Road Infrastructure Safety Assessment

Ian Appleton
Principal Safety Auditor
New Zealand Transport Agency
Wellington

Introduction

The New Zealand Transport Agency (NZTA) has developed a procedure called Road Infrastructure Safety Assessment (RISA). RISA enables NZTA to monitor a road controlling authority's (RCA's) performance over time with respect to road safety. RISA provides the RCA with a tool to understand where the greatest road user benefits from improved road safety infrastructure can be gained

RISA has been developed as an evidence-based tool following previous experience with safety auditing of existing roads.

Summary

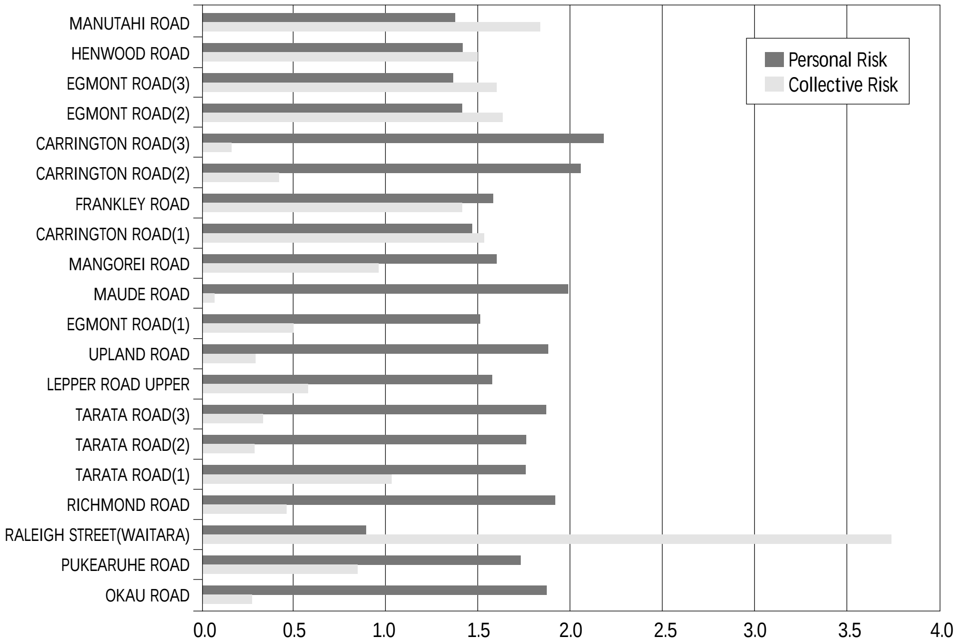
The main features of RISA

- RISA is a practical tool. A team of three people can complete the assessment of the roads and prepare a preliminary report in 3 days.
- RISA Is evidence based. The basis of RISA is the world-wide research that relates infrastructure features to crash rates. In the fieldwork the team assesses the extent or the absence of these infrastructure features.
- RISA assesses road networks. The RISA team selects a stratified random sample of roads to assess. The team can have confidence that it can scale up the results to the whole road network.
- RISA assesses intersections using a compliance with good practice test.
- RISA assesses rural sealed roads.
- A fuller description is provided later in this paper

Typical results from a RISA

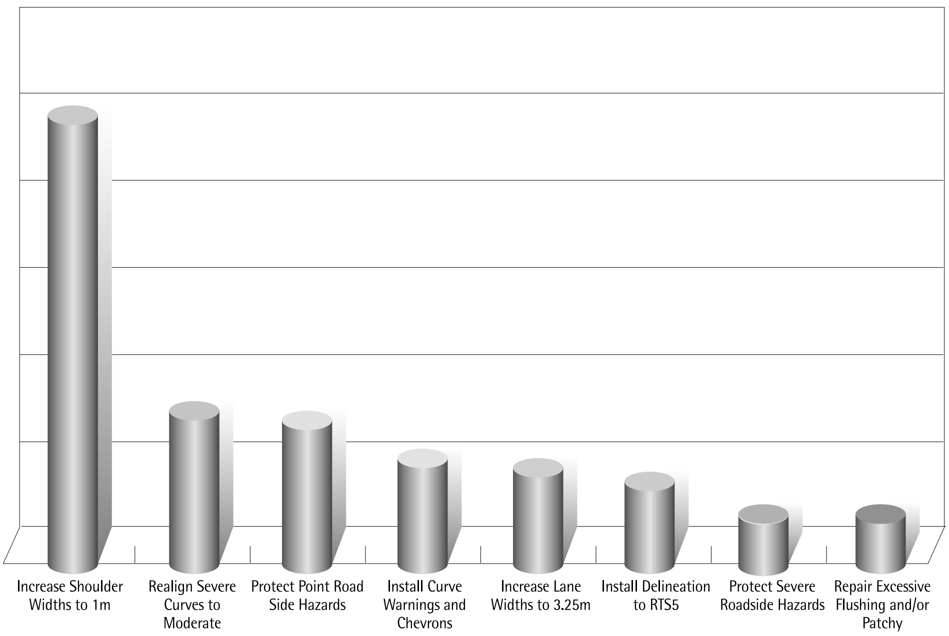
- Personal and Collective risks. RISA calculates the relative risk of each road assessed as Personal Risk (risk to the individual driver) and Collective Risk (risk to all road users). Figure 1 shows the results from a recent assessment. Personal risk (in red) relates to crash rates. Collective risk (in blue) relates to the number of crashes.

