Report

Actual and Perceived Risk and Effects on Driver Behaviour Report

Prepared for NZ Automobile Association Research Foundation

By Beca Ltd (Beca)

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Revision History

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A	Jerry Khoo	Draft for Client Review	18/10/2013
B	Jerry Khoo	Issue for Stakeholder meeting	08/11/2013
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Action	Name	Signed	Date
Prepared by	Jerry Khoo		9/5/14
Reviewed by	Peter George, Marcus Brown		9-5-14
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on behalf of	Beca Ltd		

Executive Summary

The AA Research Foundation engaged Beca Limited and the Traffic and Road Safety Research Group of the University of Waikato (TARS) to undertake research on actual and perceived road safety risk and its effects on driver behaviour.

The project aims were to clarify in a New Zealand context:

- where actual risk (the objective risk which is directly measurable) matches drivers' perceived risk (indirectly measurable); that the road is self-explaining in terms of risk
- where objective risk is greater than drivers' perceived risks; that the environment is *not as safe* as perceived by drivers
- what perceptual cues are used by drivers to measure their perceived level of risk.

To better understand the subjective risks perceived by drivers, the following experimental methods were carried out:

- **Web survey.** This consisted of ranking the risk based on a series of photographs, which provided indication on risk recognition of specific road features.
- **Drive-over survey.** This survey consisted of ranking the risks on sections of road based on video clips.
- **In-person video survey.** This survey consisted of ranking the risks on sections of road through actually driving the routes.

Based on the experimental methods carried out in this research, the research findings have been summarised below in line with answering the four primary questions investigated in this research.

What level of risk is experienced by drivers on hazardous New Zealand roads?

There is evidence to suggest some relationship between drivers' perception of risk and the actual level of hazard on New Zealand roads (as measured by the KiwiRAP RPS).

The roadside hazards however are not always perceived as risks by the drivers. The intersection risks appear to be recognised and understood, as found from the web survey, but are possibly under perceived in the other surveys when a longer segment of route is involved. This suggests that further work is required by safety professionals to ensure drivers understand the level of risk on less safe roads in order to minimise crashes.

What road features do drivers use to judge driving risk?

The road features that drivers use to judge driving risk mainly comprise:

- **Road geometry**. This research has found that horizontal curves (i.e. tight corners and the number of bends) were perceived as higher risks (even with barriers) than straighter roads with other roadside hazards (such as power poles).
- **Signage**. This research has found that presence of signage such as low speed advisory signs at bends and chevrons, high crash rate signs, "slow down" speed signs, were perceived to convey reduced safety margins for the road.

Which hazardous road situations are under-recognised by New Zealand drivers?

This research indicated several risks associated with some road features on New Zealand roads are under-recognised by drivers.

- **Roadside hazards**. From the research, there was little to suggest that drivers perceive the risks of roadside hazards. There was also evidence to suggest that drivers slow down when they perceived a road being less safe. Based on the drive-over survey carried out, it was found that drivers would generally only slow down due to road geometry, and some instances the road cross section features. However drivers tend not to adjust speed based on roadside hazards.
- **Presence of side roads**. The web survey has indicated that the risks associated with presence of side roads are well recognised. However, these risks are possibly less well perceived in the other surveys when longer segments of a route are involved. When driving along longer segments there is a higher demand required on the driver's visual, motor skills[1] and cognitive resources, and it is likely that the intersection risk is sub-consciously not perceived when other features (such as road geometry) are more dominant.
- **Double yellow lines**. The research has found that drivers perceived the more open sight distance from straight road to be of lower risk compared to roads with tight and/or numerous bends. However, the presence of double yellow lines (no overtaking) indicated a reduction in perceived (subjective) risk.

What countermeasures can be used to convey a more accurate perception of risk?

This research has found that certain countermeasures provide a more accurate perception of risks. These include:

- **Signage** – Presence of signage such as curve (low speed) advisory signs / chevrons, high crash rate signs, were perceived to convey reduced safety margins for the prevailing road. Analysis of the dataset indicated that electronic 'Slow Down' advisory signs were also an effective method of conveying the actual (objective) risk and aligning it with the driver's subjective risk judgement.
- **Road markings** – This is some anecdotal evidence that drivers rely on road markings as one of the cues for risk perception. The research indicated that road markings such as double yellow lines have an effect on risk perception. Although not conclusive, a small sample test indicated a minor increase in perceived (subjective) risk when a wide centreline was compared against the standard centrelines. Based on this research, there is some evidence that other road markings, such as transverse line markings, could also be effective in conveying more accurate road safety risks.

[1] Movements and actions of the muscles

Table of Contents

Abstract

Driver perception of crash risk has been found in international research to have an impact on whether crashes occur at a site or along a stretch of road. The purpose of this research was to better understand, in the New Zealand context, where the objective (directly measurable) road safety risk matches drivers' subjective (indirectly measurable) risk, and its effects on driver behaviour. A better understanding of the drivers' subjective risk will allow safety professionals to communicate more effectively the risk associated with specific roads to the drivers that use them. The research attempted to addresses the following four questions.

- What level of risk is experienced by drivers on hazardous New Zealand roads?
- What road features do drivers use to judge driving risk?
- Which hazardous road situations are under-recognised by New Zealand drivers?
- What countermeasures can be used to convey a more accurate perception of risk?

This research method included three surveys, a web survey of over 500 participants, a desk-based video survey and a drive-over survey. A meta-analysis was then undertaken using the survey results and research studies to identify what risks drivers perceive and which they do not, and the effectiveness of countermeasures, including perceptual cues, in communicating road safety risk.

1 Introduction

Driver perception of crash risk has been found to have an impact on whether crashes occur at a site or along a stretch of road. While two sites may have the same level of objective risk, the site that looks less safe to drivers (higher perceived or subjective risk) often has a lower number of crashes than the one that looks safe (lower perceived or subjective risk).

A key role of traffic safety professionals is to ensure that the driving public are made aware of any risk they face on each section of the road network so that they can adjust their driving and behave in a manner required to safely negotiate the risk. This is generally achieved by applying safety countermeasures with visual cues such as delineation (e.g. raised reflective markers, edge-lines, chevrons and edge marker posts), signage, crash barriers and hazard markers. Previous research (Charlton, 2011) has found that roads can be made to appear more risky to drivers in order to improve one's driving behaviour, although it was noted that additional research would be required to understand what aspects of the roads could be visually changed to produce safer driving.

While there is considerable research on the impact of safety countermeasures on objective risks (or the actual number of crashes), research is limited, especially in New Zealand, on perceived or subjective crash risk. **The purpose of this research is to better understand where the objective (directly measurable) road safety risk matches drivers' subjective (indirectly measurable) risk, and its effects on driver behaviour**. A better understanding of the drivers' subjective risk will allow safety professionals to communicate more effectively the risk associated with specific roads to the drivers that use them.

The project aimed to clarify in a New Zealand context:

- where objective (directly measurable) risk matches drivers' subjective risk (indirectly measurable); i.e. the road is self-explaining in terms of risk
- where objective risk is greater than drivers' subjective risk; the environment is *not as safe* as perceived by drivers
- what perceptual cues are used by drivers to measure their subjective level of risk.

By identifying the factors contributing to correlation between objective and subjective risk, the research points towards areas of further investigation and trials in terms of ways to use cues in the road environment to align objective risk afforded by the road with drivers' subjective risk perceptions.

In relation to the aims of this research, the four primary questions investigated in this research are:

- What level of risk is experienced by drivers on hazardous New Zealand roads?
- What road features do drivers use to judge driving risk?
- Which hazardous road situations are under-recognised by New Zealand drivers?
- What countermeasures can be used to convey a more accurate perception of risk?

A parallel research study by the Traffic and Road Safety Research Group of the University of Waikato (TARS) has been commissioned by the AA Research Foundation on this research topic. TARS have used different research methods to attempt to answer the same research questions. A separate report will look to bring together the key findings of both studies and look at opportunity for cross-validation of the results. Combined the two research projects should increase the breadth of our understanding on how drivers perceive risk and what aspects of road risk are under-recognised by New Zealand drivers.

1.1 Report structure

The background to this research is given in Chapter 2, with the remaining sections covering:

- data collection and analysis (Chapter 3)
- research findings and conclusions based on the experimental methods carried out (Chapter 4).

2 Background

The AA Research Foundation engaged Beca Limited (formerly Beca Infrastructure Ltd) and the Traffic and Road Safety Research Group of the University of Waikato (TARS) to undertake research in this important topic. At the request of AA Research Foundation, both parties agreed to collaborate in this research.

Each team would emphasise different testing methods, according to their individual strengths and areas of expertise. These complementary methods would provide opportunity for cross-validation of the data and an increased breadth and depth to understanding how drivers perceive risk and what aspects of road risk are under-recognised by New Zealand drivers.

These complementary testing methods in answering the primary questions of this research are illustrated Figure 2-1.

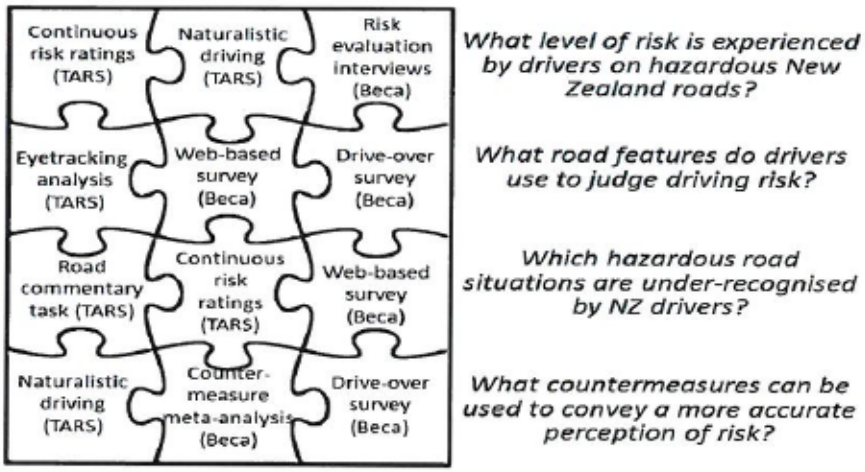


Figure 2-1: Beca and TARS Research Testing Methods

2.1 Measuring Objective (Actual) Risks

The objective risks of various sections of the New Zealand state highway network have been assessed using KiwiRAP (New Zealand Road Assessment Programme). This risk measurement is based on both the historical crash data reported, as well as on the level of safety features 'built-in' to the road (and roadside). The KiwiRAP consists of three 'protocols', namely:

- **Risk Mapping** - uses historical traffic and crash data to produce colour-coded maps illustrating the relative level of risk on sections of the road network.
- **Star Rating** – road inspections look at the engineering features of a road (such as lane and shoulder width or presence of safety barriers). Ratings of between 1 and 5 Stars are awarded to road links, depending on the level of safety 'built-in' to the road (the higher the star rating, the better the road).
- **Performance Tracking** – involves a comparison of crash rates over time to establish whether fewer – or more – people are being killed or seriously injured; and to determine if countermeasures have been effective.

The Star Ratings are derived from a Road Protection Score (RPS). This risk score is determined via evaluation of each of the road's design elements. The RPS is calculated for every 100-metre section of road using the three primary crash types, namely head-on, run-off road and intersection crashes.

The RPS score for each individual crash type is a function of underlying crash risk associated with the road layout or more particularly the type of traffic using that type of road, the impact that the presence or absence of the various road engineering features will have on the underlying crash risk and factors for each crash type. The road features that contributed to the RPS scores for each individual crash type are summarised in Table 2-1.

