

4X STOP; WHOSE MOVE?

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ABSTRACT

Four-way stop controlled intersections are an uncommon phenomenon in New Zealand. In recent years, media has featured instances of these intersections where users have both supported the slow speed environment that is created and complained of near misses and confusion as to who has right of way.

This paper summarises the results of a study undertaken to better understand user perception and behaviour and the safety performance of four-way stop intersections. Stemming from a 'whose move?' question of priority faced when traversing a four-way stop intersection, a crash study, user perception survey and review of legislation has been undertaken to investigate the application and performance of four-way stop intersections.

The perception survey highlighted the sense of challenge and safety that users experience compared to other forms of unsignalised crossroads intersections and showed little consensus regarding the 'whose move' priority scenario.

The crash history of five 4-way stop and 16 other unsignalised crossroads intersections was analysed and compared. While the small sample and low occurrence of crashes limited the ability to draw conclusions, no key safety risks were found for the four-way stop intersections analysed.

While review of relevant legislative framework showed that vehicles must stop then give way to all approaching vehicles, it highlighted ambiguity surrounding the application of road rules at four-way stop intersections. The uncertainty of road users corresponds with the lack of clarity in legislation and highlights the need for further clarification.

The analysis of user perceptions, safety and legislation informs practitioners about the application of four-way stop controlled intersections and the issues of uncertainty surrounding them.

INTRODUCTION

This research paper summarises a study of crossroads intersections with stop controls on all approaches, as illustrated in Figure 1. Stemming from a 'whose move?' priority quandary encountered when traversing a four-way stop intersection, the efficacy of four-way stop controls was questioned. From a traffic engineering and transport planning perspective, ambiguity with regard to user priority and right of way is generally managed to mitigate risk and prevent accidents occurring. The 'whose move' dilemma regarding the application of priority rules at four-way stop intersections epitomises the challenges that four-way stop intersections pose for users.

This paper seeks to improve understanding of the use of four-way stop intersections and whether they achieve their desired design outcomes. It presents findings from research into user perceptions, safety performance and legislation of four-way stop intersections.



Figure 1. Four-way stop intersection (adapted from NZ Transport Agency 2015).

BACKGROUND

Four-way stop intersections are generally implemented to reduce vehicle speeds and improve safety outcomes. A summary of international studies indicates that four-way stop controls reduce the occurrence of crashes by approximately 45% compared to other unsignalised crossroads intersections, excluding roundabouts (Elvik et al. 2009). This summary is restricted to frequency and excludes crash severity.

While these controls may improve safety, there are some adverse effects on mobility and the environment. Four-way stop controls are known to increase delay at intersections (Elvik et al. 2009; Henriksson 1992), as expected because all users are required to stop prior to traversing the intersection. A 1992 study in Sweden found that four-way stops resulted in a 10-20% increase in emissions compared to two-way stops (Henriksson 1992). While this is somewhat outdated and not specific to New Zealand, an increase in emissions is expected due to increased stopping and starting.

New Zealand media has featured four-way stop intersections in recent years. Reports highlight the differing views relating to the intersections. For example, Stuff labelled a four-way stop crossroads as "*Wellington's most puzzling intersection*" (George 2016). Within the news article, the NZ Transport Agency and the Automobile Association (AA) responded to give way rule queries. The Agency advised that users should give way to their right, whereas the AA general manager said that users should first stop then make eye contact and use courtesy. The public voiced varying views about the intersection, including support and safety concerns relating to confusion and road rage.

Four-way stop intersections, although relatively uncommon, can be found across New Zealand in both urban and rural areas. These intersections are much more common in some countries overseas, such as the United States of America (Elvik et al. 2009).

METHODOLOGY

To analyse the efficacy of four-way stops as a form of intersection control, this assessment considered:

- User perceptions gathered through qualitative surveys
- Their safety performance compared to other forms of non-signalised intersection control; and
- The legislative and regulatory framework

User Perceptions

An online survey was conducted to gather information about how people perceive and use four-way stop intersections in New Zealand, including:

- Responder demographics – including involvement in the industry and familiarity with intersection design, age and gender
- Use of four-way stop intersections – including frequency, mode, locations of four-way stop intersections, which car they believe has right of way in the situation illustrated in Figure 2 and why



Figure 2. 'Whose move' situation (adapted from NZ Transport Agency 2015).

