respondents regarding the need to give way at an upcoming intersection when presented with stop sign ahead and T-junction ahead/T-junction beyond curve signs. There was less consensus when respondents were presented with a give way sign ahead sign, with a substantial number of respondents unsure as to whether to expect the need to give way to other traffic.

When presented with intersection advanced warning signs used to warn of an upcoming intersection on a major (non-controlled) approach, there was generally less consensus with many respondents expecting the need to give way to other traffic. This effect was lessened with the addition of arrows on the signs, suggesting that recent changes to the Australian Standards requiring the use of arrowed cross road ahead and side road ahead warning signs have helped reduce driver confusion.

5.4 Overall conclusions

Regarding the main topic of this report (a comparison of uncontrolled, give way and stop controlled intersections), there appears to be some benefit to the use of greater control (e.g. stop control instead of give way control) at four-way intersections. This finding was reflected in the literature review, with a general consensus regarding reduced crash risk when greater control was used to replace lesser control.

5.5 Recommendations

Results of this study, particularly the survey, highlighted important issues of road user perception and awareness at intersections. In order to help rectify these issues, the following recommendations are made.

- A residual of road users do not correctly identify expecting the need to give way at non-signalised intersections (approximately 4-10% of survey respondents). It is therefore recommended that redundancy be introduced at intersections where such confusion and therefore error could lead to severe outcomes. Redundancy could come from treatments that reduce outcome severity or likelihood of error. Safe System intersection designs, which are focussed on eliminating the potential for severe outcomes should an error occur, are recommended as a priority treatment for introducing redundancy.

- Uncontrolled T-junctions appear to elicit confusion in a proportion of road users (approximately 7% of survey respondents). It is recommended that all uncontrolled T-junctions be treated with, at a minimum, give way control.
- A substantial proportion of road users appear to be more confused about the expecting the need to give way at upcoming intersections where a superseded (without directional arrow) side-road or cross road ahead sign is present. It is recommended that these superseded signs be identified and replaced with updated signs as a priority action.
- While there appears to be some benefit to the use of greater control (e.g. stop control instead of give way control) at four-way intersections, the reasons behind this are unknown. It is recommended that further research be undertaken to gain a better understanding of these reasons.

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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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Appendix A: online survey questions

The following encompasses the questions presented to respondents in the RAA online survey. The questions and images are the same as those presented to respondents; however they are presented here in a different format to that used in the online survey.

General Information

Question 1.1: What is your residential postcode?

Response 1.1: Free text

Question 1.2: What age range are you within?

Response 1.2: Single answer selection:

- 18 – 24 years old
- 25 – 34 years old
- 35 – 44 years old
- 45 – 54 years old
- 55 – 64 years old
- 65 – 74 years old
- 75 – 84 years old
- 85 and over

Question 1.3: For how long have you held an unrestricted (i.e. no “L” or “P” plate required) driver’s licence?

Response 1.3: Single answer selection:

- Less than 1 year
- 1 – 2 years
- 3 – 4 years
- 5 – 9 years
- 10 – 14 years
- 15 – 19 years
- 20 years or more

Question 1.4: Which of the following vehicle(s) have you driven/ridden in the last 6 months?

Response 1.4: Multiple answer selection:

- Bicycle
- Motorcycle
- Passenger vehicle (e.g. car, van)
- Heavy vehicle (e.g. truck, bus)
- I have not driven/ridden any of these vehicles in the last 6 months

Question 1.5: In the past 6 months, how frequently have you driven on metro roads?

Response 1.5: Single answer selection:

- Never
- Rarely
- Sometimes
- Often
- Most days

Question 1.6: In the past 6 months, how frequently have you driven on regional roads/highways?

Response 1.6: Single answer selection:

- Never
- Rarely
- Sometimes
- Often
- Most days

Question 1.7: On average, how many hours per day do you spend driving?

Response 1.7: Single answer selection:

- Less than 1 hour
- 1 – 2 hours
- 3 – 4 hours
- 5 or more hours

Question 1.8: How would you rate the speed that you generally drive at compared to most other drivers on the road?