Figure 1: Personal and Collective Risk Scores



- Network Risk Number. RISA takes the Collective Risk Scores and data on traffic volumes to scale up these results to the whole network and creates a Network Risk Number. This is an abstract number. It relates to the number of crashes on the network.
- "What if" scenarios. RISA uses the input field sheets to explore the effect of various scenarios by changing the input data. For example, what would be the effect if all roads had sealed shoulders of 1 m?
- Figure 2 shows the results of the "What if" scenarios using the same recent RISA. It shows that the greatest reduction in risk on the network can be achieved by increasing the width of sealed shoulders. However, this is an expensive item, so that it may not necessarily be the most cost-effective treatment.

Figure 2: Reduction in Network Risk for implementing network wide treatments



- Intersections: These are assessed for compliance with good practice. The Austroads Guide (Austroads 2007) specifies sight distance requirements. Figure 3 shows that about one-third of intersection failed this test. Figure 4 shows compliance with other safety related design issues. Compliance ranged from 100% (conspicuity) to 0% (Conflict points separated).

Figure 3: Safe Intersection Sight Distance Assessment

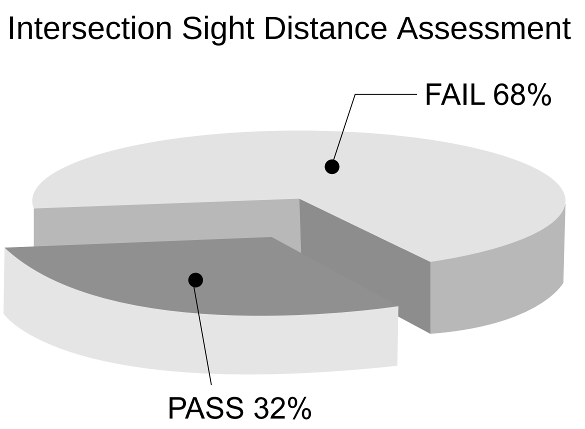
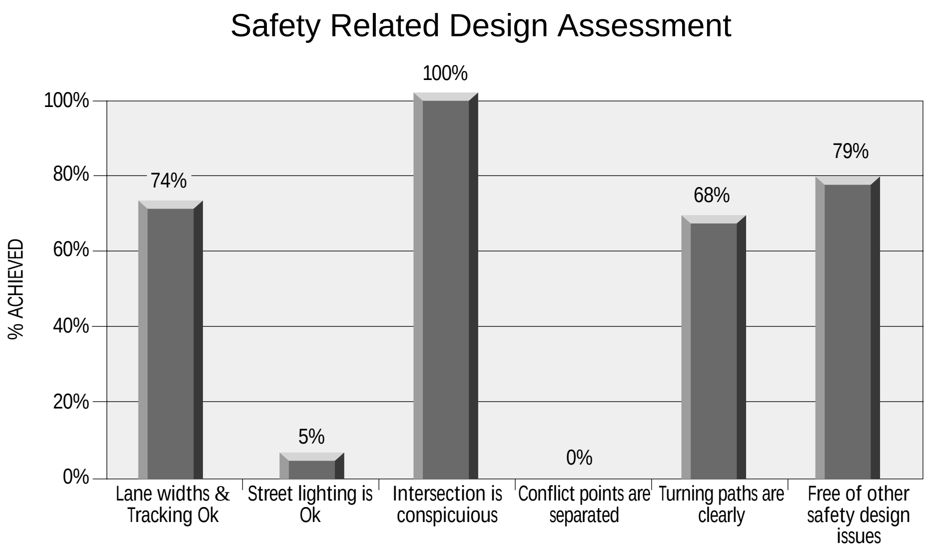


Figure 4: Intersection Safety Related Design Issues



- Recommendations are made at the policy and programme level, and apply to the whole network. An example is: Review the application of curve warning and speed advisory signs for out of context curves in accordance with [the manual].