Table 2-1: Road Engineering Features Impacting RPS

RPS Components	Road Engineering Features Considered to Impact RPS
Head-on	■ Lane width ■ Sealed shoulder width ■ Horizontal alignment ■ Terrain ■ Overtaking ■ Delineation ■ Median type
Run-off Road	■ Lane width ■ Sealed shoulder width ■ Horizontal alignment ■ Terrain ■ Delineation ■ Roadside hazard offset left / right ■ Roadside hazard severity left / right
Intersection	■ Intersection type ■ Adjoining road characteristics ■ Alignment of legs ■ Intersection sight distance ■ Right turn provision ■ Left turn provision

The section RPS is then calculated using the following equation:

Section RPS = A * Run-off Road RPS + B * Head-on RPS + 2*Σ Intersection RPS

where A and B are defined as; B=1-A , and

*A = 0.000481 * 2 – 0.024947 x + 0.864791*

where: x = AADT / 1000; and

Set A = 0.55 for x >30, and Set A = 1.00 for divided roads

A is known as the Run-off Road Volume Split Factor

The conversions from RPS to Star rating are based on the following bands:

5-star: RPS 0 - 1.05

4-star: RPS 1.05 to <4.5

3-star: RPS 4.5 to <10

2-star: RPS 10 to <25

1-star: RPS 25 +

Since risk scores and therefore Star Ratings, often fluctuate over a given length of road, the predominant Star Rating is assigned to each given section of road.

The table below briefly describes the typical features within each Star Rating band.

Table 2-2: Typical Features within each Star Rating

Star Rating	Description of Features	
	Divided Road	Undivided Road
5	Straight with good line marking, wide lanes and sealed shoulders, safe roadsides and occasional grade separated intersections. Roads with a local, minor or major at-grade intersection cannot achieve a 5-Star Rating.	No undivided road can achieve a 5-Star Rating.
4	Deficiencies in some road features such as lane width, shoulder width or roadside hazards.	Straight with good overtaking provision, good line marking and safe roadsides. Such a road will not achieve a 4-Star Rating if it has high traffic volumes.
3	Major deficiencies in some road features. These may include poor median protection against head-on crashes, many minor deficiencies and /or poorly designed intersections at regular intervals.	Deficiencies in some road features such as alignment, roadsides, and /or poorly designed intersections at regular intervals.
2	Many major deficiencies such as poor alignment, poor roadside conditions and median protection, and poorly designed intersections at regular intervals.	Major deficiencies in some road features such as poor roadside conditions and /or many minor deficiencies such as insufficient overtaking provision, narrow lanes, and /or poorly designed intersections at regular intervals.
1	Poor alignment, in mountainous terrain, narrow lanes, narrow shoulders, severe roadside conditions and many major intersections.	Poor alignment, in mountainous terrain, narrow lanes, sealed shoulders, poor line markings and severe roadsides conditions

The corresponding Risk Protection Scores (RPS) and Star Rating for the sites used in this research were extracted from the NZ Transport Agency's KiwiRAP Analysis Tools (KAT) from their online services. Further breakdown of the scores were also obtained from NZ Transport Agency to enable comparisons with the perceived risk when certain road engineering features are isolated.

The comparison and analysis of the objective risks to the subjective risks perceived are further detailed in the following section.

3 Data Collection and Analysis

To better understand the subjective risks perceived by drivers and answer the research questions, the following experimental methods were used for this research:

- Web survey
- Drive-over survey
- In-person video survey.

These experimental methods are further detailed in the following sections. The objective risks, based on KiwiRAP data, were collected for the sites selected in these experimental methods. This approach was discussed earlier in Section 2.1.

3.1 Web Survey

A web survey was selected to obtain a cross-section of the subjective risks perceived by New Zealand drivers. The web survey that was undertaken had an alternative forced-choice design (participants were 'forced' to rank two/three images by their levels of perceived risks).

As the focus of the study was on understanding the relative perceived risks of various road features by drivers, the photographs selected for use in the survey comprised of differing road features such as:

- Median barriers
- Road markings
- Presence of signs
- Curves (and grade of road)
- Objects at the roadside
- Roadside ditches
- Wide median.

The web survey included questions related to demographics (age and gender) and driving experience (type of driving licence, driving distance), in addition to perception of relative safety risk (the images). This online survey was launched and distributed to the New Zealand Automobile Association members on the 4th April 2013, and ran until the 30th April 2013. A total of 559 responses were collected during this period, which was higher than the 100 participants initially targeted. The breakdown on age, gender and driving experiences of the respondents are illustrated in Figure 3-1 to Figure 3-4.

