SPEED LIMIT SETTING: A SAFE SYSTEMS APPROACH

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ABSTRACT

The adoption of the safe systems approach through the Safer Journeys, New Zealand Road Safety Strategy 2010-2020, has meant greater attention is being paid to New Zealand's speed limits setting process. This paper focusses on two apects of Land Transport Rule: Setting of Speed Limits (Rule 54001/2) and the criteria set out in Schedule 1: Speed Limits New Zealand (SLNZ) to see how these can be adapted to the safe systems approach. The first apsect is the lack of guidance around the three key elements used to determine the speed limit, operational speed data, the crash data and the calculated speed rating. The second aspect is the emphasis in the process on roadside development rating over roadway rating. Through a literature review, qualitative survey of transport professionals' and an analysis of the recent lowering of the speed limit tolerance during public holidays this paper concludes that overall the Rule and SLNZ process is adequate but there are elements that require clarification to align them with safer systems thinking. These include a more refined consideration the role of operational speed data and a move towards a more proactive approach to crash analysis drawing from KiwiRAP and greater consideration of road features and geometry in the rating process.

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INTRODUCTION

Currently in New Zealand, speed limits are set legislatively through Land Transport Rule: Setting of Speed Limits Rule 54001/2 first enacted in 2003 and subsequently amended in 2005 and 2007 (the Rule). Schedule 1: Speed Limits New Zealand (the SLNZ process) of the Rule, sets out the specific criteria for determining the appropriate speed limit for a road including the speed rating calculation. This process was developed using what the Federal Highway Administration (FHWA) (2012) identifies as an engineering approach which focuses on operating speeds, roadside development and road function. The FHWA identifies this as one of the four common approaches to setting speed limits throughout the world, the others being the expert systems approach, the optimisation approach and the safe systems approach.

In 2010 the Ministry of Transport (MoT) released the Safer Journeys: New Zealand Road Safety Strategy 2010-2020 (the Safer Journeys Strategy). This strategy demonstrates a shift away from an engineering approach to road safety by adopting a safe systems approach. Originating in the Netherlands and Sweden the safe systems approach reframes the way road safety is conceptualised. This is achieved by recognising that both practitioners and road users have shared responsibility and that the transport system needs to be designed to be more forgiving in order to reduce the seriousness of crashes (International Transport Forum, 2008). The safe systems approach is being increasingly adopted throughout the Organisation of Economic Development (OECD). With the International Transport Forum (ITF) recommending in 2008 that '*all countries, regardless of their level of road safety performance, move to a Safe System approach to road safety'* (ITF, 2008: 5). The Safer Journeys Strategy does this by identifying that all parts of the transport system i.e. roads, road environments and the way roads are used, need strengthening.

The Safer Journeys Strategy includes a series of action plans which focus on different aspects of the transport system. These include the Safe Speeds Action Plans which focus on the need to ensure that speed limits better match the road environment. The 2013-15 Safe Speeds Action Plan includes a national review of the current legislation and it is hoped that this research will contribute to that process.

There are already a number of other investigations occurring into managing speed limits by the New Zealand Transport Agency (NZTA), various academics and Road Controlling Authorities. Several of these have been prompted by the Safer Journeys Strategy and its action plans. These focus on aspects including changes to enforcement, the use of variable speeds, self-explaining roads trials and investigations of various engineering measures. This research focuses on the fundamental basis to setting speed limits, the Rule and the SLNZ process. This is an area which has received only very limited attention to date as identified by both Koorey (2011) and Charlton (2012).

This paper focuses on how two specific aspects of current Rule and SLNZ process could be strengthened to align them more closely with the safe systems approach and therefore the Safer Journeys Strategy. The first aspect considers how to apply a safe systems approach to dealing with the inconsistencies between the three key elements which play a part in determining the appropriate speed limit. These are the operational speed data, the crash data and the calculated speed rating under the SLNZ process. The second aspect this paper focuses on is a specific element of the speed rating process - the prioritisation of roadside development over road features and geometry, and whether this continues to be appropriate under the safe systems approach. These are conceptualised in Figure 1 below. This analysis is drawn from a wider research project into the speed limits setting process which was funded by the Institute of Professional Engineers New Zealand (IPENZ) Transportation Group (TG) 2013 Study Award. The research report goes into much greater detail on both of these aspects and a range of other issues[1].

[1] The full report is available on request.