What is the basis of RISA?

This section describes in more detail the components of RISA concentrating on those aspects which are of interest to IRTAD conference delegates. The components are:

- Research data
- The risk model
- Sampling
- The assessment methodology
- Performance measure

Earlier paper (Appleton et al 2004, 2005, and 2006) set out in detail the background to the development of RISA and the research and investigations used for arriving at the current survey and risk rating methodology.

Research data

RISA is evidence-based. A search of research literature world-wide found many reports of research relating infrastructure features to crash rates. The research was very varied: in age; in quality; and in relevance to New Zealand. Wilkie and Tate (2003) describe the research and its synthesis into a form useful for a risk model.

ARRB Research is undertaking a major Austroads research programme to assess risk involving road, traffic and roadside infrastructure. Road Safety Risk Reporter (ARRB 2009) is a periodic newsletter which disseminates findings from the Austroads programme. These are monitored to ensure that the basis of RISA remains current.

The following is an example of the use of research data. Much of the literature examined expresses percentage crash reductions for certain crash types. The presence of edgelines on rural roads decreased the crash rate by 34% for single vehicle loss of control crashes. The New Zealand Ministry of Transport traffic crash database has been used to determine frequency of crash type and adjust the reduction to suit. Single vehicle loss of control crashes account for 31.3% of all NZ crashes, so the reduction overall for edgelines is 10%.

The risk model

Before a risk model could be developed, a method of assigning risks to a particular road had to be developed. The chosen method comprised of:

- Creating a benchmark road
- Comparing the road to be assessed against the benchmark road
- Assigning risk factors to the differences between the assessed road and the benchmark road and
- Combining the risk factors to create a risk score for the assessed road.

The benchmark road is not a special road. Some of its features are common to rural roads in New Zealand, for example, it has 3.5m. lane widths. Other features are most unusual, for example, the benchmark road has no roadside hazards.

For ease of the arithmetic, the benchmark road has a risk of 1.0. Each feature is assigned a risk relative to the benchmark road's features, and is multiplied by the extent (or exposure) of that feature. The model is a simple additive model and results in a risk score relative to the benchmark road. This model is known to be a simplification, it ignores any interactions that might occur, for example, road side hazards are more important on the outsides of curves than they are on straights.

The risk score is calculated per km of road so that roads of unequal lengths may be compared. The risk scores are relative risks and are called “Personal Risk”. They are the red scores in Figure 1 above. Personal risk relates to crash rates. A risk of 1.2 means that a person traveling on this road has a 20% higher risk of a crash than when traveling on the benchmark road.

As a general rule low volume roads have high risk relative to the benchmark road, and higher volume roads have a relative risk closer to the benchmark road.

Next, the traffic volume is combined with the risk scores to create the “Collective Risk” i.e. the risk to all road users. The Collective risk relates to crash numbers. The blue scores in Figure 1 are Collective Risks. This shows that Raleigh Street, while one of roads with the lowest personal risk scores, has the highest collective risk score. This is simply because Raleigh Street is the highest volume road assessed. It also indicates that it may be better to make a small difference in high volume roads than a big difference in low volume roads.

Sampling

It is not practical to assess all the roads in a network. A sample is based on the distribution of travel (as measured by VKT) on the network. The table below shows the length and VKT on the rural roads in the authority whose results are shown above. The “Km required” is based on a target sample of 100km.

Table 1: Vehicle Kilometres traveled on example network by ADT band.

ADT Band	Length of sealed rural road (km)	Rural travel (MVKT)	% of MVKT	Km required
ADT < 100	341	6.81	11%	11
ADT < 100-500	364	27.85	44%	44
ADT <500-2000	70	26.42	42	42
ADT <2000-4000	2	1.76	3	3
Total	777			100

For operational reasons, road lengths typically of 5km are selected at random within each volume band to meet the target length. This stratified random sample is selected so that the findings for the selected roads can be scaled up to a network level.