- Perceptions of challenge and safety at four-way stop intersections compared to other control configurations at unsignalised crossroads intersections.

The survey participation recruitment was undertaken using social media and word-of-mouth, applying snowball sampling.

Safety Performance

Study Site Identification

Initial research showed that there were limited means to identify four-way stop intersections in New Zealand aside from word-of-mouth. As such, the user perception survey was used to identify possible study sites. This also provided the option for comparing respondents' comments with specific intersections that they had identified.

To allow for comparisons of different forms of control at unsignalised crossroads intersections, clusters of intersections with similar contexts were analysed. The four-way stop intersections identified in the perception survey and surrounding intersections were assessed to identify clusters that met the following criteria:

- Contain multiple crossroads intersections with a variety of forms of control:
 - Stop controls on one of the intersecting roads, no controls on the other road
 - Give way controls on all four approaches

- Give way controls on one of the intersecting roads, no controls on the other road
- Four leg roundabout
- Each intersection within the cluster required:
 - Similar surrounding land use, e.g. residential
 - Similar road classifications, e.g. intersection of two local roads
 - Comparable traffic counts or catchment areas where traffic counts were unavailable
 - Similar users, i.e. geographically close

The clusters identified were all located within Christchurch. While this is an important part of the methodology, it was not deliberate and was instead an outcome of the perception survey and above criteria.

Crash Data

Crashes within a 50m buffer of the selected intersections have been extracted from the NZ Transport Agency's Crash Analysis System (CAS). The crash history from the previous ten years (2008 – 2017, inclusive) has been analysed.

The CAS crash reports were analysed in order to identify commonalities in crash factors and movements.

Safety Metrics

Three safety metrics; Collective Risk, Personal Risk and Level of Safety Service have been used in this analysis.

- Collective Risk is measured as the total number of fatal and serious crashes or deaths and serious injury equivalents per intersection in a five-year crash period (NZ Transport Agency 2013)
- Personal Risk is the risk of death or serious injury to each vehicle entering the intersection (NZ Transport Agency 2013)
- Level of Safety Service (LoSS) is a measure of the historic intersection safety performance relative to that expected based on a statistical analysis of New Zealand intersections. It identifies intersections that perform poorly relative to similar intersections of the same configuration, considering the speed environment, intersection form and amount of traffic travelling through the intersection. LoSS calculations do not require any additional information beyond that used to calculate Personal Risk.

The risk metrics have been calculated and categorised for each intersection based on the methodology outlined in the NZ Transport Agency's High Risk Intersection Guide (NZ Transport Agency 2013). While the Guide uses a five-year crash history, a ten-year analysis period was used for the crash study due to the low traffic volumes and low crash instance at the intersections analysed.

Where traffic volumes were available for only one of the intersecting roads, the volumes of each road were assumed to be equal. This assumption was considered sufficient because four-way stop intersections typically involve roads of similar flows and the Personal Risk metrics were reported as bands rather than values, meaning the results were not highly sensitive to volume.

Legislative and Regulatory Framework

Relevant legislation has been reviewed with the purpose of identifying priority rules associated with four-way stop intersections. This includes the New Zealand Road Code and the New Zealand Land Transport Rule 2004.

FINDINGS

User Perceptions

Respondents and Familiarity with Four-Way Stop Intersections

There were 70 full responses collected for the perception survey. Table 1 contains key statistics relating to respondent demographics and familiarity with four-way stop intersections.

Table 1. Summary of responses to demographic and familiarity questions.

Responses		70
Age	18 – 24	27%
	25-34	24%
	35-44	19%
	45-54	17%
	55-64	6%
	Did not specify	7%
Gender	Female	56%
	Male	31%
	Diverse	1%
	Did not specify	11%
Occupation involved traffic engineering / transportation planning / traffic safety enforcement	Very familiar with 4x Stop intersections from a design sense	3%
	Aware of design considerations for 4x Stop intersections	12%
	Not familiar with 4x Stop intersection design	16%
Frequency of use of four-way stop intersections	Often (at least weekly)	13%
	Sometimes (between weekly and monthly)	13%
	Occasionally (less than monthly)	46%
	Do not recall using one	28%
Mode primarily used at four-way stop intersections	Drive	73%
	Passenger in driven vehicle	1%
	Cycle	9%
	Walk	1%
	Do not use them	16%

Perceptions of Challenge and Safety at Different Crossroads Intersections

Figures 3, 4 and 5 compare the level of confusion and safety felt by drivers/passengers, cyclists and regular users respectively. This showed that motorists found four-way stop intersections the most challenging whereas cyclists and regular users did not experience the same level of challenge. People felt safest at roundabouts, followed by four-way stop intersections.