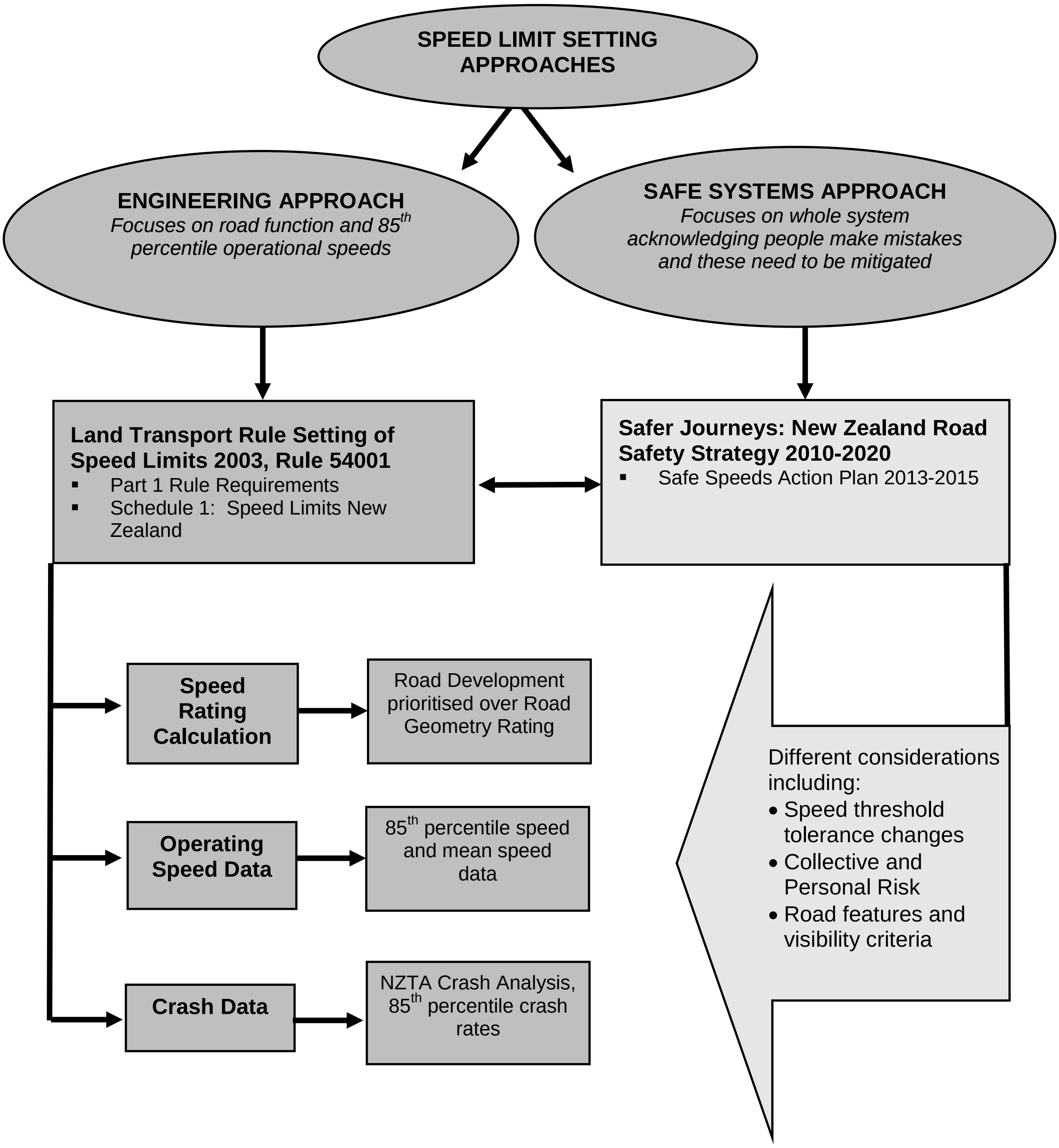

Figure 1: A flow chart conceptualising key elements the Rule and SLNZ process and the interaction with aspects of the Safer Journeys Strategy

METHODOLOGY

To investigate these two aspects of the speed limit setting process the methodology for this research included.

- A literature review of both international and local research, strategies and polices.
- A qualitative survey of transport professionals' views on the current Rule and SLNZ process using Survey Monkey, an online resource (the survey). A total of 65 responses were received.
- A snapshot analysis of the recent trials conducted by the NZ Police to lower speed limit threshold tolerance during public holidays looking at NZ Police data and tube count data collected from a range of roads in the Auckland Region.

OPERATIONAL SPEED DATA, CRASH DATA AND THE SPEED RATING: ANALYSIS AND CLARIFICATIONS

Situations can and often do arise during the SLNZ process where there are contradictions between what the speed rating, operational data and crash data results recommend in terms of the most appropriate speed. For example, when the overall speed rating process recommends a higher speed limit than the operational speed data or crash history would support. Or when the roadside development rating (land uses and vehicle accesses) supports a higher speed limit than the roadway rating (road geometry, function etc.). This second example is discussed later in this paper.

Section 3.2(5) of the Rule provides the only criteria for what to do if the proposed speed limit differs from that calculated through the SLNZ process. The criteria states that a speed limit different from that calculated may be set if it '*is the safe and appropriate speed limit for a road with regard to the function, nature and use of the road, its environment, land use patterns and whether the road is in an urban traffic area or a rural area'.* This is somewhat a catchall phrase which while implying greater flexibility is difficult to interpret or implement. The criteria also includes a reference to Section 3.2(6) if the speed limit is less than 50km/h, which isn't able to be covered in this paper[2].

The vagueness of the criteria means that it comes down to professionals relying on their judgement to determine how to deal with such contradictions. This can lead to inconsistencies in how the Rule is applied. To explore this aspect further the following question was asked in the survey, '*When undertaking a speed limit review how much emphasis do you put on each of the following to determine the appropriate speed limit, with 1 being the greatest weight is given to this aspect and 3 the lowest'.* The results are summarised in Figure 2 and Table 1 below.