Response 1.8: Single answer selection:

- Slower than most
- About the same speed as those around me
- Faster than most

Question 1.9: Considering all factors (e.g. the road environment, other drivers, your own driving ability), how safe do you perceive the task of driving to be?

Response 1.9: Single answer selection:

- Very safe
- Moderately Safe
- Neither safe nor dangerous
- Moderately dangerous
- Very dangerous

Question 1.10: What do you perceive to be the source of greatest risk to your own safety as a road user?

Response 1.10: Single answer selection:

- My own actions
- The actions of other road users
- The road environment that I am driving along

Question 1.11: What are the top three (3) driver behaviour issues that most concern you? (Please select your top 3)

Response 1.11: Multiple answer selection:

- Drug driving
- Drink driving
- Speeding
- Tailgating
- Inattention
- Driver fatigue
- Reckless driving
- Non-restraint/seatbelt wearing
- Mobile phone usage/texting
- Child restraint misuse
- Other

Intersection safety part 1

Question 2 preamble: In the following questions, you will be shown a series of scenarios and asked to rank how safe you perceive performing a right turn to be.

Question 2.1: Scenario: You are driving a passenger vehicle and approaching a “cross road” intersection along a metro road.

Question 2.1: How safe do you perceive performing a right turn to be?

Image 2.1:

Response 2.1: Single answer selection:

- Very safe
- Moderately Safe
- Neither safe nor dangerous
- Moderately dangerous
- Very dangerous

Question 2.2: Scenario: You are driving a passenger vehicle and approaching a “cross road” intersection along a metro road.

Question 2.2: How safe do you perceive performing a right turn to be?

Image 2.2:

Response 2.2: Single answer selection:

- Very safe
- Moderately Safe
- Neither safe nor dangerous
- Moderately dangerous
- Very dangerous

Question 2.3: Scenario: You are driving a passenger vehicle and approaching a “cross road” intersection along a metro road.

Question 2.3: How safe do you perceive performing a right turn to be?

Image 2.3:

Response 2.3: Single answer selection:

- Very safe
- Moderately Safe
- Neither safe nor dangerous
- Moderately dangerous
- Very dangerous

Question 2.4: Scenario: You are driving a passenger vehicle and approaching a “cross road” intersection along a metro road.

Question 2.4: How safe do you perceive performing a right turn to be?

Image 2.4:

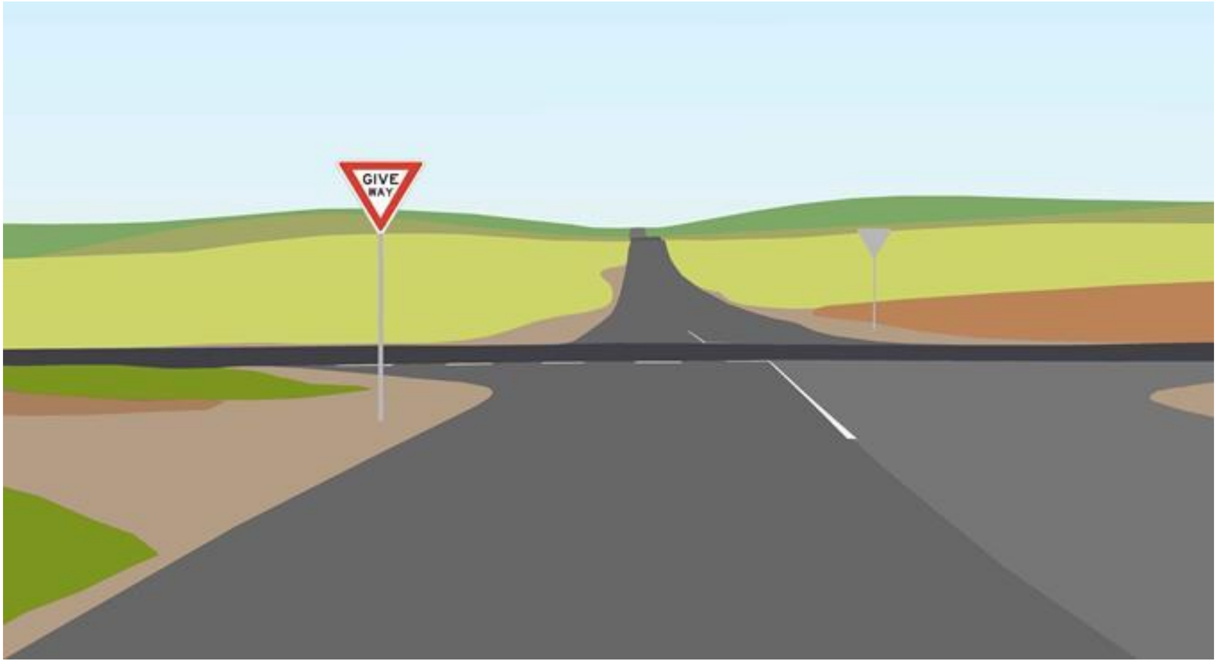
Response 2.4: Single answer selection:

- Very safe
- Moderately Safe
- Neither safe nor dangerous
- Moderately dangerous
- Very dangerous

Question 2.5: Scenario: You are driving a passenger vehicle and approaching a “cross road” intersection along a regional road.

Question 2.5: How safe do you perceive performing a right turn to be?

Image 2.5:



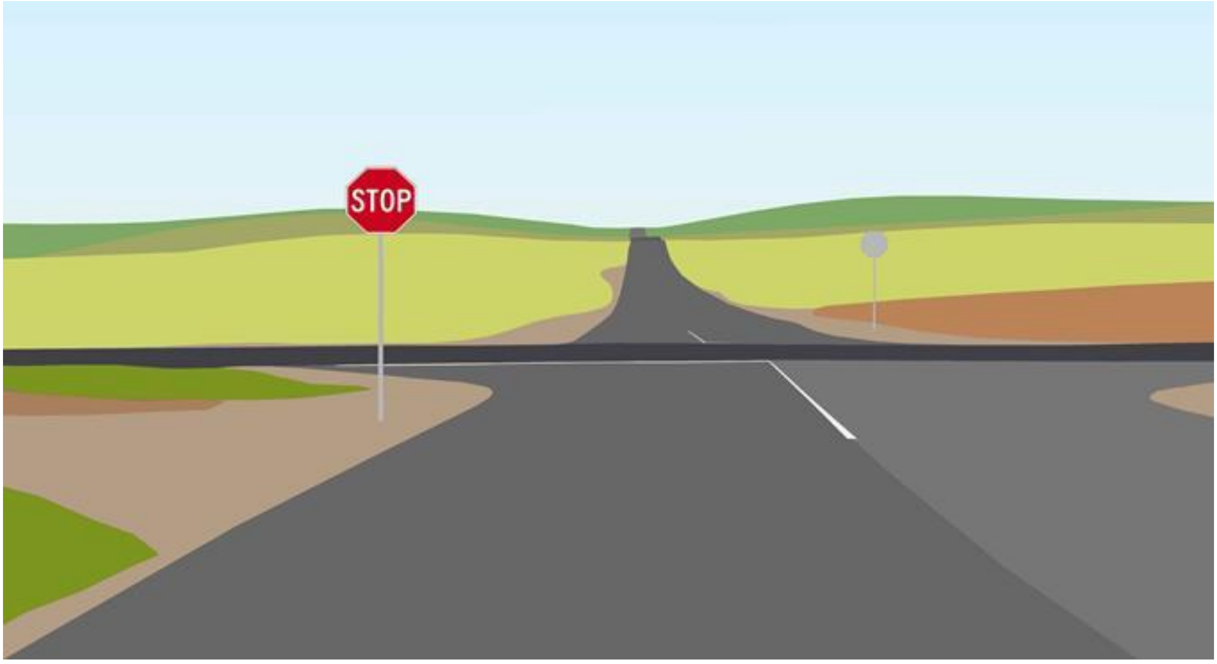
Response 2.5: Single answer selection:

- Very safe
- Moderately Safe
- Neither safe nor dangerous
- Moderately dangerous
- Very dangerous
-

Question 2.6: Scenario: You are driving a passenger vehicle and approaching a “cross road” intersection along a regional road.