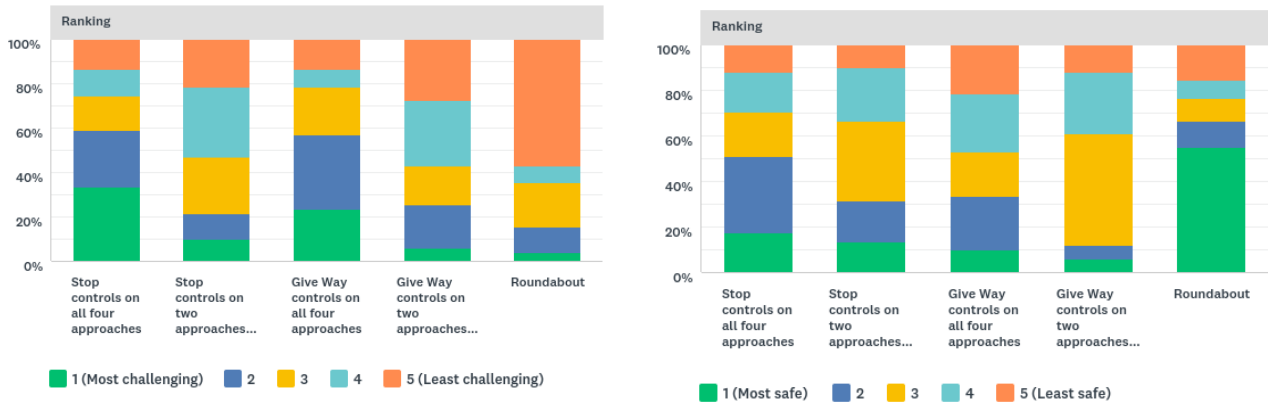


Figure 3. Ranking of crossroads intersections in terms of how challenging (left) and safe (right) responders feel they are, as a driver (n=51).

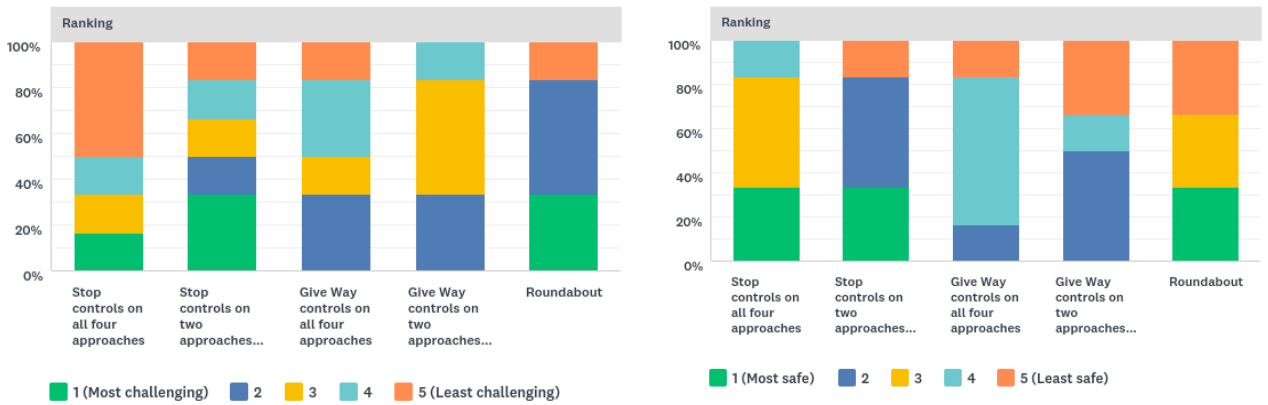


Figure 4. Ranking of crossroads intersections in terms of how challenging (left) and safe (right) responders feel they are, as a cyclist (n=7).