[2] Please refer to the full research report for a critical analysis of the processes for setting speed limits less than 50km/h

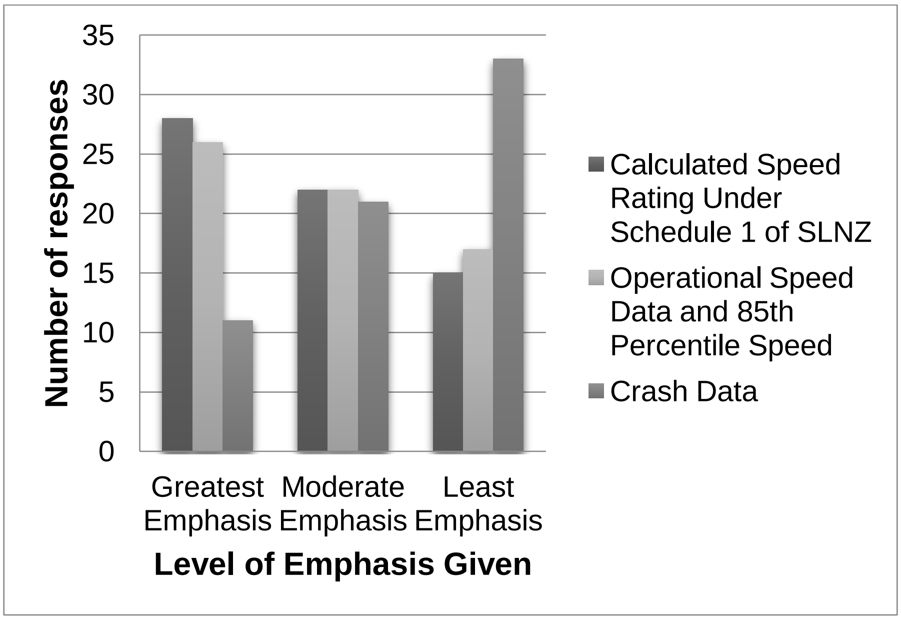

Figure 2: Graph showing the weighting given to the different aspects considered

	Calculated Speed Rating	Operational Speed Data	Crash Data	Total preference
Order of preference	1	2	3	18
	2	1	3	15
	3	1	2	11
	1	3	2	10
	2	3	1	7
	3	2	1	4

Table 1: Detailed breakdown weighting responses

Figure 2 demonstrates that the calculated speed limit and the operational speed data are almost given equal weighting as the primary factors that are considered, with crash data a noticeable third. However, when these are broken down further in Table 1 it is noted that the results are much more mixed. This indicates that there is greater variety in how these three aspects of the speed limit setting process are interpreted and that greater guidance is required to ensure a consistent approach.

This research proposes that applying a safe systems approach to these three key elements will result in more consistency, both in terms of what is considered when analysing the data and how they are evaluated by professionals. Next the current approach to operational speed data and crash data is examined to analyse how they are currently applied and what changes could be made to align them with a safe systems approach. The paper then examines one element of the speed rating calculation, the prioritisation of roadside development over road features and geometry and discusses potential changes through a safe systems lens.

OPERATING SPEED DATA: ENGINEERING VS SAFE SYSTEMS APPROACH

As discussed the FHWA (2012) identifies four general approaches to the process of setting speed limits, the engineering approach, the expert systems approach, the optimisation approach and the safe systems approach. These approaches are effectively variations on a theme as overall they do focus on the same elements i.e. road function, geometry, roadside development, operational speed data and crash history. The difference lies in which aspects they emphasise and how this then translates into determining the most appropriate speed limit. As identified previously the Rule and SLNZ process is based on the Engineering Approach[3].

The Engineering Approach considers both the 85th percentile operating speeds and road function to calculate the base speed limit. The FHWA (2012) identifies that the 85th percentile could be considered the tipping point between acceptable speed behaviour and unsafe behaviour and that it reflects what the vast majority of drivers consider the maximum appropriate operating speed. This is something reflected in Section 3.4 of the SLNZ process. This section sets out the criteria in terms of the role the operational speed data plays in setting speed limits. It states that, *'the mean speed and the 85th percentile speed on a road should not be significantly greater than the speeds specified in Table SLNZ3* [shows mean and 85th percentile operating speeds]*. On medium- to high-volume roads the standard deviation becomes important, as a road with a narrow distribution of speeds is less hazardous than one with a wide distribution. If operating speeds exceed the values specified in the table, it is likely that additional measures such as engineering, enforcement, education and publicity will be necessary to reduce speeds.'*

Austroads (2008) identifies that the use of 85th percentile speeds as a key determinant of the speed limit setting process has been losing traction because it is not in keeping with a safe systems approach to road safety. This point is reinforced by recent work in the United Kingdom which advises that when there isn't a consistent relationship between the mean and 85th percentile speeds it can indicate that '*drivers have difficulty in deciding the appropriate speed for the road*' (Department for Transport, 2013: 12). This point is further emphasised by the National Cooperative Highway Research Program (NCHRP) (2006) report which identifies that there is often very little compliance by motorists with existing speed limits and therefore relying on their collective judgement rather than expert engineering advice can be problematic. Consequently, the following question was asked as part of the survey, '*There has been a historical emphasis using 85th percentile operating speeds as key determinant of the appropriate posted speed limit. Do you still believe that this is the most appropriate percentile to use, please explain your answer?'*

Of the respondents 49% agreed that the 85th percentile was still the most appropriate percentile to use when setting speed limits. The majority identified as outlined above that is was because it reflected the collective judgement of the majority of drives as to the appropriate speed for the environment. Several also pointed out that it is the practice internationally.

A further 25% stated that they did not think it was the most appropriate percentile to use. Several factors were identified in these responses including: the fact that it doesn't allow for vulnerable road users such as cyclists and pedestrians; that the mean speed is a better indication of what drivers think; and, that it effectively condones that 1 in 7 drivers is driving over the speed limit.