Network Risk

The Collective Risk scores of the sampled roads are combined to create a Network Risk, as follows.

In each traffic volume band:

Band Risk = Sum (Collective Risks) X Sum (VKT in Band) / Sum (VKT in Sample)

The Network Risk is the sum of the Band Risks.

It is the Network Risk that represents the contribution that the road infrastructure features make to the number of crashes on the network, and will be used as a performance measure.

Intersections

Intersections are treated differently from mid-blocks. There is sufficient research data available to create a risk model for mid-blocks. However the same is not true of intersections. The majority of the research for safety at intersections relate to the form of the intersections, to traffic volume and turning movements. There is less research data available to build a risk model based on engineering features. For example, if the required sight distance is 200 m. but only 150 m. is available, how does that increase the risk of a crash at the intersection?

Until there is sufficient research data to build a risk model, RISA uses a compliance with good practice test. These assessments result in a pass/fail process. The assessments are in two parts:

- Design issues (e.g. Safe Intersection Sight distance) (Figures 3 & 4)
- Maintenance Issues (e.g. Quality of the road markings) (not shown)

No attempt is made to combine mid-block and intersection assessments because they are made on different bases.

RISA fieldwork

Survey methodology

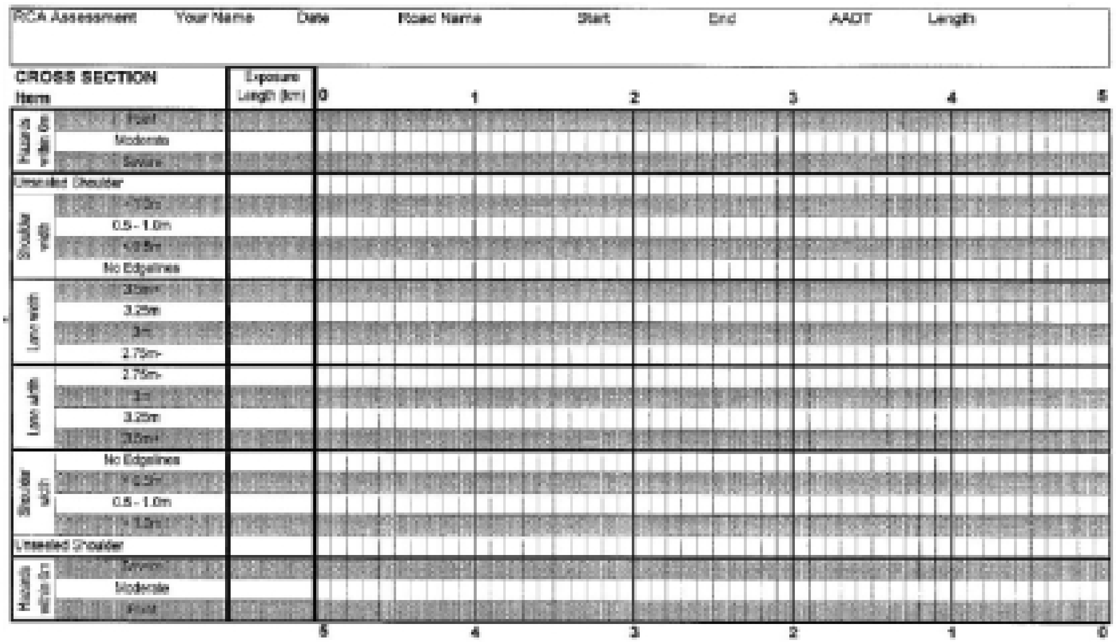
The method requires a team of 3 people and a driver. At present the team collects all the information by a visual inspection of the road. The selected route, typically 5km in length, is driven 4 times: once in each direction as normal operating speed and agat a slower speed, typically at 60kph. Normal operating speed is required to assess horizontal alignment. The slower speed is required to assess roadside hazards.

Each person has one survey form to complete. The forms are:

- Cross Section : Lane & Shoulder widths and Roadside hazards
- Alignment : Horizontal Curves and delineation
- Surface & miscellaneous : Surface condition, accessways and one lane bridges.

The Cross Section form is shown in Figure 5.

Figure 5 : The cross section survey form



A guideline (NZTA 2008) describes how the infrastructure features are interpreted and recorded on the survey forms. The assessment determines the exposure lengths of the presence or absence of the features on the forms. These data are then entered into a Macro which:

- Validates the entry data
- Calculates the results and
- Creates the charts used to report the results.