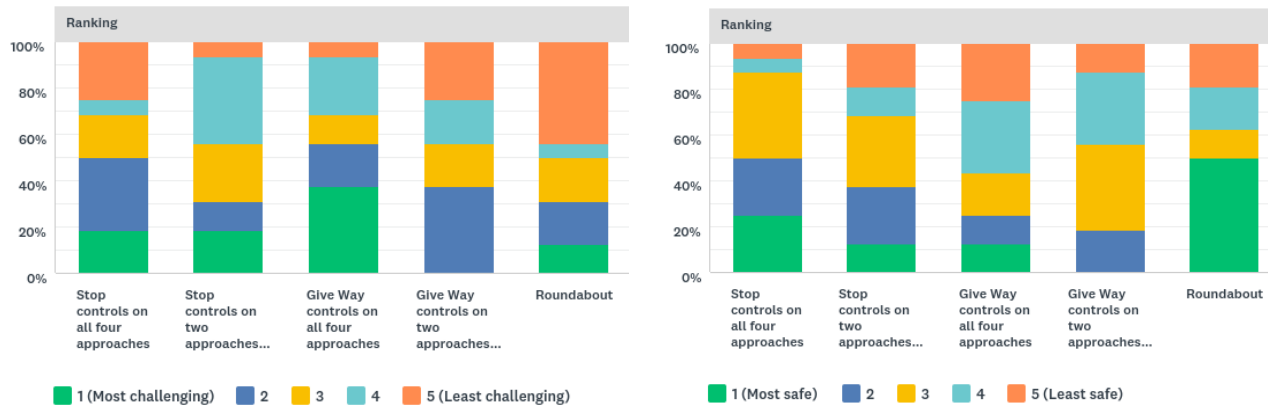


Figure 5. Ranking of crossroads intersections in terms of how challenging (left) and safe (right) responders feel they are, as a regular user (at least weekly, n=16).

Application of Priority / Give Way Rules

Figure 6 summarises the response to the priority question posed in the survey.

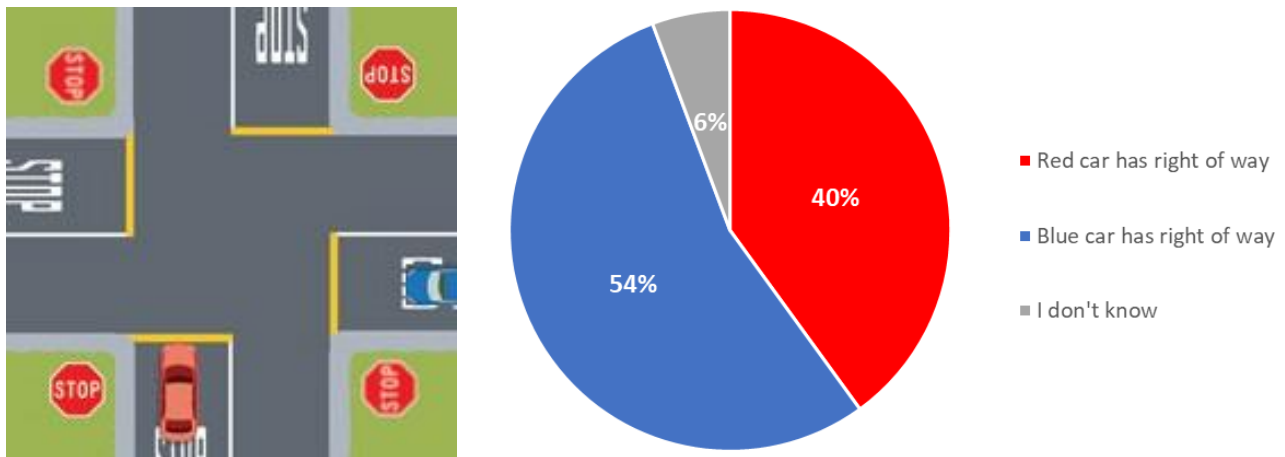


Figure 6. Priority scenario (adapted from NZ Transport Agency 2015) and breakdown of overall response to the question asking which car has priority (n=70).

Of the ten responders who stated they were “aware of design considerations” or “very familiar from a design sense” with four-way stop intersections, six said the red car has right of way and four said the blue car has right of way.