The remaining 26% of respondents provided a variety of answers. A number pointed out that the wording of the question was incorrect and misleading. In hindsight this is correct. Under Section 3.4 of SLNZ it states that the mean and 85th percentile speed on a road should not be higher than that stated in Table SLNZ3. As one respondent pointed out the 85th percentile is more important for enforcement purposes and this is discussed further below. Other comments included that fact that there was a division between those that used mean speeds and those that used the 85th percentile while others commented on the fact that the operating speed should reflect the roadside development.

The responses show that clearly this aspect of the Rule is open to interpretation and there needs to be further clarification around the role the operational speeds have in the speed limits review process. This paper outlines two specific issues with SLNZ Section 3.4.

First, the international literature demonstrates that people's perceptions of the appropriate speed are influenced by enforcement. Mannering (2009) identified that a driver's perception of a safe speed was strongly determined by how fast they could travel before they would be given speeding

[3] For a full literature report please refer to the full research report.

ticket. Mannering notes that this was based on a sample set of 1,000 drivers in a specific geographic location and caution must be used if applying it in a more general sense. However, he points out that the findings are statistically significant and show that '*drivers are linking perceptions of safety to the likelihood of being ticketed – possibly reflecting the belief that officers will ticket only when safety is threatened'* (2009: 104).

The Safer Journeys Strategy notes that by '*moderating both mean and excessive speeds [we] could significantly reduce road deaths and serious injuries*' (2014). Consequently, this research sought to see if altering the speed tolerance threshold over which a driver is ticketed affected their behaviour. As part of the Safer Journeys Strategy the NZ Police have been trialling reduced threshold tolerance levels over public holiday periods where there have historically been higher incidents of serious and fatal crashes. The most significant trial to date was over the 2013-14 Christmas break (1 December to 31 January). Called the 'Safer Summer' campaign the results showed a marked change in drivers' attitudes toward speed including the following when compared to the previous four summer periods (NZ Police 2014a):

- a 36-51% drop in the proportion of drivers speeding over 100km/h;
- a 26% reduction in road deaths;
- a statistically significant drop in vehicle mean speeds by 0.5-1.5km/hr;
- a 47-62% drop in the number of drivers exceeding 104 km/h.

The NZ Police data does indicate that there is a psychological link between driver behaviour and the level of speeding that is tolerated. Consequently, this may have implications for the analysis of operating speeds as part of the Rule. Specifically, that the speed limit setting process uses the mean and 85^{th} percentile speed to assist in calculating the appropriate speed limit, therefore a higher tolerance may be leading to higher speed limits being set.

To test this hypothesis further a series of tube counts were undertaken on six roads in the Auckland Region during the Easter 2014 break (See Figure 3 below). The combination of Easter and Anzac Day falling in the same week in 2014 meant that the NZ Police had decided to enforce a 4km/h tolerance threshold for the whole week from Good Friday 18 April until the following Sunday 27 April. This provided a good opportunity to compare data both from the week before and the week during the lowered threshold to see if there was any difference in speeds and in particular the mean and 85^{th} percentile. These roads were selected to capture data from different geographic areas throughout the region and on different types of roads as shown in Figure 3.

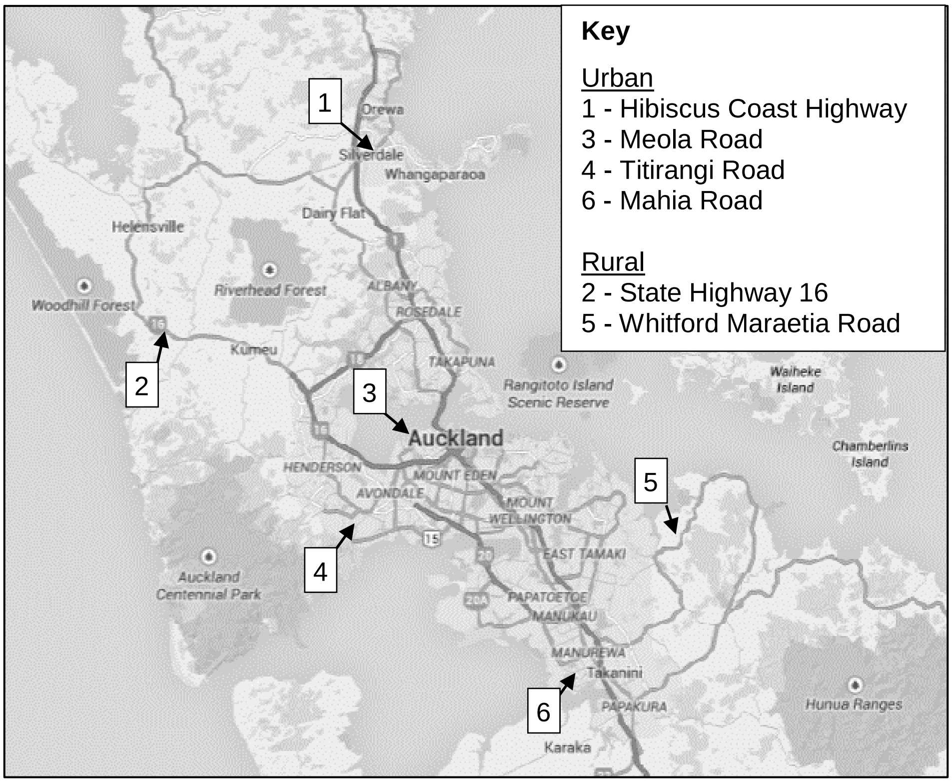

Figure 3: Map showing the locations of the different tube counters around the Auckland Region

The two weeks of data were analysed. Week 1 was from Friday 11 to Thursday 17 April, where there was greater leeway in the threshold tolerance up to 10km/h. Week 2 covered Friday 18 to Thursday 24 April where the threshold tolerance was lowered to 5km/h over the posted speed limit. A significant storm event occurred in Auckland over the 2014 Easter weekend. Consequently, there were some technical difficulties with the counts which resulted in gaps in the data, but these were not significant.