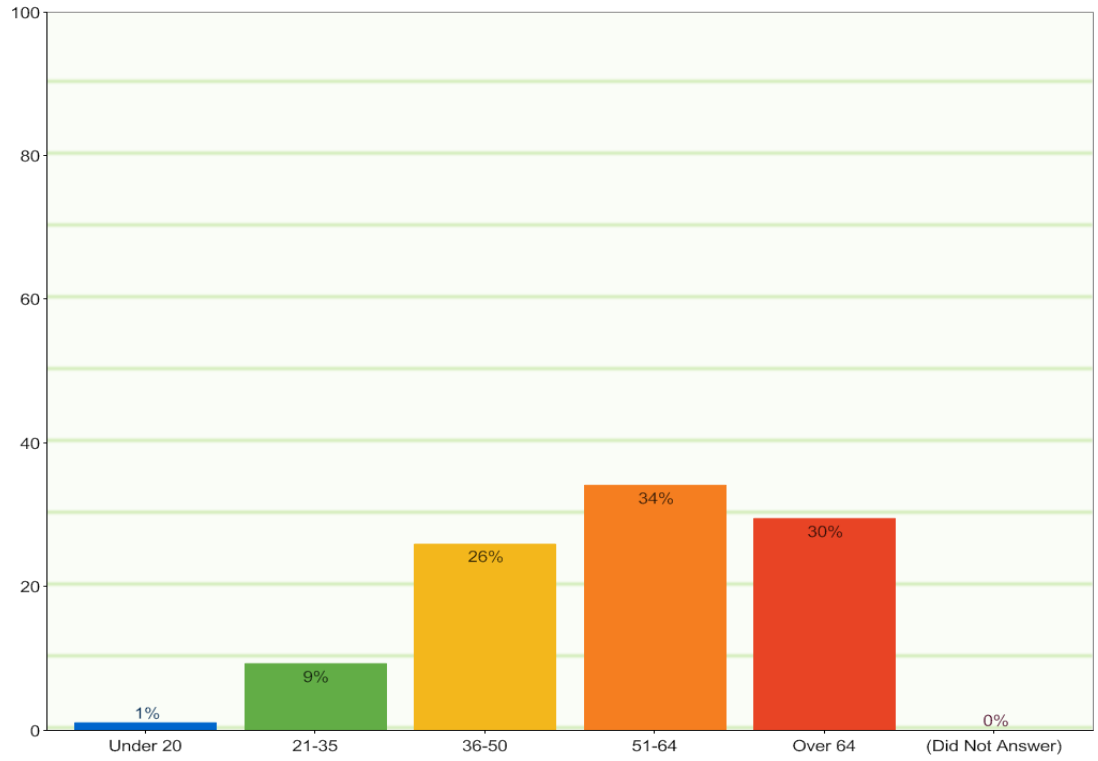


Figure 3-1: Web Survey Participant Age Range

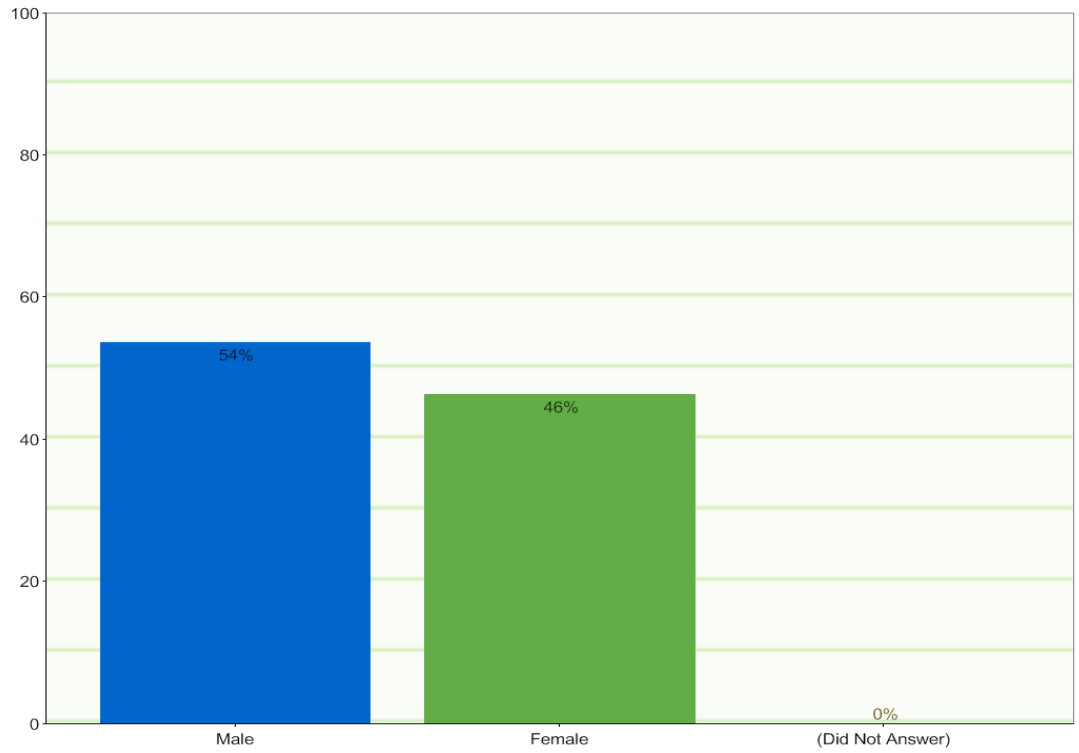


Figure 3-2: Web Survey Participant Gender

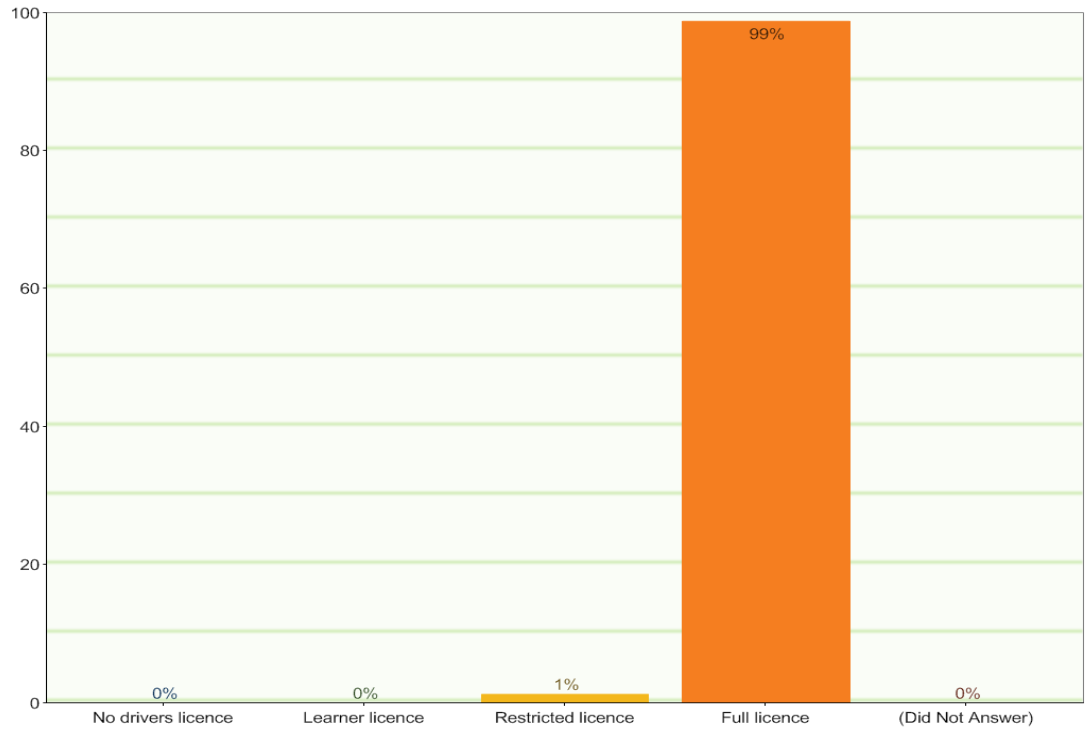


Figure 3-3: Web Survey Participant Drivers Licence Type

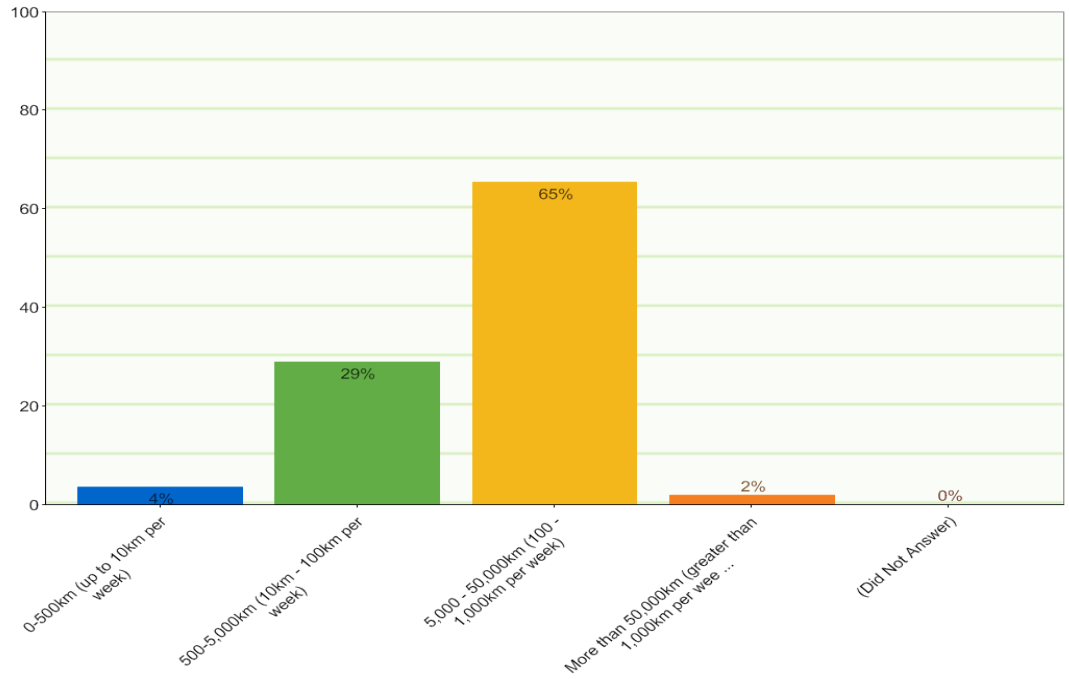
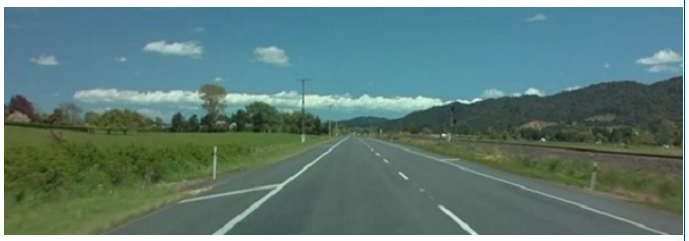


Figure 3-4: Web Survey Participant Annual Driving Distance

Although majority of survey respondents were aged over 50 years old (64%), this sample is deemed appropriate as this is only slightly higher representation compared to the current Automobile Association membership. Some research, such as Charlton (2011) has found that the type of events and situations that drivers consider hazardous appear to differ from driver to driver, with some of the largest differences found for drivers with different levels of experience. A stratified analysis[2] of the results has been undertaken to assess whether there is different results for different age groups and gender.

The following tables summarise the web survey results of perceived risk rated by the participants and a comparison with the objective risks from the KiwiRAP road ratings (RPS). The results for the perceived risk ranking were presented as 1 being “least risky” through to 2 or 3 (depending on number of photos) as most risky.

[2] Method of sampling from a population

Question 6	Perceived Risk Ranking Scores (lower score being less risky)	Objective Risks (KiwiRAP RPS) and Road Features	Perceived Ranking	Objective Risk Ranking
	**Mean:** All - 1.13 Under 50 – 1.23 Under 35 – 1.07 Male – 1.15	**Average RPS:** 7.22 **Star Rating:** 3-Star **Road Features:** ■ Wide shoulder ■ Straight road ■ Roadside ditch	Less Risky	Less Risky
	**Mean:** All - 1.87 Under 50 – 1.77 Under 35 – 1.93 Male – 1.85	**Average RPS:** N/A **Star Rating:** N/A **Road Features:** ■ Curved road ■ Vertical curve crest ■ Presence of poles and heavy vegetation at roadside	More Risky	More Risky

Findings:

This question was asked to “warm-up” the participants on the web survey between choosing a relatively straight forward “answer“. The results above indicate that the participants understood the meaning of the question posed to them.

There is minimal difference in the results found between different age groups and by gender.

Question 7	Perceived Risk Ranking Scores (lower score being less risky)	Objective Risks (KiwiRAP RPS) and Road Features	Perceived Ranking	Objective Risk Ranking
	**Mean:** All - 1.21 Under 50 – 1.23 Under 35 – 1.34 Male - 1.23	**Average RPS:** 2.9 **Star Rating:** 4-Star **Road Features:** ▪ Four-lane divided carriageway ▪ Median barrier ▪ Wide shoulder ▪ Noise wall	Less Risky	Less Risky
	**Mean:** All - 1.79 Under 50 – 1.77 Under 35 – 1.66 Male – 1.77	**Average RPS:** 4.5 **Star Rating:** 3-Star **Road Features:** ▪ Two-lane undivided carriageway ▪ Narrow shoulder	More Risky	More Risky

Findings:

The above results indicate that the participants' perception of risks correlate to the objective risks. This indicates that participants mainly perceive divided carriageway (and possibly wider shoulder) feature(s) being less risky than an undivided carriageway.

There is minimal difference in the results between different age groups and gender.

Question 8	Perceived Risk Ranking Scores (lower score being less risky)	Objective Risks (KiwiRAP RPS) and Road Features	Perceived Ranking	Objective Risk Ranking
	**Mean:** All - 1.49 Under 50 – 1.44 Under 35 – 1.43 Male – 1.56	**Average RPS:** 17.6 **Star Rating:** 2-Star **Road Features:** ■ No roadside shoulder ■ Horizontal curve with 55km/h curve advisory sign ■ Fence and power poles	**Less Risky, except for Male particpants**	**More Risky**
	**Mean:** All - 1.51 Under 50 – 1.56 Under 35 – 1.57 Male – 1.44	**Average RPS:** 16.8 **Star Rating:** 2-Star **Road Features:** ■ Roadside shoulder and barrier ■ Horizontal curve with 55km/h curve advisory sign	**More Risky, except for Male particpants**	**Less Risky**

Findings:

For this question, there is an insignificant difference in perceived risks in these two scenarios, although most (with exception of male participants) had the image with barrier rated slightly riskier, which is opposite to the objective risks.

The results for this question could be interpreted as drivers perceiving the risks of a roadside barrier (which normally protects vehicles from more severe roadside hazards) to be slightly more risky than scenario where there is minimal / moderate roadside hazards.

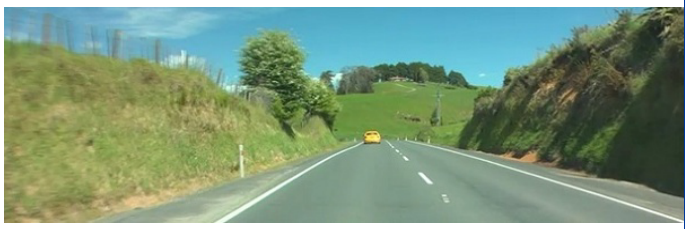
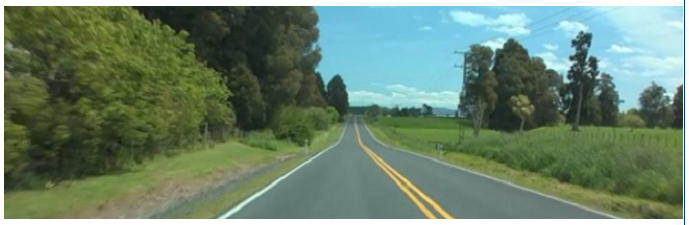
The results also indicate that there is minimal difference in the results between different age groups and gender.

Question 9	Perceived Risk Ranking Scores (lower score being less risky)	Objective Risks (KiwiRAP RPS) and Road Features	Perceived Ranking	Objective Risk Ranking
	**Mean:** All - 2.16 Under 50 – 2.12 Under 35 – 2.09 Male – 2.16	**Average RPS:** 5.26 **Star Rating:** 3-Star **Road Features:** ▪ Passing lane ▪ No overtaking lines ▪ Moderate clear zone width	**Most Risky**	**Least Risky**
	**Mean:** All - 1.72 Under 50 – 1.78 Under 35 – 1.88 Male - 1.67	**Average RPS:** 6.51 **Star Rating:** 3-Star **Road Features:** ▪ Roadside barriers ▪ Wide shoulder	**Least Risky**	**2nd Most Risky**
	**Mean:** All - 2.12 Under 50 – 2.10 Under 35 – 2.03 Male – 2.18	**Average RPS:** 7.22 **Star Rating:** 3-Star **Road Features:** ▪ Wide and hatched shoulder ▪ Roadside ditch	**2nd Most Risky**	**Most Risky**

Findings:

In this question, participants rated the scenario with passing lane as the most risky, closely followed by the last image, with the image having guardrails on a straight rated the least risky amongst the three images. Combined with findings from Question 8, this suggests that a roadside barrier is deemed safer when there are other moderate roadside features (such as ditches), but not smaller roadside features such as fence.

The results for this question indicate that participants' perceived passing lane to be most risky despite this scenario actually having the lowest RPS. This could potentially be attributed to perception on higher speeds for overtaking vehicles. There is minimal difference in the results between different age groups and gender.

Question 10	Perceived Risk Ranking Scores (lower score being less risky)	Objective Risks (KiwiRAP RPS) and Road Features	Perceived Ranking	Objective Risk Ranking
	**Mean:** All - 2.40 Under 50 – 2.31 Under 35 – 2.24 Male – 2.45	**Average RPS:** 7.71 **Star Rating:** 3-Star **Road Features:** ▪ Roadside bank ▪ Limited road shoulder	**Most Risky**	**2nd Most Risky**
	**Mean:** All - 2.04 Under 50 – 2.05 Under 35 – 1.90 Male – 2.05	**Average RPS:** 8.19 **Star Rating:** 3-Star **Road Features:** ▪ Limited road shoulder ▪ No passing lane lines ▪ Roadside ditch	**2nd Most Risky**	**Most Risky**
	**Mean:** All - 1.56 Under 50 – 1.58 Under 35 – 1.86 Male – 1.50	**Average RPS:** 1.9 **Star Rating:** 4-Star **Road Features:** ▪ Motorway, divided multi-lane carriageway ▪ Roadside barriers ▪ Good shoulder width	**Least Risky**	**Least Risky**

Findings:

In this question, the participants mainly rated the motorway being the least risky, which is consistent with the RPS.

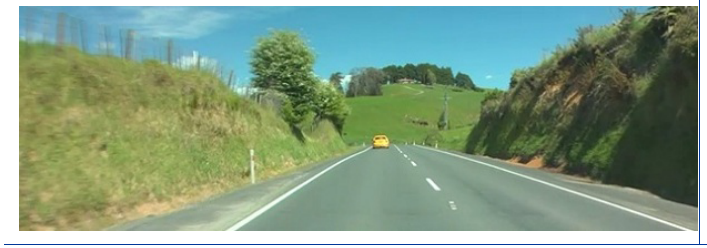
The first image, where there are roadside banks on both sides of road, was rated as the most risky. This could suggest that participants view the roadside banks to be more risky than the roadside ditch / trees, which implies that the participants' risk perception could be influenced by size of hazard or the consequences of crashing into the hazards (rigid and large road side bank vs more flexible trees / vegetation).

This results suggest that drivers under 35 years of age could be under-perceiving the risks of roadside hazards, particularly those that may not be obvious such as narrow shoulder width and roadside ditch.