From the 36 responders under the age of 35, 64% said the blue car has right of the way, 30% said the red car has right of the way and the remainder said they did not know. Conversely, the majority (55%) of those 35 and older said the red car has priority, 38% said the blue car has priority and the remainder did not know. T

The majority of female respondents (56%) said the blue car has right of way, with 34% saying the red car has priority. Of the male respondents, 50% said the blue car has priority, 45% said the red car has priority and 5% did not know.

Of the 16 regular (at least monthly) users, 11 said the blue car has priority, four said the red car has priority and one did not know.

When prompted to provide reasoning as to why they thought the blue/red car had priority, 51% referred to give way rules, 33% said the red car has priority as it stopped first and the remaining 11 respondents did not provide reasoning (more than the number of people who answered “I don’t know” to the priority question). Of the 51% who cited give way rules, 8% said they apply the give way rules and treat the intersection like a roundabout. 48% said they would give way to their right and two responders said they would give way to their left.

Further Comments

Other notable comments provided in the survey include:

- *Four way intersections are only challenging when there is a significant difference in traffic volumes between the two roads*
- *Four way stops only work in very low traffic environments – they cause mayhem if the traffic volume increases*
- *The speed and volume of the traffic both impact my feelings of challenge and safety at intersections. The control of give way of stop do not really make much difference to me. A roundabout does feel safer as the speeds are often lower and drivers are concentrating on checking half conflicting movements. At four way intersections there are more aspects to check, including right turn queues and for me in built up areas – parking, pedestrians/crossing points, bus stops etc all complicate an intersection use from a driver*

perspective

- *My feeling of safety at a roundabout is much lower on a bike than in a car (I feel much less safe on a bike in that situation)*
- *Four-way controlled intersections provide uncertainty as not all people remember the give way to your right rule*
- *I think four way stops are under utilised as a cost effected safety device, including in rural situations. There have been a number of fatal crashes at four arm intersections that four way stop would have likely prevented.*
- *It's a bit concerning that at some intersections it seems that human eye-contact is what determines right-of-way*
- *I think a lot of people are confused by four-way stop intersections so in a real world situation if I felt like the blue car didn't know what it was doing I might just wait and use the "give way to your right" rule instead*
- *Kiwis are very bad at coming to a complete stop at stop signs*
- *There are many more factors to consider: speed, vehicle and driver attitude/aggression, other vehicles not shown, width of road, dominant flow, etc.*
- *Four way intersections are less common in NZ and there are different views on who has priority. Pedestrian and cycle movements are more challenging at these types of intersections particularly considering vehicle gap acceptance time where drivers are not focused on peds and/or cyclists*

Safety Performance

Three areas were identified as meeting the study site selection criteria detailed in the safety performance methodology. As shown in Table 2, 21 unsignalised Christchurch intersections were analysed. Nine are located in the wider Riccarton area, four are in Hornby and eight are in Richmond. The annual breakdown of crashes by severity and the calculated Collective Risk, Personal Risk and LoSS are given for each intersection.

Owing to the low instance of crashes that have occurred at the intersections over the previous ten years, no crash commonalities were identified. None of the crashes reported at the four-way stop intersections were associated with the form of control.

Table 2. Summary of the configuration and safety performance of each of the intersections analysed.