The results showed that overall there was little change in the mean speed or 85th percentile on any of these roads over the two week period despite the change in the speed threshold tolerance[4]. These results are different to those reflected in the police data over the Christmas 'Safe Summer' trial. There are likely to be two key reasons for this. First, the weather clearly played a factor in the driving conditions over the 2014 Easter break. Vehicle speeds on all of the roads were at or below the posted speed limits for the majority of the two week period. Second, none of these roads have fixed speed cameras indicating existing speeding issues in the areas where the tube counters were located. The Police enforcement would have focused more on areas where there are known speeding issues to try and reduce the incidence of serious and fatal crashes.

Consequently, the NZ Police data does support Mannering's (2009) hypothesis that changing the speed limit tolerance threshold does alter peoples driving behaviour. However, the tube count data indicates that it isn't necessarily the case on all roads. This indicates that both the 85th percentile and mean speeds can be influenced by enforcement in areas where speeding is already an issue. Consequently, in those cases caution should be used in assessing the road's speed limit solely based on Section 3.4 of the SLNZ. However, if NZ Police do reduce the speed limit tolerance threshold permanently, something it is understood is being considered, the effect of the tolerance level on the 85th and mean operating speeds may be less of an issue.

As discussed previously the international literature demonstrates that there is a move away from the use of 85th percentile speeds as a determinant in setting speed limits. The psychology behind what drivers perceive is an appropriate speed for the environment is influence by numerous factors

[4] Please refer to the full research report for a detailed analysis

both in terms of external sources and personal characteristics (Charlton et al (2014) and Charlton (2012)). The above discussion reveals that both the 85th percentile and mean speeds can be sensitive to enforcement measures in particular circumstances as Mannering (2009) also found. Therefore continuing to rely on the collective judgement of drivers as a reliable measure could be questioned under the safe systems approach.

There is increasing evidence that the severity of a crash increases exponentially the faster the speed (Cameron and Elvik, 2010; Kloeden, McLean and Glonek, 2002). Cameron and Elvik (2010) found in their review of 60km/h speed zones in Adelaide that if no vehicles exceeded 60 km/h in these zones then there would be a 25% reduction in casualty crashes. Further, that nearly 60% of crashes could be eliminated if those travelling between 61 and 75 km/h had their speeds reduced to 60km/h.

Based on calculations developed by Kloeden, McLean and Glonek (2002) and previous research by the NZ Police (2014b) the likelihood of casualty crash doubles for every 5 km/h above a 60 km/h posted limit and for every 10 km/h above a 100 km/h posted limit. Further, a 5% decrease in average speed leads to around 10% fewer injury crashes and 20% fewer fatal crashes. Consequently, given the safe systems emphasis on reducing crash severity it is recommended that in addition to the mean and 85th percentile speeds, consideration also be given to how such operational speeds effect crash severity.

CRASH DATA

Section 3.5 of the SLNZ requires crash data to be analysed when setting speed limits on arterial roads but also recommends it be assessed for all speed limit reviews. First, the overall crash rate is compared to national data for similar roads i.e. same speed and road function, similar development and engineering features. Then second, a special crash-type analysis can be conducted that identifies what crash types may be affected by a change in the speed limit. It is recommended that the crash rate is monitored after the speed limit is changed to ensure that it doesn't exacerbate the accident rate or specific types of crashes. Section 3.5 concludes that '*the existing crash rate should be below the 85th percentile of the national crash rate for similar roads. If the crash rate exceeds the 85th percentile for similar roads, additional engineering and enforcement, in conjunction with the change in speed limit, will probably be required to reduce it. This is just as important when reducing the speed limit as when increasing it, because it is unlikely that a reduction in speed limit alone will reduce the crash rate*'.

There is also a danger in accepting an 85th percentile crash rate which is comparative to other similar roads if in fact the crash rates are generally poor on those types of roads or vice versa. Actually undertaking this type of 85th percentile analysis is not as straightforward as the rule indicates. Typically data is first obtained for a five year period from the NZTA Crash Analysis System (CAS). Then Section A6.6 'Typical injury accident rates and prediction models' of the Economic Evaluation Manual (2013) is used to determine if the crash rates are typical for that type of road or not. This approach is in contrast to the safe systems approach which focuses on reducing the crash rate overall and in particular the number of fatal and serious injury crashes. Consequently, one of the most common criticisms levelled at the crash data analysis in the Rule is that it is too reactionary.

A potential means to address the reactionary nature of the current process is through reconceptualising the level of risk. The New Zealand Road Assessment Programme (KiwiRAP), which started in 2008 and is based on the International Road Assessment Programme (iRAP) assesses the risk level of rural roads. KiwiRAP takes a more proactive and holistic safe systems approach by measuring the risk associated with a road in terms of collective and personal risk. Collective risk is a measure of the total number of fatal and serious injury crashes over a section of road and can be used to determine where the best safety improvements can be made. Personal risk measures the danger to individual drivers assessing what their likelihood is of being involved in a serious of fatal injury crash. From these two calculations the overall risk level for the road can be determined.