Question 2.6: How safe do you perceive performing a right turn to be?

Image 2.6:



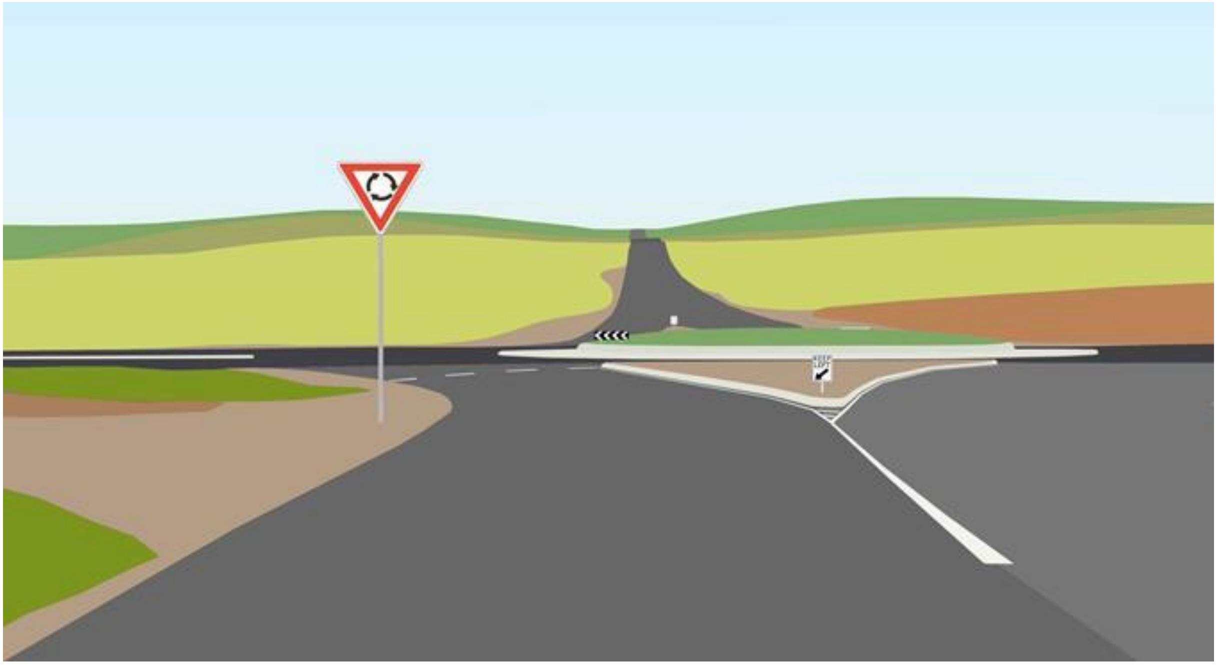
Response 2.6: Single answer selection:

- Very safe
- Moderately Safe
- Neither safe nor dangerous
- Moderately dangerous
- Very dangerous

Question 2.7: Scenario: You are driving a passenger vehicle and approaching a “cross road” intersection along a regional road.

Question 2.7: How safe do you perceive performing a right turn to be?

Image 2.7:



Response 2.7: Single answer selection:

- Very safe
- Moderately Safe
- Neither safe nor dangerous
- Moderately dangerous
- Very dangerous