Question 11	Perceived Risk Ranking Scores (lower score being less risky)	Objective Risks (KiwiRAP RPS) and Road Features	Perceived Ranking	Objective Risk Ranking
	**Mean:** All - 2.38 Under 50 – 2.31 Under 35 – 2.07 Male – 2.37	**Average RPS:** 6.6 **Star Rating:** 3-Star **Road Features:** ▪ Wide centreline ▪ Moderate shoulder width ▪ Side road	**Most Risky**	**Least Risky**
	**Mean:** All - 1.56 Under 50 – 1.44 Under 35 – 1.50 Male – 1.60	**Average RPS:** 12.35 **Star Rating:** 2-Star **Road Features:** ▪ Light pole ▪ Narrow shoulder width ▪ Roadside ditch	**Least Risky**	**2nd Most Risky**
	**Mean:** All - 2.06 Under 50 – 2.26 Under 35 – 2.43 Male - 2.04	**Average RPS:** 16.8 **Star Rating:** 2-Star **Road Features:** ▪ Roadside shoulder ▪ Barrier ▪ Horizontal curve with 55km/h curve advisory sign	**2nd Most Risky**	**Most Risky**

Findings:

The participants' (except male participants) perceived the straight road with wide centreline and side road to be the most risky, even when compared to the last image with a curve. It can be concluded that the participants perceive presence of side road to be highly risky, or that wide centreline may be perceived as risky even though this feature is designed to improve safety (although not directly measured by KiwiRAP RPS). The male participants meanwhile, had rated the third image with a curve to be the most risky, followed by the wide centreline with presence of side road. The results from this question are not consistent with the RPS. The results indicate that a straight section of road (even with minimal road shoulder and roadside furniture) is correctly perceived to be less risky than a curve with some roadside shoulder.

Question 12	Perceived Risk Ranking Scores (lower score being less risky)	Objective Risks (KiwiRAP RPS) and Road Features	Perceived Ranking	Objective Risk Ranking
	**Mean:** All – 2.60 Under 50 – 2.62 Under 35 – 2.64 Male - 2.63	**Average RPS:** N/A **Star Rating:** N/A **Road Features:** ▪ Side road with right turb bay ▪ Power pole ▪ Straight road	**Most Risky**	N/A
	**Mean:** All – 1.77 Under 50 – 1.75 Under 35 – 1.60 Male - 1.79	**Average RPS:** 7.00 **Star Rating:** 3-Star **Road Features:** ▪ High crash rate sign ▪ Power pole ▪ Minimal shoulder ▪ Roadside ditch	**2nd Most Risky**	**More Risky**
	**Mean:** All – 1.64 Under 50 – 1.63 Under 35 – 1.76 Male - 1.58	**Average RPS:** 7.71 **Star Rating:** 3-Star **Road Features:** ▪ Roadside bank ▪ Limited road shoulder	**Least Risky**	**Less Risky**

Findings:

This question further confirms the findings in Question 11, whereby the participants perceive presence of side roads to be highly risky. This is followed by the second and third image with insignificant seperation between the last two images (which is consistent with the RPS). This indicates that participants perceive the presence of high crash rate sign to be of similiar / slightly higher risks compared to the last image with roadside banks, which was perceived to be the most risky in Question 10. The results indicate that there is minimal difference in the results between different age groups and gender.

3.1.1 Web Survey Key Findings

Metadata from the web survey, including the comments provided at the end of the survey, were analysed and further detailed in Section 3.4. The conclusions that can be drawn from this survey are as follows:

- **Road Features**

Table 3-1: Web Survey Road Feature Perception

Road Feature	Findings
Curves	The presence of this feature was consistently perceived as **higher risk** compared to straights with other moderate roadside hazards (such as ditch and power poles). This could be due to the perceived risk introduced by potential loss of vehicle control and/or the potential for a limited sightline distance as a result of roadside obstructions.
Side Road	Presence of side road consistently perceived as **higher risk** compared to presence of roadside furniture (i.e. power poles, barriers, warning signs). In some instances driver risk perception was increased further possibly due to the presence of narrow shoulder width and/or the presence of roadside power or telegraph poles preventing the use of shoulders for emergency manoeuvres. Inadequate and/or road markings perceived to be confusing (i.e. wide centreline) in this survey may have also increased the perceived risk associated with the presence of side road possibly due to higher driver workload required to interpret such road markings.
Divided carriageways	Participants perceived divided carriageways (i.e. motorways) to be **less risky** than undivided carriageways.
Roadside Barriers	▪ On **curves**, participants perceived roadside barriers to be **slightly more risky** than scenario without barrier, where there is minimal / moderate roadside hazard (fence and power poles) ▪ On **straight sections**, participants perceived roadside barriers to be **less risky** compared to sections where there are moderate roadside features (such as ditch and power poles). The above suggests that the risk perception on use of roadside barriers is dependent on the road curvature, and that this could potentially be used as countermeasures on curves where higher risk perception from drivers is required.
Passing Lanes	This feature was perceived as **higher risk** compared to other straight roads without minor road side hazards (such as fence, guardrails and ditch).
Roadside Features	▪ **Major (more visible) roadside hazards** were general perceived as **higher risk**, compared to low / moderate hazards such as vegetation, ditch and power poles. ▪ **Roadside shoulder width**. There is some evidence that wide road shoulder were perceived to be safer than narrow road shoulder, although there is **no strong evidence** that this contributes to the overall decision making process with the presence of other road features being compared to in this survey.

- **Stratified Sampling**

  Based on the web survey results, it has been found that there is very little difference in the responses between different age groups and gender. There is some evidence nonetheless that

the participants under 35 years of age may have under-perceived the risks of the non-obvious roadside hazards on a straight road, such as roadside ditch and narrow/limited shoulder width.

- **Perceived vs Objective Risks**

  Generally, it has been found that the perceived risks ranking do not necessary match with the objective risks ranking, with only 40% of images presented were ranked in the same order as the objective risks measured through KiwiRAP RPS[3]. Further comparisons of the risk ranking have been made to ascertain whether there is a better relationship when certain components of the RPS are removed (refer Figure 3-5 below for KiwiRAP RPS components).

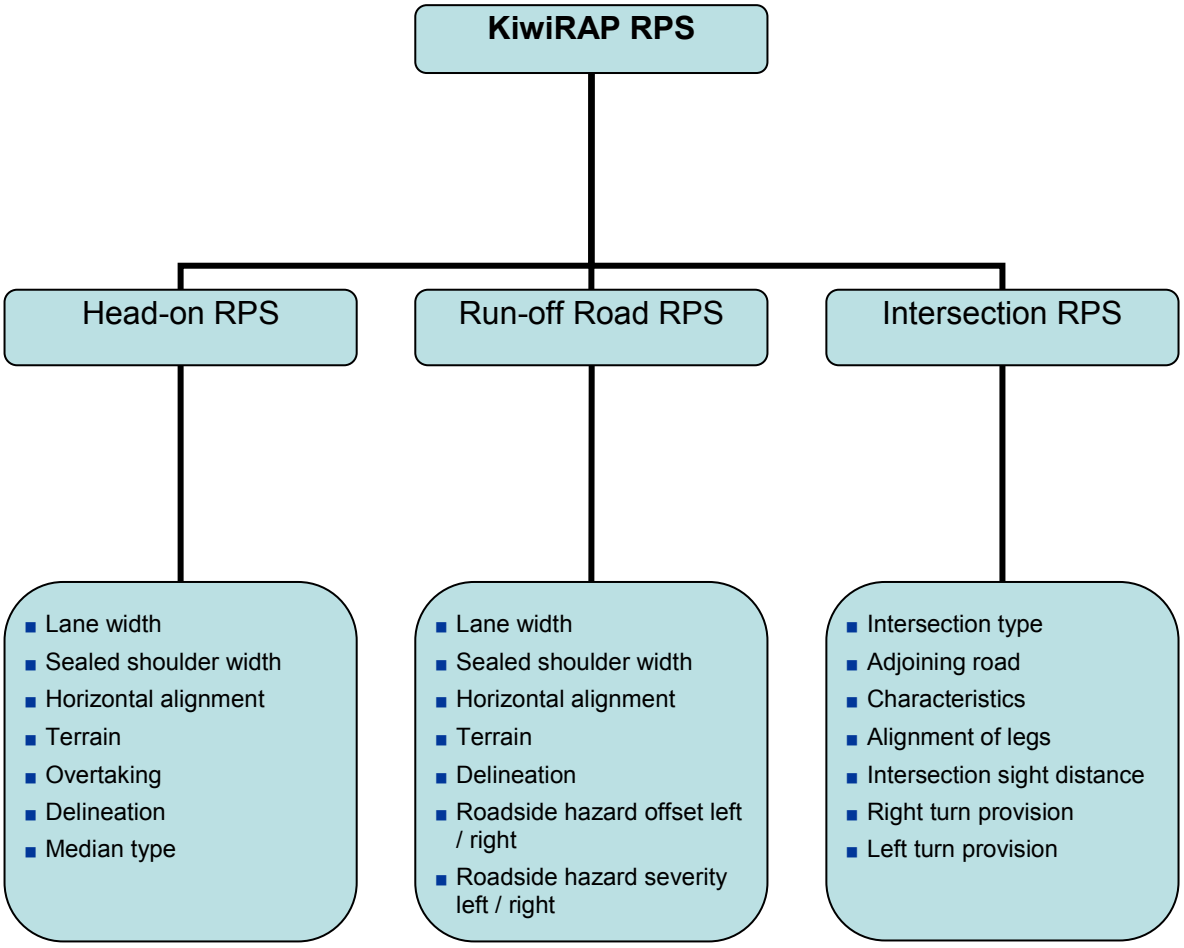


Figure 3-5: KiwiRAP Road Feature Elements within each RPS Component

It was found that when the entire Run-off Road RPS are omitted from the overall RPS, the survey results show 87% of images were ranked in the same order to this revised RPS score. This was the highest matching results from all other possible combinations tested (including removing individual elements from RPS). This suggests that the participants do not necessarily perceive the run-off road elements correctly, either under or over perceiving some of the elements in their risk perception. There is no difference in the risk ranking results (40% matching) when the entire Intersection RPS is omitted from the RPS. These tests suggest that the roadside hazards are possibly under perceived in the participants risk ranking.

[3] Only for sites where RPS is available.

3.2 In-person Video Survey

In-person interviews, using videos of several sections of state highways were also carried out to assess subjective risk perception. A total of six participants viewed the video sections and answered a series of questions (see Appendix A for Questionnaire). These questions included the perceived safety rating (scale of 1-10 from safest to most risky), perceived safe driving speed, and the noted safe features and hazards. The participants were then asked to assess the level of risks on counter-measures, which were digitally inserted into photographs.

The road section videos were selected to provide a range of objective and subjective risk elements and ranged between 2km and 5km such that the sections are relatively homogeneous throughout each of the segment selected. The localities for these sections are illustrated in the following figures.

Figure 3-6: Sections 1 to 3 Locality Plan

Figure 3-7: Section 4 to 7 Locality Plan

The in-person video survey interview results, ranked by the average perceived safety rating, are summarised in Table 3-2.

Table 3-2: In-person Video Survey Results Summary, Ranked by Safest Perceived Rating

Section	Average Perceived Safety Rating	Average Perceived Safe Speed (km/h)	Std. Dev Perceived Safe Speed (km/h)	Noted Safe Features									Noted Hazards							KiwiRAP RPS (Overall Safety Ranking, 1 being safest)
				Signage	Straight Road	Flat Terrain	Wide Shoulder	Passing Lane	Central Median / Divived Carriageway	Good Visibility	Lighting	Double Yellow Lines	Side Road	Sharp Corners	Lots of Curves	Roside Activities	Narrow Shoulders	Limited Overtaking Opp.	Merging	
2	2.5	103	9.4																	2.6 (1)
1	3.2	95	6.1																	11.0 (6)
6	3.2	95	14.7																	11.0 (6)
3	3.8	89	8.4																	9.6 (3)
5	4.3	84	3.5																	10.6 (5)
7	4.3	77	8.5																	9.8 (4)
4	4.6	74	6.4																	9.4 (2)

Legend

	Noted Safe Feature
	Noted Unsafe Feature
	Feature not noted

A series of pictures were then digitally manipulated and participants were then asked to rate the level of perceived risks. The researcher who interviewed the participants noted that all participants intuitively tried to seek the differences between the images, and the researcher constantly reminded the participants that the purpose of the survey was to understand their perceived risks to avoid the participants being primed to provide the answers that were deemed as 'correct' answer. The results are shown below.