Analysis

Results

The main results of a RISA are given in the summary section above. These comprise:

- The mid-block personal risk scores for each road for each of the three survey forms (not shown)
- These combined to create the personal risk scores for each road (Figure 1)
- Calculation of the Collective Risk scores for each road (Figure 1)
- Calculation of the Network Risk Number
- The reduction in the Network Risk Number for implementing network wide treatments (Figure 2)
- The Safe Intersection Sight Distance Assessment (Figure 3)
- The Intersection Safety Related Design Assessment (Figure 4)
- The Intersection Safety Related Maintenance Assessment (not shown)

Recommendations

The RISA team uses the reduction in the Network Risk Number (Figure 2) as a guide to making recommendations. The team needs to be experienced to ensure that recommendations are practical. Recommendations are aimed at a high level ? at policies and programmes, and are phrased cautiously, for example:

- Review the current practice of...
- Consider developing and implementing a programme of...

No formal costing of the recommendations is made, but the team uses its knowledge of road engineering in formulating its recommendations.

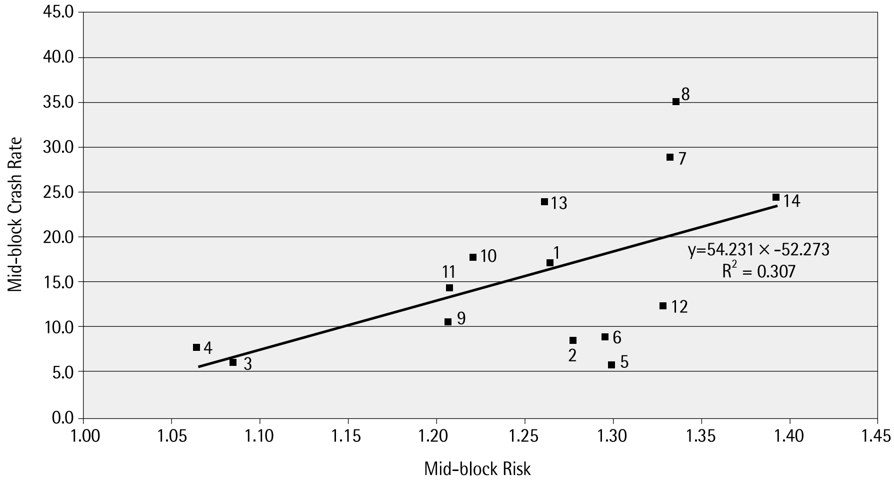
Performance Measurement

For Performance measurement or benchmarking, RISA uses the Network Risk Number. As noted above, the Network Risk Number represents the contribution that the road infrastructure features make to the number of crashes on the network. But the Network Risk Number is network dependent; it is dependent on the length of the network and on traffic volumes. Therefore it is not valid to compare the Network Risk Numbers of different networks. RISA will assess authorities' networks at periodic intervals. Monitoring the Network Risk over time will provide the measure of performance.
RISA has been in operation for only a year. Monitoring data will be available only at the second round of assessments.

Verification

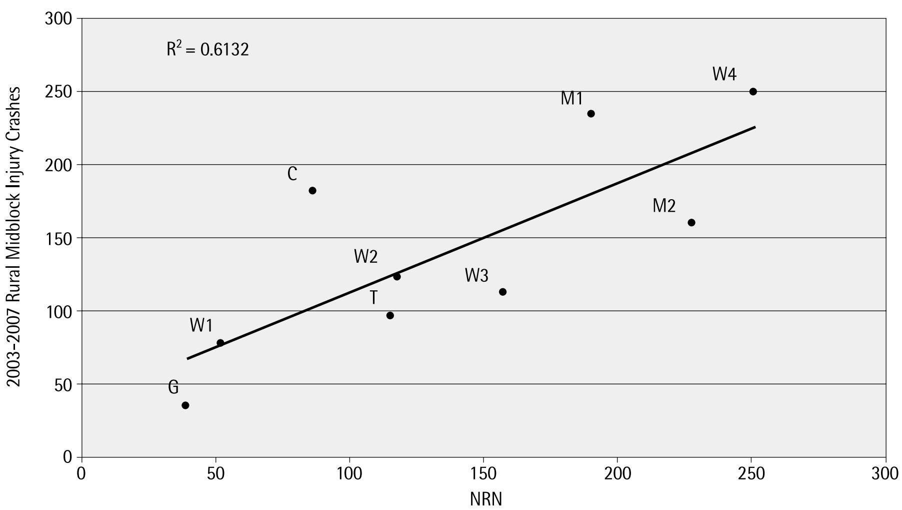
The basis of RISA is the research that relates infrastructure features to crash rates. Therefore the RISA Risk Scores, more specifically, the Personal Risk Scores, should relate to the actual crash rates on the roads assessed. Crash rates reflect the performance of the "system" - the road, the vehicles and the road users - whereas RISA assesses the performance of only one component - the road - so a close match is not expected. A comparison for one RISA has been made. It excluded intersection features and intersection crashes. The comparison is very encouraging as shown in Figure 6.