This type of risk assessment was initially rolled out on the State Highway network but is now also being adopted on the local road network. One of the first such examples is the partnership between Auckland Transport and Abley Transportation Consultants. The project provides interactive maps illustrating the personal and collective risk throughout the Auckland Region's road network (http://maps.abley.com/AT/RiskMapping/). It is understood other Road Controlling Authorities are considering doing the same. This approach illustrates that while the CAS crash data is helpful to understand what has happened it is not in itself enough under the safe systems approach to identify potential risk areas. The proactive identification of future risk areas could provide the additional information required to determine if in fact the proposed speed limit is actually appropriate for that road. It is therefore recommended that consideration be given to amending Section 3.5 of the SLNZ process to take into account the collective and personal risk of the road and the implications of these to determine what speed limit is appropriate and any engineering measures that may be required to support this.

DEVELOPMENT RATING VERSUS ROADWAY RATING

The SLNZ rating process separates the speed limit calculation into two parts. The roadside development rating considers frontage land uses and accesses along the road and side roads. The roadway rating includes geometry, different transport modes, parking, traffic controls and the road function. The higher the rating number calculated the lower the recommended speed limit. According to Section 1.1 'Speed Limits Policy' and Section 2.1 'Urban Speed Limits (50km/h)' of the Rule, when the road geometry encourages higher speeds than the speed limit determined by the roadside development rating engineering techniques should be used. For example narrowing traffic lanes and installing calming measures.

However, the Rule doesn't recommend any means to address situations where the roadside development calculation supports a higher speed than the road geometry can necessarily safely facilitate. Instead Section 4.3 of SLNZ states the opposite. Requiring that the roadway rating number '***must** be reduced to that of the development rating*.' (emphasis added, SLNZ, 2007) when calculating the average rating if the roadway rating calculation is higher i.e. recommends a lower speed.

In order to gauge the wider professional body's perspective on this aspect of the Rule and SLNZ process the following question was asked as part of the survey, '*SLNZ states that "Although road geometry is also a factor in determining a speed limit, it is secondary to roadside development." Do you agree or disagree with this approach, please explain?'*. The results were quite mixed. Of the respondents 29% agreed with the approach taken in SLNZ, 49% disagreed and 21% didn't agree or disagree but provided alternative explanations.

Support for the existing SLNZ approach hinged on the fact that increased roadside development generally lowers speed limits anyway. This is based on the argument that such development is the most obvious cue that the environment has changed and that drivers need to travel slower because of increased vehicles and other road users. Further, several respondents commented that road geometry can be mitigated by engineering measures such as signage and surface treatments.

A number of those that disagreed with the SLNZ approach believed that roadside development and road geometry should be given equal waiting in the process. Several also discussed the issues they had faced particularly on rural roads where the road geometry was poor but the lack of roadside development supported higher speeds and this then determined the speed limit. Several respondents summarised their statements by stating that the current SLNZ approach wasn't in keeping with the safe systems approach as it was too inflexible to deal with these types of situations.

Of the 21% that didn't agree or disagree alternative explanations were provided. The majority of these pointed out that it was situation dependent as the road geometry became more important on rural roads but in urban environments the frontage development was the most important aspect.

Another key argument made by some survey respondents was that drivers were more able to perceive the danger from the road geometry than from roadside development, arguing that this was why the roadside development rating should be given more weight. However, this contradicts the other argument used, as outlined above, which supports the emphasis on roadside development because land use frontages provide more visible cues to slow down. Further, Charlton et al (2014) found that drivers weren't necessarily that good at identifying riskier environments or objects, particularly objects that may not contribute to a crash but would make the severity much worse such as poles and ditches.

The only reference to roadway geometry in the SLNZ process is in Table SLNZ9 of the Roadway Rating. This identifies three alignment types, open, average and limited visibility. No definitions of these three types of visibility are provided to clarify how these should be determined. The following question was therefore asked in the survey, '*Table SLNZ9 Roadway Rating - Geometry identifies three alignment types, open, average and limited visibility. What do you use to differentiate between these three types, i.e. standards such as Austroads, policy documents, experience etc.? Further, do think there needs to be more guidance on these and why?'*

Once again there were a diverse range of answers to this question. Several respondents, 37%, did believe that more guidance was needed. However, 30%, of these respondents stated that they primarily used experience but that for less experienced engineers, further guidance would help.

In total 21% identified that they relied on their own experience and no other information with phrases such as 'rule of thumb' and 'gut feel' being used. Several also qualified their statements by pointing out that it is only a small aspect of the rating and that it was simple and common sense.

A further 26% identified that they either use standards like Austroads for guidance or use a combination of their own experience and such standards. There were also some other interesting responses including the suggestion that *'The notion that limited visibility is a "bad" thing is completely as odds with the northern European countries who actively encourage limited visibility as they know these support slower traffic speeds'.* Fourteen percent also said that they didn't know or didn't have the qualifications/experience to answer this question.

Overall, the variety of responses to the survey question do support the need for further guidance and clarifications to be developed around these terms, to ensure they are applied consistently. The key issue is determining the point at which visibility shifts from one category to the next e.g. the transition point between 'Open' and 'Average' visibility. While experience plays a part in this determination there will be different perceptions as to where these transition points are leading to inconsistencies in how this part of the calculation is applied.

To clarify what is meant by these three categories consideration could be given to the following aspects. Austroads Part 4a (2010) provides a detailed analysis on determining sight distances for intersections. These basic principles could equally be applied to traveling along a road as the factors that determine visibility to an approaching hazards, be it an intersection, a bend or something else, are the same. These are a driver's reaction time, longitudinal deceleration rates based on the speed of travel and vertical height parameters (e.g. driver eye height). Consequently, the Approach Sight Distances (ASD) outlined in Table 3.1 of Austroads Part 4a (2010) could be used to assist determining the visibility along with the calculations provided for variables such as horizontal curves.