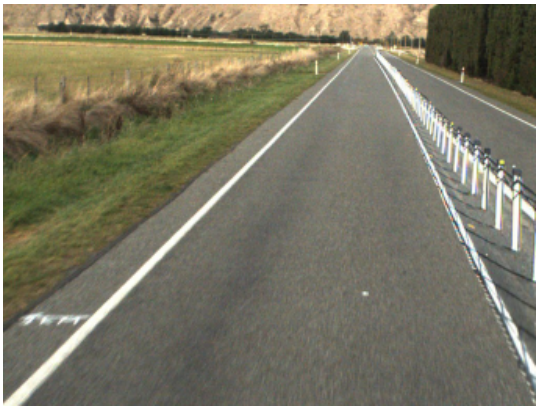
Image – Set 1	Perceived Safety Score (lower score being less risky)	Perceived Safety Ranking
 **(EXISTING)**	Average Rating: 2.2 Std Deviation: 1.1	**Least Risky**
 **(WITHOUT SIGNAGE)**	Average Rating: 4.0 Std Deviation: 1.6	**Most Risky**
 **(WITHOUT NO PASSING LANE MARKING)**	Average Rating: 2.3 Std Deviation: 1.2	**2nd Most Risky**

Findings: Results strongly indicate that absence of signs at curve was perceived to be the most risky.

Image – Set 2	Perceived Safety Score (lower score being less risky)	Perceived Safety Ranking
 **(EXISTING)**	Average Rating: 3.3 Std Deviation: 1.1	**Less Risky**
 **(WITHOUT SIGNAGE)**	Average Rating: 4.9 Std Deviation: 1.6	**More Risky**

Findings: Absence of signs at curve was again perceived to be more risky.

Image – Set 3	Perceived Safety Score (lower score being less risky)	Perceived Safety Ranking
 **(HIGH CRASH RATE SIGN)**	Average Rating: 2.0 Std Deviation: 1.2	Equal 3rd Most Risky
 **(EXISTING)**	Average Rating: 2.0 Std Deviation: 1.3	Equal 3rd Most Risky
 **(WIDE CENTRELINE MARKINGS)**	Average Rating: 2.5 Std Deviation: 1.3	**Most Risky**

Image – Set 3	Perceived Safety Score (lower score being less risky)	Perceived Safety Ranking
 **(WIDE SHOULDER)**	Average Rating: 2.2 Std Deviation: 1.6	**2nd Most Risky**
 **(WIRE ROPE MEDIAN BARRIER)**	Average Rating: 1.5 Std Deviation: 1.3	**Least Risky**

Findings: Median separation (wire rope) was perceived to be least risky, while a wide centreline markings was perceived to be the most risky. There is little difference between wide and narrow shoulders, and the presence of High Crash Rate signs.

3.2.1 In-person Video Key Findings

Metadata from the survey, including the comments provided, were analysed and further detailed in Section 3.4. The conclusions that can be drawn from this survey are as follows:

The following conclusions can be drawn from the results of the in-person video survey:

- **Road Features**

Table 3-3: In-person Video Survey Road Feature Perception

Road Feature	Findings
Median Separation	Section 2, where there is median separation, was **perceived as the safest section**. The countermeasure survey also identified the median separation perceived as the safest countermeasure.
Road Geometry	There is some anecdotal evidence to suggest that the **perceived safer road sections** to be predominantly influenced by the **desirable road geometry features** (for example the noted good visibility, straight road section). This is further supported by the less desirable road geometry features (i.e. sharp corners and high number of curves) noted in the perceived unsafe road sections.
Presence of Side Roads	While presence of side roads was perceived as an unsafe feature on some road sections, this however, **does not appear to influence the perceived safety rating on the road sections**.
Signage	Road signage (such as curve advisory signs) was **perceived as safe feature**.
Roadside Hazards	There is **little mention of roadside hazards**, such as roadside ditch, power/light poles and banks, which is taken into account and measured in KiwiRAP RPS. This indicates that over a longer distance (compared to a precise location survey carried out in the web survey), the participants have not recalled or noted these to be of significant concern.
Wide Centreline	By providing some buffer between opposing vehicles, the wide centreline would be safer for motorists (but this is not directly measured through KiwiRAP RPS) but from the countermeasure survey, wide centreline was **perceived to be less safe** compared to the existing scenario with normal painted lane lines. This could be attributed to confusion attributed to unfamiliarity of the markings, as reported in the Wide Centreline Trial Report (Beca, 2012), where drivers reported being uncertain as to what the road marking was indicating.

- **Perceived Risks vs Objective Risks**

  While Section 2 was correctly perceived as section with lowest risks, there is **no strong evidence** between perceived risks and the overall RPS based on:

  – Comparison of safety rankings between the perceived and objective risk (shown in Table 3-2).
  – Plot of the perceived rating against the overall RPS, as shown in Figure 3-8.

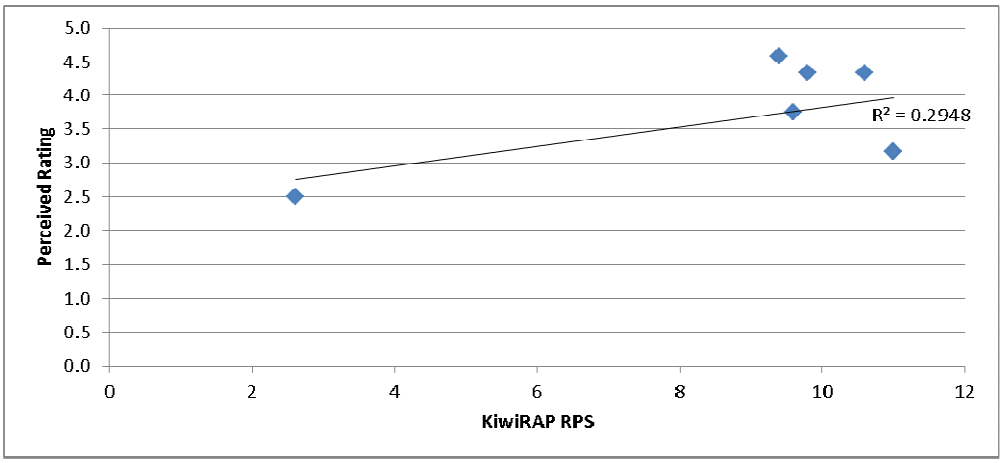


Figure 3-8: Perceived Risk vs RPS

Further analysis was carried out to assess whether there is a stronger relationship when parts of the RPS scores are omitted (refer Table 2-1 or Figure 3-5 on page 21 for KiwiRAP RPS components). It was found that when the entire Intersection RPS and parts of the Run-off RPS (lane width and delineation), the coefficient of determination[4] (R Squared) increases to a maximum of 0.51 based on all the combinations tested (refer Figure 3-9). The R Squared is still a relatively low figure, and this is most likely due to relatively small sample set for this survey. From the above test carried out, this suggests that the Intersection and Run-off Road elements are incorrectly perceived (either over or under perceived by the participants). Given the low sampling data, it is inconclusive whether the risks for these elements are over or under perceived.

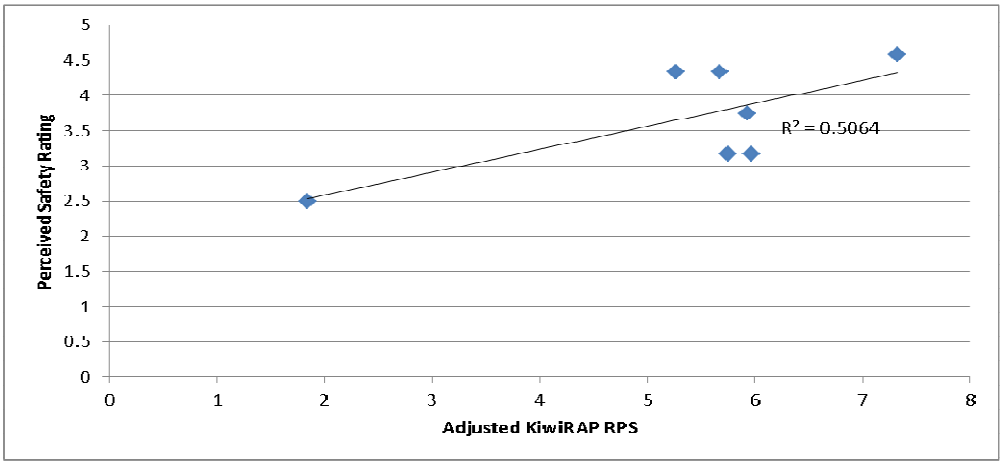


Figure 3-9: Perceived Risk vs Adjusted RPS

- **Perceived Safety vs Perceived Safe Speeds**

  There is a **strong relationship** between the perceived safety and perceived safe speed, whereby the lower the perceived safety risks, the higher the perceived safe speeds are (Figure 3-10.

[4] A coefficient which indicates how well data points fit a statistical model.

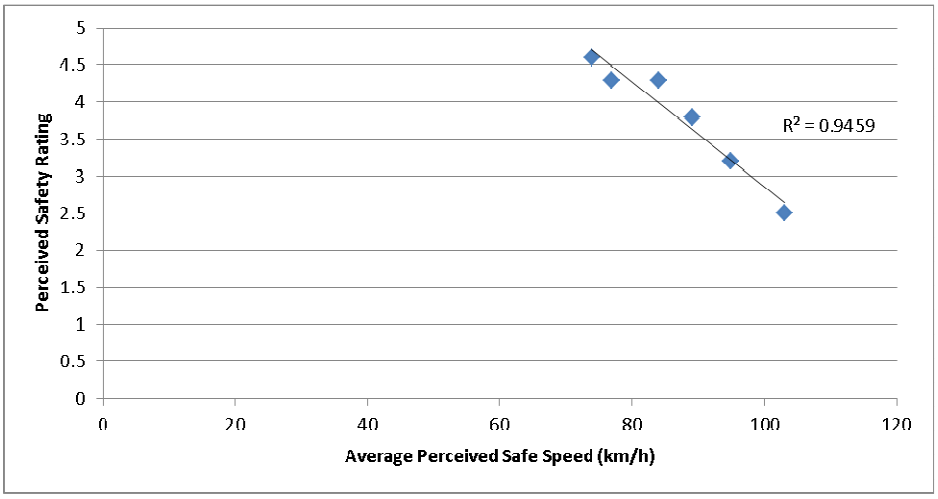


Figure 3-10: Perceived Risk vs Perceived Safe Speed

3.3 Drive-over Survey

A sample of six drivers was selected to drive over one of the 20km video routes, accompanied by a researcher, and after the drive they were interviewed on their subjective experience of risk.

The route selected for the drive-over was State Highway 75, approximately between Tai Tapu and Pranui Beach Road intersection (on link between Christchurch and Akaroa). This route was one of the routes used in the risk evaluation project (Tate & Turner, 2007).

For this survey, each driver was asked to firstly drive through the entire length (back and forth).Each driver was then asked to drive through each section and stopped at a safe location for answering their perceived risks. Similar survey questions were repeated at the end of each section for the return journey.

Figure 3-11: Drive-over Survey Locality Plan

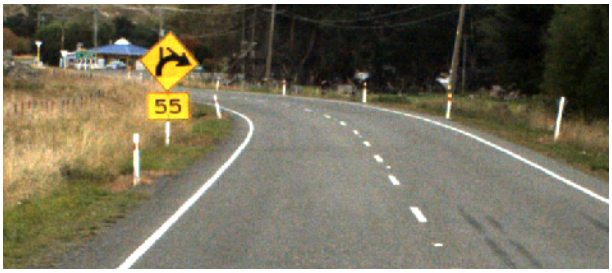
The questions used for this survey are presented in Appendix B. The sub-sections used and sample images in the survey were:

- Section 1

- Section 2

- Section 3

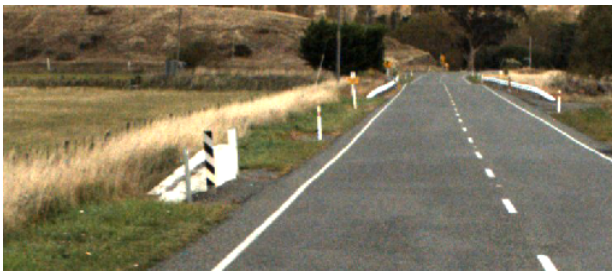
- Section 4



- Section 5

- Section 6

- Section 7



- Section 8

The in-person video survey interview results, ranked by the average perceived safety rating, are summarised in Table 3-4 .