Cluster	Intersection			Road classification		Control Configuration	AADT		Number of Crashes by Severity				Risk Metrics (2008-2017)		
	#	Road 1	Road 2	1	2		1	2	Fatal	Serious	Minor	Non-Injury	Collective	Personal	LoSS
A - Riccarton	1#	Matai Street	Harakeke Street	Local	Local	4x Stop	989*	989	-	-	-	-	Low	Low	I
	2	Rata Street	Rimu Street	Local	Local	4x Stop	1117*	1117	-	-	-	1	Low	Low	I
	3#	Puriri Street	Hinau Street	Local	Local	2x Stop	1458	1458*	-	-	1	2	Low	Low	I
	4#	Totara Street	Konini Street	Local	Local	2x Stop	None available		-	-	-	1	Low	Low	I
	5	Wainui Street	Peveler Street	Local	Local	2x Stop	1640	1640*	-	-	6	9	Low Medium	Medium High	IV
	6	Tui Street	Weka Street	Local	Local	Roundabout	2326	2326*	-	-	1	1	Low	Low	I
	7	Woodbury Street	Apsley Drive	Local	Collector	Roundabout	3273	3208	-	-	2	2	Low	Low	II
	8	Tika Street	Centennial Avenue	Local	Local	2x Give Way	None available		-	-	-	1	Low	Low	I
	9	Worthy Street	Corfe Street	Local	Local	2x Give Way	None available		-	-	1	-	Low	N/A	
B - Hornby	10	Blankney Street	Witham Street	Local	Local	4x Stop	415	612	-	-	-	1	Low	Low	I
	11	Bennington Way	Mustang Avenue	Local	Collector	2x Stop	308*	308	-	-	-	-	Low	Low	I
	12	Napier Drive	Awatea Gardens	Local	Local	2x Give Way	None available		-	-	-	-	Low	Low	I
	13	Awatea Road	Mustang Road	Local	Collector	Roundabout	None available		-	-	-	1	Low	Low	I
C - Richmond	14	Guild Street	Slater Street	Local	Local	4x Stop	1453*	1453	-	-	-	-	Low	Low	I
	15	Dudley	Slater Street	Local	Local	4x Stop	1453*	1453	-	-	-	-	Low	Low	I
	16	Randall Street	Petrie Street	Local	Local	2x Stop	1052*	1052	-	-	1	1	Low	Low	I
	17	Warden Street	Slater Street	Local	Local	2x Stop	1453*	1453	-	-	-	2	Low	Low	I
	18	Warden Street	Chancellor Street	Local	Local	2x Stop	None available		-	-	-	-	Low	Low	I
	19	Perth Street	London Street	Local	Local	2x Give Way	None available		-	-	-	2	Low	Low	I
	20	Hope Street	Hercules Street	Local	Local	2x Give Way	None available		-	-	-	1	Low	Low	I
	21	Gayhurst Road	McBratneys Road	Collector	Collector	Roundabout	7597*	7597	-	-	2	1	Low	Low	I

*Assumed traffic counts for the calculation of Personal Risk and LoSS, used where counts are available for another approach and the roads have comparable demands.

#Intersection has a raised platform.

Legislative and Regulatory Framework

Four way stop intersections are permitted under Rule 4.2 of the Land Transport (Road User) Rule 2004 (Amended 2017). It states that “a driver approaching or crossing an intersection must give way to any vehicle approaching or crossing the intersection from his or her right”, unless they are turning or about to turn, in which case the driver “must give way to any vehicle not... making a turn” (New Zealand Government 2018).

The New Zealand Road Code does not include specific rules relating to four-way stop intersections. However, it states that at a stop sign you must “stay stopped until you have given way to all other vehicles” and “if you and another vehicle are both facing stop signs, use the give way rules” (NZ Transport Agency 2015). The give way rules reflect the legislative requirement by first stating that you must give way to non-turning vehicles. The ‘give way to your right’ rule is the final point, and only applies to situations not already specified in the rules.

DISCUSSION

The aim of this research was to better understand user perception and behaviour with regard to four way stop controlled intersections. As shown in the survey findings, there is a high level of ambiguity with regards to how these intersections are treated from a user perspective. Neither the Land Transport (Road User) Rule nor the Road Code directly state which vehicle has priority in the question posed to survey responders. As the road code specifies that vehicles should stop and then give way to all vehicles, it implies that the blue car would have priority in the situation illustrated in Figure 2. This corresponds with the slight majority of survey responses which said the blue car has right of way. As 33% of respondents reasoned, the red car may have time to proceed because the blue car is still required to stop. However, this is not reflected in legislation. The red car, having stopped, and checked it was safe to proceed through the intersection, would still need to give way to the blue car – or any car approaching from the right. This poses an additional source of ambiguity – is ‘approaching’ irrespective of distance? The Land Transport Rule does not define ‘approaching’. The closest clarity may be in the definition of ‘visible’; “able to be seen from a safe stopping distance” (New Zealand Government 2018). This does not provide adequate legibility for the case of four-way stop intersections.

The results show that there is insufficient guidance to address the confusion experienced by users of four-way stop intersections. Refined legislation may not result in a greater consensus to the survey priority questions, however it would at least enable people to find out and comprehend the answer.