For example on an 80km/h road with a reaction speed of 2 seconds, a driver needs 114m to stop safely. A normal road design would consider a design speed that is 10 to 15% above the posted speed limit. Consequently, for an 80km/h road 'Open Visibility' could equate a distance of or greater than the ASD for a posted speed of 90km/h, 139m. To determine ‘Average Visibility’ it could be based on the ASD range between 10km above and 10km below the posted speed. For an 80km/h road that would be between 90km/h and 70km/h so the average visibility would be between 139m and 92m. If the visibility falls below the ASD for the speed that is 10km below the posted speed limit then it could be considered ‘Limited Visibility’ e.g. below 92m for an 80km/h road.

Another aspect that could assist in clarifying these visibility criteria relates to the ability to see road delineations. Dravitzki, Munster and Laing (2002) sets out minimum performance requirements for delineation in the New Zealand context. They identify that there are a number of factors that influence this, including the age of the driver. While the ratings process needs to be kept high level their conclusions are useful. They identify that at least 2seconds driving time of forward visibility is required to see delineation clearly, while acknowledging that the wider literature recommends between 3 seconds and 10 seconds. As road markings and signage provide vital guidance and cues for drivers, particularly on approach hazards, considering the forward visibility of delineation elements could be a useful way to consider frame these categories.

Clearly further research is required into how exactly these categories are defined. The survey data demonstrates that to ensure a consistent approach is used, much great clarity is needed. There are a number of ways to do this including the use of the ASD calculations from Austroads and the visibility of delineation markings.

However, as the survey also revealed, features other than visibility should also be considered when assessing road geometry. The safe systems approach encourages the development of more forgiving environments. This has been adopted in the Safer Journey’s Strategy through an action plan for Safe Roads and Roadsides 2013-15. One of the cornerstone documents of this action plan is the 2011 High Risk Rural Roads Guide (HRRRG) (NZTA, 2011). This guide provides a detailed assessment of roadside hazards and measures to try and improve or remove these. Obviously, there are numerous situations where little can be done about roadside hazards either because of the environment or costs and time restrictions. Factoring these into the speed limit calculation would therefore be a more simple way to reduce crash severity.

The HRRRG draws on the KiwiRAP assessment (discussed above). The KiwiRap assessment also includes a Road Protection Score (RPS) which assesses various road design features including lane width, shoulder width, terrain (gradient), horizontal alignment, run-off road risk score, head-on risk score, intersection risk score, and the roadside risk score, roadside hazard offset and roadside hazard severity for each side of the road (Charlton et al. 2014). These features are rated every 100m, in the same way that the speed rating calculation works. These features could be added to the rating calculations process so that road geometry is more fully considered in the process.

The inclusion of these additional road geometry elements in the SLNZ rating calculation would provide a more balanced assessment of the roadway rating aspects alongside the roadside development. Treating these two aspects of the rating process equally would address some of the existing contradictions as identified by the majority of survey respondents. This change would also have implications on the wider interpretations of the Rule. For instance as noted Section 1.1 and Section 2.1 of the Rule advise that where road geometry encourages higher speeds than the speed limit determined by the roadside development rating engineering techniques should be implemented. It would be interesting to note what effect a more detailed consideration of the road geometry aspects would have on this scenario and whether there would continue to be so many examples where the roadway rating encouraged higher speeds.

CONCLUSIONS AND RECOMMENDATIONS

This paper presents a critical analysis of two aspects of the speed limits setting process in New Zealand through a safe systems lens. The two aspects are part of a wider research project undertaken for the IPENZ Transportation Group Study Award. Overall the Rule and SLNZ process provide an adequate and consistent way to set speed limits in New Zealand and are comparable, if not more wide-ranging, than other speed limit setting processes used overseas. However, modifciations are required to various aspects of the Rule and the SLNZ process to algin them with the safe systems approach that has now been adopted in New Zealand.

There is limited ability in the current Rule and SLNZ process to deal with contradictions between what the speed rating, operational data and crash data results recommend in terms of the most appropriate speed. Clearly, there are strong psychological aspects to how drivers perceive speed and the speed tolerance threshold can be a determining factor on roads where there are known speeding issues. Further, there is a move away from the reliance on the 85th percentile in the international literature due to increased questioning as to how well drivers actually perceive risk and whether their collective judgement is such a reliable measure. Research into the relationship between speed and the severity of crashes indicates that even the smallest reduction in speed can have a significant effect on severity and this is at the core of the safe systems approach. Consequently, the following recommendations are proposed to clarify Section 3.4 of the SLNZ process:

- That reducing the speed limit tolerance threshold clearly has an effect on the 85th percentile speeds on road where speeding is an issue. That while the data shows this effect isn't apparent on local roads the national data shows that serious consideration should be given to reducing the threshold permanently.
- That the use of the mean and 85th percentile speed as the only measures or current operational speeds should be reconsidered and other factors such as crash severity factored in.

The current crash data analysis recommended in Section 3.5 of the SLNZ process is limited and quite reactive in nature. The Safer Journeys Strategy drawing on KiwiRAP is increasingly focusing on the collective and personal risk to road users as part of the crash data analysis. This is a safe system approach which provides a more proactive means to assess the likelihood of crashes on the road and what can be done in terms of the speed limit to address such risks rather than a reactive assessment of whether the crash history is typical or not for that type of road. It is recommended that Section 3.5 is adapted to take into account the following:

- Move away from the focus on the 85th percentile crash rate comparison with similar road to use the more formalised procedures in the Economic Evaluation Manual, including a consideration of the cost aspects and the implications of these to the most appropriate speed.
- Assess the collective and personal risk of the road and the implications of these to determine what speed limit is appropriate and any engineering measures that may be required.