Table 3-4: Drive-over Survey Results Summary, Ranked by Safest Perceived Rating

Section	Average Perceived Safety Rating	Average Perceived Safe Speed (km/h)	Average Driven Speed (km/h)	Noted Safe Features						Noted Hazards							KiwiRAP RPS (Overall Safety Ranking, 1 being safest)
				Signage	Good Visibility	Straight Road	Wide Road	Wide Shoulder	Smooth Road Surface	Narrow Road	Lack of Overtaking Lanes	Lots of Curves	Sharp Corners	Side Road	Poor Pavement Surface	Inconsistent Advisory Speed	
1	2.8	97	87		■	■	■		■		■						6.4
5	2.9	95	84	■	■						■						6.4
4	3.3	96	88	■	■	■							■		■		11.0
6	3.3	91	83	■	■				■	■						■	6.6
8	3.4	96	87	■					■						■	■	8.7
3	3.5	88	80	■			■			■			■	■			8.5
2	3.8	91	82		■		■						■			■	9.2
7	4.1	88	82	■				■	■		■	■					9.7

Legend

■	Noted Safe Feature
■	Noted Unsafe Feature
	Feature not noted

3.3.1 Drive-over Survey Key Findings

Metadata from the survey, including the comments provided, were analysed and further detailed in Section 3.4. The conclusions that can be drawn from this survey are as follows:

- **Road Features**

Table 3-5: Drive-over Survey Road Feature Perception

Road Feature	Findings
Road Geometry	There is some anecdotal evidence to suggest that the **perceived safer road sections** to be predominantly influenced by the **desirable road geometry features** (for example the noted good visibility, straight road section). This is further supported by the less desirable road geometry features (i.e. sharp corners and high number of curves) noted in the perceived unsafe road sections.
Roadside Elements	Other road features, such as roadside hazards (shoulder width, barriers, roadside objects and presence of side roads) were either not noted, or when noted **did not appear to have a strong influence in the participants' perceived rating scores**. For example on Section 4, which has the highest RPS, was not perceived to be a highly risky site by the survey participants. This section has two side roads on one of the curves, and this was not noted by any of the participants (refer Section 4 snapshot of this on Page 32).
Curve Advisory Speed Signs	There is some anecdotal evidence to suggest that the **perceived safety for a road section to be reduced** when curve advisory speed signs were perceived to be inappropriate for a given curve. This further supports the above finding on influence of road geometry on perceived safety, with other inappropriate signage further elevating the perceived risks.

- **Perceived Safe Speed vs Average Driven Speed**

  Average driven speed for each section is between 8km/h and 10km/h lower than the perceived safe speed. By combining the speed data from this survey with the data collected from Turner and Tate (2009), it has been found that there is **some relationship between the objective risk (RPS)** and the **vehicle speeds** (refer boxplot in the following figure).

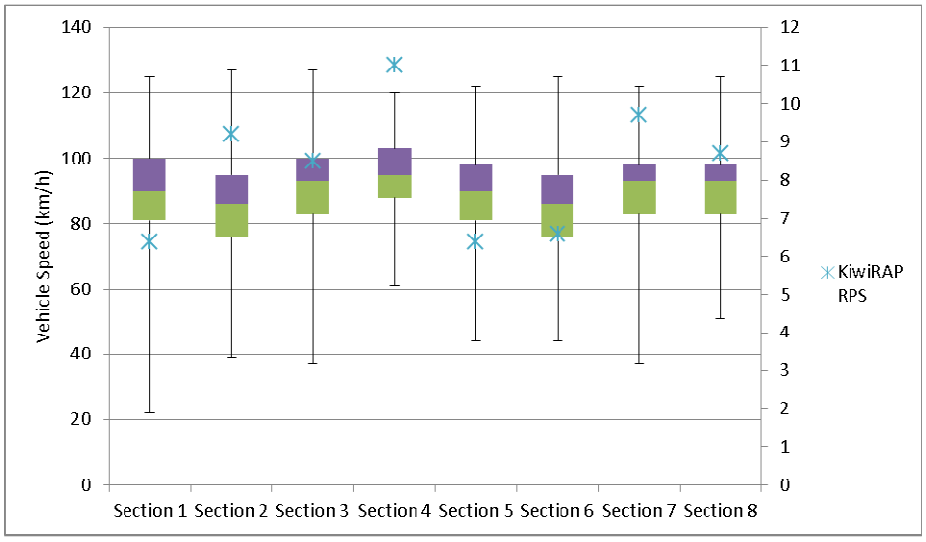


Figure 3-12: Actual Speed Data (Combined with Turner and Tate, 2009) and Overall RPS[5]

Isolating some parts of the RPS (entire Intersection RPS component and elements of the Run-off RPS, namely lane width, sealed shoulder, delineation and left hand side severity) appears to provide a better relationship between the vehicle speeds and partial objective risk (refer following figure).

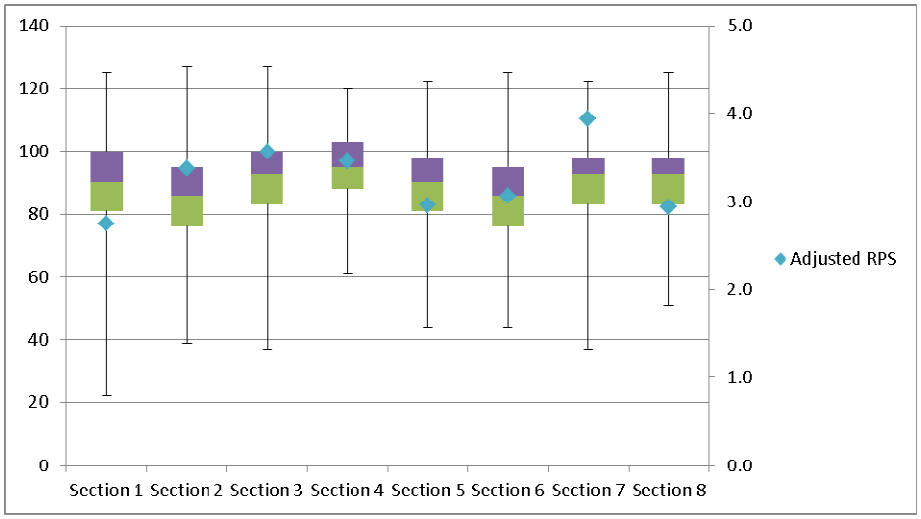


Figure 3-13: Actual Speed Data (Combined with Turner and Tate, 2009) and Adjusted RPS[5]

- **Perceived Risks vs Objective Risks**

  There is **some relationship** between the **perceived risk and objective risks** (RPS), based on comparison of safety ranking between the perceived and objective risk (refer Table 3-4). This

[5] Box and whisker plots showing spread between the minimum (bottom whisker), 25th percentile (bottom of box), mean (purple / green interphase), 75th percentile (top of box) and maximum (top of whisker) speeds.

finding can be further confirmed through comparing the perceived and objective risk scores[6] (KiwiRAP RPS, refer following figure.

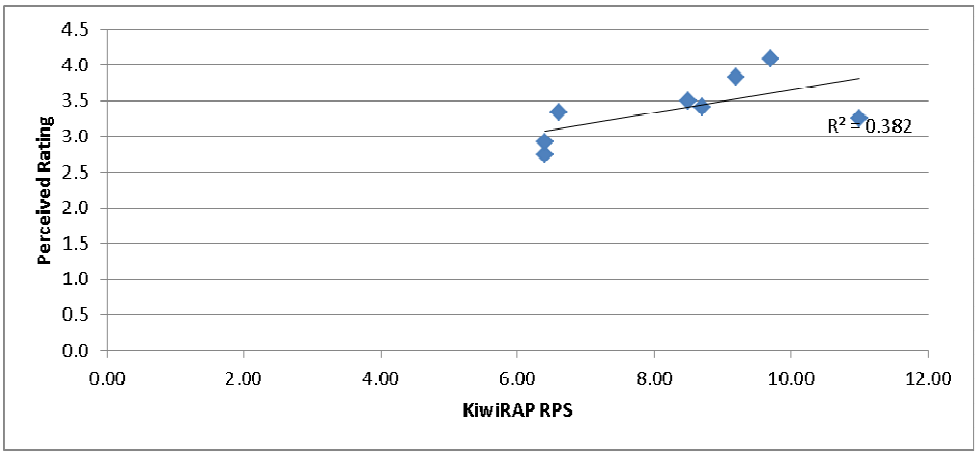


Figure 3-14: Perceived Risk vs RPS

Further analysis found that when isolating the entire Intersection RPS component and elements of the Run-off RPS (lane width, sealed shoulder, delineation and left hand side severity), the coefficient of determination increases to a maximum of 0.67 based on all combinations tested[6] (refer below).

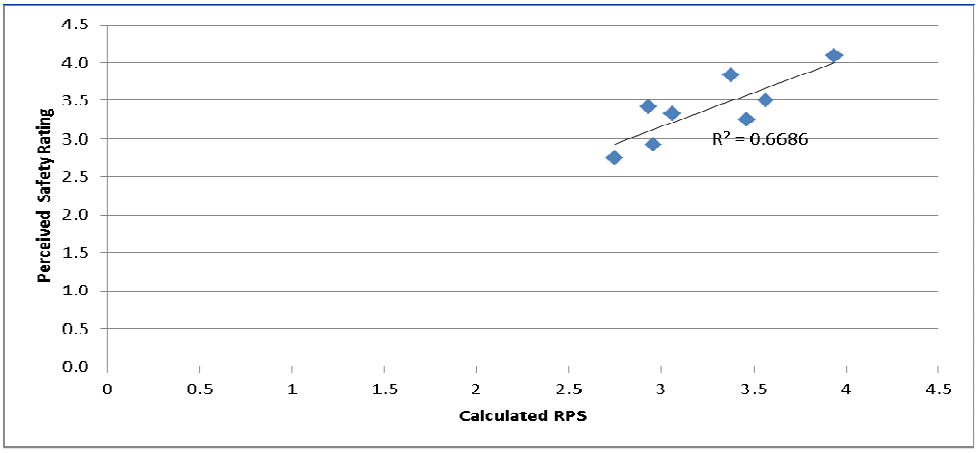


Figure 3-15: Perceived Risk vs Adjusted RPS

[6] The survey results were based on a relatively small sample set, which could explain the relatively low coefficient of determination (the R Squared values)

3.4 Meta-Analysis

Meta-analysis was undertaken using the survey results and research studies to identify what risks drivers perceive and which they do not, and the effectiveness of countermeasures, including perceptual cues, in communicating road safety risk. The metadata collated from the three Beca surveys (as per detailed in Sections 3.1 to 3.3) was analysed in combination with observations derived from the Wide Centreline Report (Beca, 2012) and Transverse Lines Marking Report (Martindale and Urlich, 2010). This dataset, comprised of these five metadata fields, provided information specific to Risk Countermeasures as was the focus of this analysis.

In the analysis of this metadata the following primary aspects were considered in deriving the underlying patterns and themes from which the analysis findings are outlined:

- Survey participant demographics
- Test image content including
    - Geometric road network layout
    - Signage
    - Road markings
    - Roadside (and on road) features
- Perceived risk ratings
- Opinions and comments collected from survey results
- Actual speeds (from drive-over survey)
- Objective risk ratings
- External report findings.

Subjective ratings, opinions and comments from participants were compared against one other and also against the features of a given image or road section. A number of common themes were identified as flowing through the metadata and those have been identified and expanded on as findings below.

The web-based survey, with 559 respondents, provided a diverse range of metadata where themes common throughout the analysis provide a reasonable level of confidence with analysis findings. In the case of both the in-person video and drive-over surveys the relatively limited sample set (6 participants for each) displayed the influence of subjectiveness in respondent risk ratings. This limitation resulted in inconclusive data spread where analysis findings are provided with a low level of confidence.

The survey content and technique is considered sound, however it is recommended that any further study in this area include both an increase in participant numbers (specifically for the drive-over and in-person video surveys) and use of digitally altered images for the web-survey.