Figure 6 : Relationship between Mid-block Injury Crash Risk and RISA Personal Risk Scores.



Equally the Network Risk Number should relate to the number of crashes on the network. The same comments about the "system" apply. Figure 7 shows the comparison of the Network Risk Number for 9 Authorities' RISA with the number of injury crashes on rural roads (excluding intersection crashes). Again a close match is not expected, but the result is very encouraging.

Figure 7: Network Risk Number (NRN) compared to rural road injury crash numbers



What next?

NZTA uses RISA as an operational tool and has an ongoing programme of assessing Road Controlling Authorities networks at the rate of about 12 per year. The programme includes a continuous improvement plan. The elements of the plan are as follows:

- Improve the analysis tools, especially the "What if" scenarios to make them interactive;
- Keep abreast of new crash research by monitoring the results of the Austroads project (ARRB 2009) and others; and improve the evidence base for the RISA risk allocations;
- Develop an intersection risk model to replace the current compliance with good practice model, when sufficiently robust research results are available;
- Consider including maintenance issues - for example, how should poor maintenance of edge marker posts be incorporated into the model? - by monitoring New Zealand and overseas research;
- Investigate ways to improve the efficiency of RISA, most obviously, through the use of automated data collection, including visual images
- Consider applying the same principles to urban roads and possibly rural unsealed roads
- Monitor the development of related techniques overseas and in New Zealand, especially the various RAP programmes (for example: iRAP, KiwiRAP) and techniques like NetRisk (ARRB)

Conclusions

NZTA has developed a procedure called Road Infrastructure Safety Assessment (RISA). RISA enables NZTA to monitor a road controlling authority's (RCA's) performance over time with respect to road safety. RISA provides the RCA with a tool to understand where the greatest road user benefits from improved road safety infrastructure can be gained.

RISA is a practical operational tool. It is based on international research that relates infrastructure features to crash rates, and assigns risk ratings to each of these features.

Verification of the results of RISA against actual crash rates and crash numbers is very encouraging. This indicates that RISA assessed the appropriate features in an appropriate way, and produces credible results.

NZTA conducts about 12 RISA per year.

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References

Appleton, Ian; Murray Noone, John Hannah, Sam Wilkie 2004, "Road Infrastructure Safety Assessment" Towards Sustainable Land Transport Conference, November 2004, Wellington, New Zealand.

Appleton, Ian; Murray Noone, John Hannah, Sam Wilkie 2005, "Road Infrastructure Safety Assessment" AITPM National Conference, July 2005, Brisbane, Australia

Appleton, Ian; Murray Noone, John Hannah, Sam Wilkie 2006, "Road Infrastructure Safety Assessment" 22nd ARRB Conference, October 2006, Canberra, Australia

ARRB 2009: Road Safety Risk Reporter Newsletter
http://www.arrb.com.au/index.php?option=com_content&task=view&id=106

ARRB: NetRisk - Road Network Safety Assessment
http://www.arrb.com.au/index.php?option=com_content&task=view&id=25&Itemid=30

Austroads (2007) Guide to Traffic Management - Part 6: Intersections, Interchanges and Crossings
http://www.onlinepublications.austroads.com.au/script/Details.asp?DocN=AUSTROADS64393

KiwiRAP http://www.kiwirap.org.nz/

iRAP: International Road Assessment Programme http://www.irap.net/

NZTA (2008) Road Infrastructure Safety Assessment Draft Guideline. NZTA 12 September 2008. (Internal document)

Wilkie, Sam and Fergus Tate (2003) Safety Audit of Existing Roads ? Developing a less subjective assessment. Transfund report OG/0306/24S, September 2003.