Reviewing the legislation highlighted an additional scenario which could cause confusion at four-way stop intersections. Figure 7 shows one vehicle waiting to turn right and one waiting to travel through the intersection. The give way rules in the Road Code require the turning vehicle to give way to the non-turning vehicle. This contradicts the ‘give way to your right’ rule and ‘treat it like a roundabout’ approach which survey responses referred to.



Figure 7. A second ‘whose move’ scenario for a four-way stop intersection (adapted from NZ Transport Agency 2015).

Engagement

Given that the survey indicated a relatively high sense of challenge experienced by road users at four-way stop intersections, greater community engagement could be used to encourage road user responsibility. Particularly if new four-way stop intersections are installed, the sense of challenge experienced by the public could be reduced by educating users about how they are intended to be used. However, as discussed above, the legislation is not immediately clear and should be clarified for four-way stop intersections. This would aid encouragement and enforcement of road user responsibility.

Greater engagement could also negatively affect the safety performance of four-way stop intersections. While it would likely improve user-friendliness, increased understanding and confidence of users may 'undo' the engaging slow speed environment that the intersections create.

Active Road Users

Further consideration in regard to the safety of active road users at four-way stop intersections is required. Thus far, this study has had limited regard of pedestrian/cyclist safety because few people responded to the perception survey as a pedestrian/cyclist and pedestrian and cycle crashes are reported less than motor vehicle crashes, particularly for low severity crashes (NZ Transport Agency 2013).

In urban environments, four-way stop intersections are generally located in low-speed environments or established as a speed reduction measure. As lower speed environments typically have higher numbers of active road users and vulnerable users with greater susceptibility to injury at lower speeds (NZ Transport Agency 2013), consideration of pedestrian and cycle safety is particularly important.

Forms of Control at Crossroads Intersections

Control options for unsignalised intersections have varying advantages and disadvantages. Four-way stop controls lower vehicle speeds, however the major movement is impeded and the treatment can cause uncertainty for motorists, as the perception survey indicated. Using stop or give way controls on only one of the intersecting roads maintains a clear priority and is typically more legible for users. Roundabouts are a familiar intersection type which does not favour particular movements and provides clear priority to all motorists. However, roundabouts can be less legible for active road users, can restrict movement of larger vehicles and require a greater area.

While four-way stop controls result in low speeds through intersections because all vehicles are required to stop prior to traversing, they are less efficient and ambiguity surrounding them means users sometimes rely on eye contact and courtesy to dictate priority.

Four-way stop intersections are used rarely, which is expected to contribute to the sense of challenge experienced by users. If four-way stop controls were more widely applied, increased familiarity may reduce the sense of 'challenge' and negate the extent of speed reductions which the intersections are intended to achieve. When four-way stop intersections are proposed, as with any intersection redesign, it is crucial to manage their implementation to ensure that familiar users recognise the change in control.

Limitations

There are several limitations to this initial study, including:

- The safety analysis is based on unsignalised urban intersections. While this was not intentional, the perception survey showed a focus on urban situations and only urban intersections were identified for the crash study. The user perception survey sampling method did not exclude rural populations, however only clusters identified in accordance with the criteria listed in the methodology were located in Christchurch.
- Small sample sizes limited the ability to identify statistically significant trends:

- User perception survey responses (70)
- Number of unsignalised intersections analysed in the crash study (21 intersections in three clusters, with only five four-way stop intersections)
- Inconsistent responses to the perception survey:
 - For example, 19 people said they do not remember using a four-way stop intersection yet only 11 answered “I do not use them” to the question asking how they normally travelled through four-way stop intersections
 - Some people may not have noticed that blue car was still approaching the stop control in Figure 2. This was considered when designing the survey and an explanation of the scenario was excluded in order to avoid influencing responses. However, some people may have responded differently if they had not noticed the red car had already stopped and the blue car had not.
- Non-representative survey
 - The survey was primarily answered by people residing in Auckland and Christchurch

The limitations most significantly affected the crash study. Few suitable study areas were identified and the intersections analysed had few crashes, likely due to the low volumes and low speed environments that are typically present at four-way stop intersections (particularly urban ones).

Further Study

The results and limitations of this study have highlighted several aspects that should be further researched in order to assess the application of four-way stop intersections in New Zealand.