The datasets analysed for the web survey, in-person video survey and drive-over survey are further detailed in Appendix C.

3.4.1 Expected Countermeasures and / or Safety Margins

All the surveyed data were analysed to identify the expected countermeasures and/or safety margins. These include:

Curve speed advisory signs and chevrons – Analysis has shown that curve speed advisory signs are relied upon by drivers as one of the primary sources of road data for risk evaluation. Therefore it is of great importance that advisory speeds are consistent and accurate. Survey data indicates that

drivers inherently pay attention to curve advisory speed recommendations and consider a road section including these signs to convey a more accurate level of risk. Data indicated that displaying these signs earlier before entry to the corner provided a more accurate representation of upcoming risk.

Double yellow lines whenever line of sight is obstructed – Data showed that drivers expect all sections of road where line of sight is obstructed to be marked with double yellow lines. An absence of yellow lines contributed to an elevated level of perceived risk where drivers considered them necessary but where they were not marked.

Roadside shoulder – Sample data indicated that road users expect shoulders to be wide enough to pull over (where possible) and to not be obstructed by steep banks, ditches, roadside barriers or power/telegraph poles. Participants expressed the need for shoulders to remain clear so as to enable evasive manoeuvres whenever necessary.

Roadside barriers – Where the roadside is fringed by a steep drop off motorists preferred the increased safety margin provided by the protection of a roadside barrier.

Sight distance – Data indicated the requirement for sight line distance to be maximised wherever possible.

Multiple corners and winding roads– The data indicates that sections of road containing back to back corners require signage indicating the multiple curves on entry into the first curve. Regularly spaced winding road signs posted along a winding route maintain the conveyance of continued risk.

3.4.2 Countermeasures for Accurate Risk Conveyance

From this research, the following countermeasures were analysed on their use to convey more accurate perception of risk include:

Curve speed advisory signs and chevrons – Analysis of the data set indicated that drivers perceived a reduced safety margin through the positioning of curve speed advisory signs. Where curve speed signs were present in trial images, data showed that sample drivers considered these sections of road to be 16% safer than without these advisory signs installed. Data from the drive over study indicated that corners which were not signposted with recommended curve speeds carried a much higher objective risk than was subjectively perceived by the driver prior to entering the corner.

High crash rate signs – Analysis of the data set indicated that the presence of high crash rate signs effectively conveyed to drivers that safety margins for that stretch of road were reduced. These signs aided in aligning the perceived (subjective) risk judgement and the actual (objective) risk of a section of road.

Double yellow lines – Analysis of this sample data set indicated that the presence of double yellow lines (no overtaking) road markings resulted in a reduction in perceived (subjective) risk. This finding contradicts any suggestion that as safety margins decrease, due to the reasons for a no overtaking section (e.g. corner and/or rise), so should there be a resultant increase in the driver's perceived (subjective) risk. It could be considered that the actual (objective) risk introduced by the road layout is over shadowed by the reduced possibility of collision due to opposing traffic crossing the centreline.

Median barriers – The data set analysis indicated that where median barriers were installed the perceived (subjective) risk was reduced as a result of the additional protection provided against collisions with oncoming traffic.

Wide centreline – Although not conclusive, a small sample in the digital image manipulation comparison test indicated a minor increase in perceived (subjective) risk when a wide centreline was compared against the standard white dotted line. This may indicate a level of driver confusion due to the unfamiliarity of the markings, as reported in the Wide Centreline Trial Report (Beca, 2012), where drivers reported being uncertain as to what the road marking was indicating, although the tested image had a side road, found to be perceived as high risk in this research, which may influence the risk perception.

Slow down advisory signs– Analysis of the data set indicated that electronic 'Slow Down' advisory signs were an effective method of conveying the actual (objective) risk and aligning it with the subjective risk judgement

Low light countermeasures - While not specifically measured in this set of surveys carried out by Beca, participants acknowledged that the presence of reflective edge markers and road lighting aided in providing an increased accuracy of objective risk for low light driving e.g. during hours of darkness

4 Key Research Findings

This research method included three experimental methods, a web survey with over 500 participants, a desk-based video survey and a drive-over survey. A meta-analysis was also undertaken using the survey results and research studies to identify what risks drivers perceive and which they do not, and the effectiveness of countermeasures, including perceptual cues, in communicating road safety risk. To combine the research findings, it would first be important to assess the merits associated with each of the experimental method such that meaningful conclusions could be drawn. This is described below.

Table 4-1: Survey Features and Implications

Item	Web Survey	In-person Video Survey	Drive-over Survey
Experimental Method and Implications	▪ The web survey consisted of ranking the risk based on a series of photographs, which provided indication on risk recognition of specific road features. ▪ This is deemed to provide understanding on participants' risk perception in a conscious stage.	▪ The survey consisted of ranking the risks on sections of road based on video clips. ▪ Some concurrent demands required on one's visual and cognitive resources, this survey is deemed to provide an indication of one's semi-conscious risk perception over a length of road with various features.	▪ The survey consisted of ranking the risks on sections of road through actually driving the routes. ▪ Heaviest demand placed on one's visual, motor skills[7] and cognitive resources, this survey is deemed to provide an indication of one's sub-conscious risk perception over length of road with various features.
Sampling Size	High number of participants (559 participants)	Low number of survey participants (six participants)	Low number of survey participants (six participants)
Data Reliability	Survey participants may interpret the survey questions differently but with high number of participants compared to the other two surveys, this provides with greater confidence in the survey results	Personal contact with participants enabling opportunities for queries and clarification, but data may be less reliable given low number of participants involved	Personal contact with participants enabling opportunities for queries and clarification, but data may be less reliable given low number of participants involved
Implementation Costs	Low	Moderate	High

[7] Movements and actions of the muscles

Based on the experimental methods carried out in this research, the details of research findings presented in Section 3 have been summarised in the following sections to answer the four primary questions investigated in this research.

4.1 Level of Perceived Risks

What level of risk is perceived by drivers on hazardous New Zealand roads?

The levels of perceived risks based on the three surveys carried out have been summarised in Table 4-2.

Table 4-2: Level of Perceived Risks vs Objective Risks

Web Survey	In-person Video Survey	Drive-over Survey
The perceived risks ranking matches poorly with the objective risks ranking, but the matching improved remarkably when the entire Run-off Road RPS is omitted from the overall RPS.	There is a weak relationship between the perceived risks and the overall RPS. Further analysis found that there is a slightly stronger relationship when the entire Intersection RPS and elements of the Run-off RPS (lane width and delineation) are omitted from the overall RPS.	There is some relationship between the perceived risk and objective risks (RPS), which further improves when the entire Intersection RPS component and elements of the Run-off RPS (lane width, sealed shoulder, delineation and left hand side severity) are omitted from the overall RPS.

Conclusions:

Based on the results of three surveys undertaken in this research, there is some evidence to suggest some weak relationship between drivers perception of risk and the actual level of hazard on New Zealand roads (as measured by the KiwiRAP RPS).

Further tests in all three surveys suggest that the roadside risks are under perceived in the participants risk ranking. The intersection risks appear to be recognised and understood, as found from the web survey, but are possibly under perceived in the other surveys when longer segment of route is involved.

4.2 Risk Perception of Road Features

What road features do drivers use to judge driving risk?

From this research, the road features that drivers use to judge driving risk (perceived risk) could broadly be summarised as follows:

- Road geometry. From this research, it has been found that horizontal curves (i.e. sharp corners and number of corners) were perceived as higher risk (even with barriers) than straight with other roadside hazards (such as power poles).
- Signage. Presence of signage such as curve advisory signs / chevrons, high crash rate signs, slow down speed signs, were perceived to convey reduced safety margins for the road.

4.3 Under Recognised / Perceived Road Features

Which hazardous road situations are under-recognised by New Zealand drivers?

This research has found that the risks for some road situations are under-recognised by New Zealand drivers. The features that are under-recognised are:

- Roadside hazards. From the surveys carried out, there was little to suggest that drivers perceive the risks of roadside hazards. There was also some evidence to suggest that drivers slow down when they perceived a road being less safe. Based on the drive-over survey carried out, it was found that drivers would only slow down due to road geometry, and some instances the road cross section features, but do not adjust speed based on roadside hazard.
- Presence of side roads. Whilst the web survey has indicated that the risk with presence of side roads is well recognised, this is however possibly under perceived in the other surveys when longer segment of route is involved. With actual driving requiring higher demand from one's visual, motor skills[8] and cognitive resources, it is likely that the intersection risk is sub-consciously not perceived when other features (such as road geometry) are more dominant.
- Double yellow lines. While the research has found that drivers perceived the more open sight distance from straight road to be of lower risks compared to curves, the presence of double yellow lines (no overtaking) indicated a reduction in perceived (subjective) risk.

4.4 Countermeasures

What countermeasures can be used to convey a more accurate perception of risk?

From the meta-analysis carried out, it has been found that certain countermeasures provide a more accurate perception of risks. These include:

- Signage – Presence of signage such as curve advisory signs / chevrons, high crash rate signs, slow down speed signs, were perceived to convey reduced safety margins for the road. Analysis

[8] Movements and actions of the muscles

indicated that drivers perceived a reduced safety margin through the positioning of curve speed advisory signs. Analysis of the data set indicated that electronic 'Slow Down' advisory signs were also an effective method of conveying the actual (objective) risk and aligning it with the subjective risk judgement.

- Road markings – This was some anecdotal evidence that drivers rely on road markings as one of the cues for risk perception. Analysis of datasets indicated that road markings such as double yellow lines have an effect on risk perception. Although not conclusive, a small sample in the digital image manipulation comparison test indicated a minor increase in perceived (subjective) risk when a wide centreline was compared against the standard lane lines. Based on this research, there was anecdotal evidence that other road markings, such as transverse line markings could also be effective perceptual countermeasures to indicate reduced safety margins.

While the above appears to be an effective perceptual countermeasures that could be implemented to convey more accurate perception of risk, it is important to note that any painted road marking would also present a hazard to some road users, such as motorcyclists (although this would not be measured by KiwiRAP). While signage could be an effective countermeasure to convey more accurate perception of risk, the risk of dilution of effect from proliferation use need to be better understood before being used widely.

5 References

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Appendix A

In-person Video Questionnaire

AA Driver Risk Research – In-Person Video Survey

Participant Name:

SECTION A

Question 1: What do you consider as a safe speed for this section of road?

Answer: _____

Question 2: How safe do you think this section of road is overall?

Scale 1 – 10, 1='very unsafe', 5='neither safe/unsafe', 10='very safe'

Answer:

1 2 3 4 5 6 7 8 9 10

Question 3: What do you consider safe in this section of road (if anything)?

Answer(s): _____

Question 4: What do you consider unsafe in this section of road (if anything)?

Answer(s): _____

SECTION 1

Question 1: What do you consider as a safe speed for this section of road?

Answer: _____

Question 2: How safe do you think this section of road is overall?

Scale 1 – 10, 1='very unsafe', 5='neither safe/unsafe', 10='very safe'

Answer:

1 2 3 4 5 6 7 8 9 10

Question 3: What do you consider safe in this section of road (if anything)?

Answer(s): _____

Question 4: What do you consider unsafe in this section of road (if anything)?

Answer(s): _____

SECTION 2a

Question 1: What do you consider as a safe speed for this section of road?

Answer: _____

Question 2: How safe do you think this section of road is overall?

Scale 1 – 10, 1='very unsafe', 5='neither safe/unsafe', 10='very safe'

Answer:

1 2 3 4 5 6 7 8 9 10

Question 3: What do you consider safe in this section of road (if anything)?

Answer(s): _____

Question 4: What do you consider unsafe in this section of road (if anything)?

Answer(s): _____

SECTION 2b

Question 1: What do you consider as a safe speed for this section of road?

Answer: _____

Question 2: How safe do you think this section of road is overall?

Scale 1 – 10, 1='very unsafe', 5='neither safe/unsafe', 10='very safe'

Answer:

1 2 3 4 5 6 7 8 9 10

Question 3: What do you consider safe in this section of road (if anything)?

Answer(s): _____

Question 4: What do you consider unsafe in this section of road (if anything)?