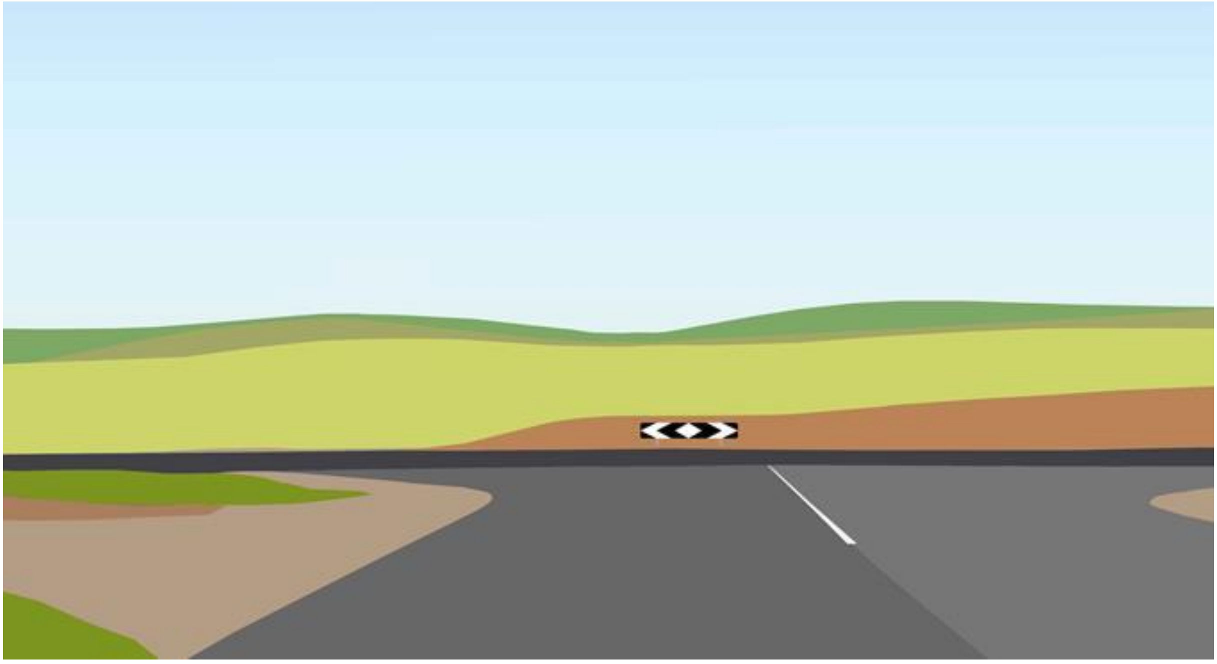
Intersection safety part 2

Question 5 preamble: In the following question, you will be shown a series of scenarios and asked to choose whether you think you will be required to give way to other vehicles.

Question 5.1: Scenario: You are driving a passenger vehicle and approaching a “T-junction” intersection along a regional road that ends at the intersection.

Question 5.1: Do you think you are required to give way to traffic on the intersecting road?

Image 5.1:



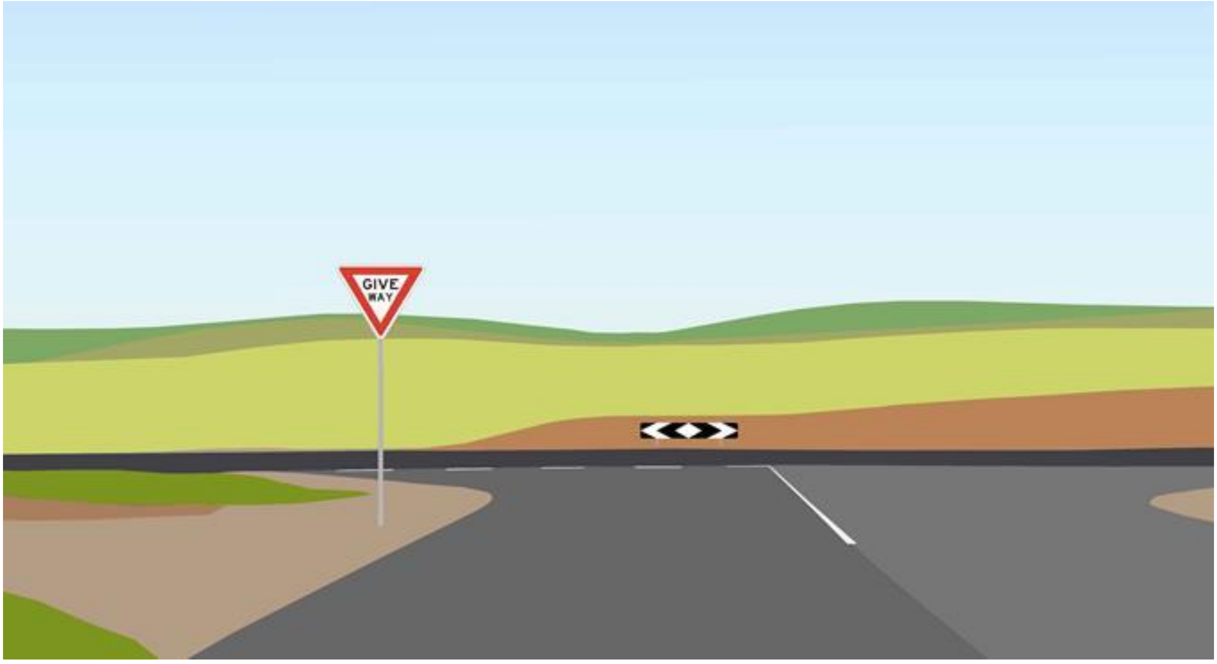
Response 5.1: Single answer selection:

- Yes, to all other traffic
- Yes, but only to traffic on my right
- No, I am not required to give way to other traffic
- I don’t know

Question 5.2: Scenario: You are driving a passenger vehicle and approaching a “T-junction” intersection along a regional road that ends at the intersection.

Question 5.2: Do you think you are required to give way to traffic on the intersecting road?

Image 5.2:



Response 5.2: Single answer selection:

- Yes, to all other traffic
- Yes, but only to traffic on my right
- No, I am not required to give way to other traffic
- I don’t know

Warning signs

Question 4 preamble: In the following questions, you will be shown a series of warning signs and asked to choose whether you think they relate to an upcoming intersection at which you will be required to give way to other vehicles.

Question 4.1: If you encountered the following traffic sign, would you expect to be required to give way to other traffic at an upcoming intersection?

Image 4.1:

Response 4.1: Single answer selection:

- Yes
- Sometimes
- No
- I don't know

Question 4.2: If you encountered the following traffic sign, would you expect to be required to give way to other traffic at an upcoming intersection?

Image 4.2:

Response 4.2: Single answer selection:

- Yes
- Sometimes
- No
- I don't know

Question 4.3: If you encountered the following traffic sign, would you expect to be required to give way to other traffic at an upcoming intersection?

Image 4.3:

Response 4.3: Single answer selection:

- Yes
- Sometimes
- No
- I don’t know

Question 4.4: If you encountered the following traffic sign, would you expect to be required to give way to other traffic at an upcoming intersection?

Image 4.4:

Response 4.4: Single answer selection:

- Yes
- Sometimes
- No
- I don’t know

Question 4.5: If you encountered the following traffic sign, would you expect to be required to give way to other traffic at an upcoming intersection?

Image 4.5:

Response 4.5: Single answer selection:

- Yes
- Sometimes
- No
- I don't know

Question 4.6: If you encountered the following traffic sign, would you expect to be required to give way to other traffic at an upcoming intersection?

Image 4.6:

Response 4.6: Single answer selection:

- Yes
- Sometimes
- No
- I don't know

Question 4.7: If you encountered the following traffic sign, would you expect to be required to give way to other traffic at an upcoming intersection?

Image 4.7:

Response 4.7: Single answer selection:

- Yes
- Sometimes
- No
- I don’t know

Question 4.8: If you encountered the following traffic sign, would you expect to be required to give way to other traffic at an upcoming intersection?

Image 4.8:

Response 4.8: Single answer selection:

- Yes
- Sometimes
- No
- I don’t know

Stop versus Give Way control

Question 6.1: Apart from the requirement to stop at a Stop sign, what other differences do you perceive between a Stop sign (

) and a Give Way sign (

)?

Response 6.1: Free text

Final remarks

Question 7.1: Do you have any additional comments that you would like to make?

Response 7.1: Free text