This paper also looked as one of the core assumptions of the current speed rating process, the emphasis on roadside development over the roadway rating and how this tied into the limited attention given to road geometry. Changes are needed to this assumption to provide a more balanced assessment of the roadway rating alongside the roadside development to align the speed rating process more closely with the safe systems approach. Further, these changes may mean that there are fewer instances where road geometry encourages higher speeds that the speed limit determined by the roadside development rating. The following changes are recommended:

- Clarifications around the definitions of open, average and limited visibility in Table SLNZ9. These could be drawn from the Austroads Part 4a ASD analysis and research into the visibility requirements for road marking delineations.
- The inclusion of additional road geometry elements in the rating calculation such as those used as part of the KiwiRAP RPS road design features which are relevant and provide a virtually transferable set of criteria to consider.

It is proposed that the recommendations in this paper could contribute to the wider discussions occurring on safe speeds in New Zealand and specifically in the review of the speed limit setting process that is currently being undertaken as part of the Safer Journey's 2013-15 Action plan. This paper only presents a summary of some of the issues and recommendations that have been developed as part of a wider research report. With changes such as those proposed in this paper it is anticipated that both the Rule and SLNZ process can be updated to come in line with the safe systems approach to road safety and provide a more constructive and supportive system to set speed limits in New Zealand.

REFERENCES

AUSTROADS (2008). *Guide to Road Safety Part 3: Speed Limits and Speed Management.* Austroads Incorporated. Sydney.

AUSTROADS (2010). *Guide to Road Safety Part 4a: Unsignalised and Signalised Intersections.* Austroads Incorporated. Sydney.

CAMERON, M.H. AND ELVIK, R. (2010). Nilsson's Power Model connecting speed and road trauma: Applicability by road type and alternative models for urban roads. Accident Analysis and Prevention, 42, p.1908.

CHARLTON, S.G., STARKEY, N.J., PERRONE, J.A. and ISLER, R.B. (2014). *What's the risk? A comparison of actual and perceived driving risk*. Transportation Research Part F, 25,p. 50

CHARLTON, S.G. (2012) Speed and Driver Perceptions. TRAFINZ Conference Paper.

DEPARTMENT FOR TRANSPORT (2013). *Setting Local Speed Limits*. Department for Transport Circular 01/2013, London.

DRAVITZKI V.K., MUNSTER, D.E. AND LAING, J.N. (2002) *Minimum Performance Requirements for Delineation.* Opus International Consultants Limited Central Laboratories Report 02-527450.

FEDERAL HIGHWAY ADMINISTRATION (FHWA) (2012). *Methods and Practices for Setting Speed Limits: An Information Report'.* The Institute of Transportation Engineers (ITE) Report # FHWA-SA 12-004.

INTERNATIONAL TRANSPORT FORUM (2008). Towards Zero: Ambitious Road Safety Targets and the Safe Systems Approach. OECD Publishing http://www.internationaltransportforum.org/jtrc/safety/targets/08TargetsSummary.pdf

KIWIRAP (2014) About KiwiRAP. http://www.kiwirap.org.nz/index.html

KLOEDEN, C.N., MCLEAN, A.J., AND GLONEK, G. (2002). *Re-analysis of travelling speed and the rate of crash involvement in Adelaide, South Australia*. Report CR 207, Australian Transport Safety Bureau, Canberra, Australia

KOOREY, G. (2011). *Implementing Lower Speeds in New Zealand*. IPENZ Transportation Group Conference, Auckland, March 2011

MANNERING, F. (2009). *An empirical analysis of driver perceptions of the relationship between speed limits and safety*. *Transportation Research Part F* 12 (2009) 99–106

MINISTRY OF TRANSPORT (2014). *The Safe System Approach*. http://www.saferjourneys.govt.nz/about-safer-journeys/the-safe-system-approach/

MINISTRY OF TRANSPORT (2011). Safer Journeys Action Plan 2011-2012. http://www.saferjourneys.govt.nz/assets/Uploads/Safer-Journeys-Action-plan-2011.pdf

MINISTRY OF TRANSPORT (2013) *Safer Journeys Action Plan 2013-2015.* http://www.saferjourneys.govt.nz/assets/Uploads/Safer-Journeys-Action-plan-2013-2015.pdf

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM (NCHRP) (2006). *Expert System for Recommending Speed Limits in Speed Zones.* Transportation Research Board NCHRP 03-67 Select Committee on Transport, Local Government and the Regions (2002). *Memorandum by the Slower Speeds Initiative (RTS 34A)* http://www.publications.parliament.uk/pa/cm200102/cmselect/cmtlgr/557/557ap43.htm

NZ POLICE (2014a) *Preliminary campaign results show significant road safety gains*. http://www.police.govt.nz/news/release/preliminary-campaign-results-show-significant-road-safety-gains

NZ POLICE (2014b) *Facts and myths about speed*. http://www.police.govt.nz/advice/driving-and-road-safety/speed-limits-cameras-and-enforcement/facts-and-myths-about-speed

NEW ZEALAND TRANSPORT AGENCY (2011). High-Risk Rural Roads Guide. NZTA, Wellington.

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