Answer(s): _____

Section 3a

Question 1: What do you consider as a safe speed for this section of road?

Answer: _____

Question 2: How safe do you think this section of road is overall?

Scale 1 – 10, 1='very unsafe', 5='neither safe/unsafe', 10='very safe'

Answer:

1 2 3 4 5 6 7 8 9 10

Question 3: What do you consider safe in this section of road (if anything)?

Answer(s): _____

Question 4: What do you consider unsafe in this section of road (if anything)?

Answer(s): _____

Section 3b

Question 1: What do you consider as a safe speed for this section of road?

Answer: _____

Question 2: How safe do you think this section of road is overall?

Scale 1 – 10, 1='very unsafe', 5='neither safe/unsafe', 10='very safe'

Answer:

1 2 3 4 5 6 7 8 9 10

Question 3: What do you consider safe in this section of road (if anything)?

Answer(s): _____

Question 4: What do you consider unsafe in this section of road (if anything)?

Answer(s): _____

Section 4a

Question 1: What do you consider as a safe speed for this section of road?

Answer: _____

Question 2: How safe do you think this section of road is overall?

Scale 1 – 10, 1='very unsafe', 5='neither safe/unsafe', 10='very safe'

Answer:

1 2 3 4 5 6 7 8 9 10

Question 3: What do you consider safe in this section of road (if anything)?

Answer(s): _____

Question 4: What do you consider unsafe in this section of road (if anything)?

Answer(s): _____

Section 4b

Question 1: What do you consider as a safe speed for this section of road?

Answer: _____

Question 2: How safe do you think this section of road is overall?

Scale 1 – 10, 1='very unsafe', 5='neither safe/unsafe', 10='very safe'

Answer:

1 2 3 4 5 6 7 8 9 10

Question 3: What do you consider safe in this section of road (if anything)?

Answer(s): _____

Question 4: What do you consider unsafe in this section of road (if anything)?

Answer(s): _____

GENERAL QUESTIONS

Question : How safe do you think this section of road is overall?

Scale 1 – 10, 1='very unsafe', 5='neither safe/unsafe', 10='very safe'

Answer:

1 2 3 4 5 6 7 8 9 10

Question : How safe do you think this section of road is overall?

Scale 1 – 10, 1='very unsafe', 5='neither safe/unsafe', 10='very safe'

Answer:

1 2 3 4 5 6 7 8 9 10

Question : How safe do you think this section of road is overall?

Scale 1 – 10, 1='very unsafe', 5='neither safe/unsafe', 10='very safe'

Answer:

1 2 3 4 5 6 7 8 9 10

Question : How safe do you think this section of road is overall?

Scale 1 – 10, 1='very unsafe', 5='neither safe/unsafe', 10='very safe'

Answer:

1 2 3 4 5 6 7 8 9 10

Question : How safe do you think this section of road is overall?

Scale 1 – 10, 1='very unsafe', 5='neither safe/unsafe', 10='very safe'

Answer:

1 2 3 4 5 6 7 8 9 10

Question : How safe do you think this section of road is overall?

Scale 1 – 10, 1='very unsafe', 5='neither safe/unsafe', 10='very safe'

Answer:

1 2 3 4 5 6 7 8 9 10

Question : How safe do you think this section of road is overall?

Scale 1 – 10, 1='very unsafe', 5='neither safe/unsafe', 10='very safe'

Answer:

1 2 3 4 5 6 7 8 9 10

Question : How safe do you think this section of road is overall?

Scale 1 – 10, 1='very unsafe', 5='neither safe/unsafe', 10='very safe'

Answer:

1 2 3 4 5 6 7 8 9 10

Question : How safe do you think this section of road is overall?

Scale 1 – 10, 1='very unsafe', 5='neither safe/unsafe', 10='very safe'

Answer:

1 2 3 4 5 6 7 8 9 10

Question : How safe do you think this section of road is overall?

Scale 1 – 10, 1='very unsafe', 5='neither safe/unsafe', 10='very safe'

Answer:

1 2 3 4 5 6 7 8 9 10

Appendix B

Drive-over Survey Questionnaire

AA Driver Risk Research – Driver Over Survey

Participant Name:

SECTION :

Question 1: What do you consider as a safe speed for this section of road?

Answer: _____

Question 2: How safe do you think this section of road is overall?

Scale 1 – 10, 1='very unsafe', 5='neither safe/unsafe', 10='very safe'

Answer:

1 2 3 4 5 6 7 8 9 10

Question 3: What do you consider safe in this section of road (if anything)?

Answer(s): _____

Question 4: What do you consider unsafe in this section of road (if anything)?

Answer(s): _____

Appendix C

Meta-Analysis Dataset

Web Survey Dataset

The features that influenced road user perceived (road) safety risk (perceived risk) in this survey are as follows:

- Limited or no shoulder width (sealed and/or unsealed) - The presence of limited shoulder width increased the perceived risk.
- Side Roads – The presence of side roads increased the perceived risk. In some instances driver risk perception was increased further due to the presence of narrow shoulder width and/or the presence of roadside power or telegraph poles preventing the use of shoulders for emergency manoeuvres.
- Power and telephone poles located on the roadside - The presence of roadside power/telegraph poles increased the perceived risk.
- Roadside banks and ditches - The presence of roadside banks and ditches increased the perceived risk.
- Curves and corners including their impact on sight line distance - The presence of curves and corners in the road layout increased the perceived risk. This included both the risk introduced by potential loss of vehicle control and/or the potential for a limited sightline distance as a result of roadside obstructions.
- Other vehicles using the road, including their impact on sight line distance - The presence of other vehicles on the road increased the perceived risk. Increased risk perception is due to both the potential for oncoming traffic to cross the centerline, in the case of non-barrier protected single carriageway, and also due to being an obstruction causing a reduction in sightline distances. In such cases, large traffic e.g. heavy vehicles/trucks have the potential to limit sightline distance further.
- Roadside barriers – The presence of roadside barriers reduced the perceived risk only where adequate shoulder width was available. Analysis indicates; that where roadside barrier installation resulted in a narrow shoulder width, perception (subjective) of driver risk was increased.
- Passing lanes – The presence of passing lanes increased the perceived (subjective) driving risk.
- Road markings, including limited width of turning lanes – Inadequate and/or confusing road markings increased the perceived risk. Where turning lanes where marked without providing adequate width, to accommodate the turning vehicle plus oncoming and trailing vehicle to pass abreast of one another, the perceived risk potential for collision was increased. Non-standard and confusing road markings resulted in an increased risk perception (subjective) due to the high driver workload required to interpret such road markings.
- Straight roads influencing higher travel speeds – A minor theme in the analysis of this data set indicates that some participants perceived straight sections of road as carrying risk potential due to traffic accidents as a result of drivers traveling at higher than posted speeds.
- Traffic advisory signage – Analysis indicates that a driver's risk perception (subjective) is most accurate when provided with advisory signage clearly conveying the upcoming road characteristics. It is important to note that where advisory signage is excessive and/or not displayed early enough in the road section, that actual (objective) risk is increased due to higher driver workload. Advisory signage such as cornering speeds and high crash rate notifications serve to covey an accurate level of risk perception (subjective).
- Traffic works – As an additional note, analysis of the data set indicated that some drivers identified traffic road cones as having the potential to represent potential upcoming risk.

In-person Video Survey

Analysis of the data set indicated that as the perceived (subjective) risk of a given road section increased, there was a proportional decrease in average road speed traveled through the section. Average speed travelled through a section of road decreased by 10% where the perceived (subjective) road risk was increased by approximately 10% on the average safety measurement (perceived) reported by participants.

Analysis of the video survey data sample indicates a relationship between road features and countermeasures and the perceived risk reported. Average perceived safe speed, provided by video survey participants, decreased as the perceived risk for the road section increased. Data showed that on average participants recommended a 15.5km/h reduction in speed as perceived risk increased by 10% (on a standardised 1-10 measurement scale). Specific features and countermeasures recognised as impacting perception of risk were as follows:

- Passing lanes – The inclusion of passing lanes in the road layout decreases the perceived risk. However, where passing lanes were considered too short to safely complete a passing manoeuvre and/or merging of the lanes was posted without adequate distance to the point of merging, the perceived driving risk increased.
- Road/lane width and roadside shoulder width – As per the data collected from both the web based survey and drive over survey, narrow lane and/or a narrow shoulder width increased driver perception of risk. A minor theme in the data set related narrow lane/shoulder width to an increase in perceived driving risk for cyclists.
- Curve speed advisory signs and chevrons – As per the data collected from the both the web based survey and drive over survey, the absence of speed advisory signs positioned at the entry of curves increased the perceived driving risk.
- Where participants were presented with multiple images digitally altered to remove the curve advisory sign from one of the set. The data indicated that the perceived risk of the road section increased by 16%.
- High crash rate sign –The survey data indicated that the presence of a high crash rate sign served to covey an accurate level of risk perception as risk awareness was increased in these road sections.
- Median barriers – The presence of median barriers reduced the level of perceived driver risk. This is likely due to the perceived reduction in possibility of head-on collisions with vehicles travelling in the opposite direction.
- Road markings (yellow lines) – Single or double yellow lines indicating no passing lanes, served to decrease the perceived safety risk. As per the presence of median barriers it is likely to be a result in the perceived reduction in possibility of collisions with vehicles travelling in the opposite direction.
- Traffic density – The data set indicated that the presence of higher traffic density increased the evaluated driving risk. It is expected that heavy vehicle traffic would be of additional risk concern if presented to participants for evaluation.
- Sight distance - The perceived driving risk increased where sight distance was obstructed by roadside features or other vehicles.
- Edge markers – Reflective edge markers are acknowledged to increase the risk awareness of a given road section.

Drive-Over Survey

Analysis of the drive-over survey results indicate driver speed increases with a reduction in perceived (subjective) risk. Although this is consistent with common understanding it is worthwhile noting that a small number of observed risks can substantially influence the driver's perceived risk of a given stretch of road. Therefore the placement of any number of countermeasures aimed at raising awareness of road risk has the potential to substantially influence positive driving behavior across a larger stretch of road than in the immediate vicinity of the countermeasures.

The features that influenced drivers' perception of risk in this survey are as follows;

- Quantity, intensity and camber of corners – The quantity and geometrics of corners within a section of road increased the actual (objective) driving risk and were a major component in the retrospective evaluation of perceived (subjective) risk.
- Curve speed advisory signs and chevrons – The presence of speed advisory signs positioned at the entry of curves increased the perceived (subjective) driving risk when the signs are:
  - Positioned too late in the corner
  - Mounted outside the normal range of driver view e.g. too high/low
  - Considered inconsistent in speed rating
  - Indicating single curves only where a second curve closely followed the first.
- Sight distance - The presence of curves, corners and variations in road elevation increased the perception (subjective) of driving risk where sight line distance was due to such obstructions. Decreased sight distance due to other vehicles obstructing driver view also increased perceived driver risk.
- Road/lane width and roadside shoulder width – Narrow lane and/or a narrow shoulder width increased driver perception (subjective) of risk. This perceived risk is likely due to having a restricted movement area should collisions need to be avoided through evasive manoeuvres.
- Traffic signage – Survey participants indicated clear acknowledgement that traffic signage effectively communicates increased driving risk. Signage such as curve speed, winding road, give way & stop and high crash rate signs are expected by drivers to be present to communicate the risk associated with a given section of road.
- Side roads – Perceived driver risk increased where sections of road included side roads and side roads in the road layout.
- Roadside ditches and banks – Where sections of road included ditches or banks on the roadside, the perceived (subjective) driving risk was elevated.
- Surface condition – A rough and potted road surface increased driver risk perception.
- Road marking – Inconsistent or inadequate road marking increased driver workload and therefore also increased perceived (subjective) risk. Where no passing yellow lines were expected but not present, typically on rises or perpendicular to side road side roads, drives experienced an increase in perceived risk. The presence of 'cats eyes' aided in reducing the perception of risk, it is believed that this could be due to this countermeasure supplementing the solely visual road marking with both aural and physical feedback as tires pass over these components.
- Roadside barriers – The presence of roadside barriers where they separated traffic from ditches or drop-offs, without restricting roadside shoulder width, served to reduce the perceived (subjective) risk experienced by drivers.