In terms of the perception survey, it would be interesting to extend it to a wider audience and gain more responses that gauge the perspectives of active road users. Additionally, the scenario shown in Figure 7 could be posed to gauge understanding of give way rules and how people apply them in practice at four-way stop intersections.

The safety analysis would be greatly improved by extending the crash study to include all four-way stop intersections with other control types. The existing intersection descriptions in CAS mean that this would require a significant amount of manual work at this stage. However, a larger sample size would allow for some comparisons to be made with the perception study. While LoSS provides a useful measure to compare the safety performance of different intersection configurations, it does not specify control types beyond ‘priority controlled’. A more detailed tool could be developed to allow comparison of different forms of intersection control.

It would be useful to analyse rural four-way stop intersections in addition to the urban intersections analysed thus far. While they are typically established for the same speed reduction reasons as urban four-way stop intersections, their safety performance may differ significantly. The number of clusters analysed in this study was a significant limitation, and no rural areas were identified. It would be beneficial to determine an alternative method to identify four-way stop intersections rather than relying on word-of-mouth and media coverage.

Further study into the application and performance of four-way stop intersections could consider many more factors such as speed, driver attitude, road configuration and traffic flows.

CONCLUSION AND RECOMMENDATIONS

This study sought to answer the ‘whose move’ question for four-way stop intersections and compare public perceptions with legislation and safety performance of intersections.

The study showed that four-way stop intersections generate a sense of challenge amongst users, yet users of these intersections feel relatively safe. While this could possibly seem counterintuitive, a heightened sense of challenge may contribute to a lower speed environment. This may be a

reason for the increased sense of safety perceived by users. Delving into road user legislation showed that vehicles must come to a complete stop and then apply the give way rules to all approaching vehicles, regardless of whether or not they have come to a complete stop. However, the legislation did not define 'approaching' and highlighted ambiguity surrounding four-way stop intersections. The Land Transport Rule raised an additional situation that could generate confusion for users.

While the crash history analysis was limited by its extent and statistical significance, it indicated that four-way stop intersections are not overrepresented in crash history and may have improved safety outcomes.

Four-way stop controls are sometimes implemented at crossroads intersections to slow vehicle speeds. However, there is minimal evidence of their performance compared to other forms of control. It would be beneficial to undertake a more extensive crash study to quantify safety benefits and compare these to road user perspectives. The somewhat ambiguous legislation surrounding the application of give way rules at four-way stop intersections highlighted the need for more understanding from both practitioners and general road users. This was reflected in the perception survey which indicated that both parties have mixed opinions as to who has right of way at four-way stop intersections.

Overall, studying public perceptions, legislation and crash history each highlighted and helped to explain the high level of uncertainty surrounding four-way stop intersections. While uncertainty can aid in reducing vehicle speed and creating personable environments, further research could be conducted to determine the effects of this uncertainty.

REFERENCES

Elvik, R, Høy, A, Vaa, T, Sørensen, M 2009, *The Handbook of Road Safety Measures*, 2nd edn, Emerald Group Publishing Limited, Bingley.

George, D 2016, 'Explainer: What's the big problem at Wellington's most puzzling intersection?', *Stuff*, viewed 29 October
<<https://www.stuff.co.nz/motoring/83746463/explainer-whats-the-big-problem-at-wellingtons-most-puzzling-intersection>>

Henriksson, P 1992, Uppskattning av fördröjning och avgasutsläpp i fyrvägs korsningar med olika regleringsformer, speciellt fyrvägsstopp. Statens väg- och trafikinstitut, Linköping.

NZ Transport Agency 2013, *High-risk intersections guide*, viewed 30 October 2018
<<https://www.nzta.govt.nz/assets/resources/high-risk-intersections-guide/docs/high-risk-intersections-guide.pdf>>

NZ Transport Agency 2015, *The Official New Zealand Road Code*, viewed 30 October 2018
<<https://nzta.govt.nz/resources/roadcode/about-driving/giving-way-intersections/>>

New Zealand Government 2018, *Land Transport (Road User) Rule 2004*, viewed 31 October 2018
<<http://www.legislation.govt.nz/regulation/public/2004/0427/67.0/DLM302188.html#DLM303076>>

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