Safety Performance of Low Volume Roads

Introducing

Road Infrastructure Safety Assessment

Prepared for

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Abstract

Traffic crash data for Low Volume Roads (LVRs) is generally unreliable and provides a poor measure of safety performance for such roads.

The safety performance of LVRs is influenced to some extent by traffic volume but more particularly by factors such as terrain type, road surfacing (sealed or unsealed), provision of delineation, road width, alignment, exposure to roadside hazards and other quantifiable features within the road environment. Previous research has identified the risk to motorists as a result of these individual features.

By quantifying the presence of various features within the road environment, knowing their relative risk and accounting for their exposure to passing traffic, it should be possible to determine the expected safety performance of any road or section of road, including LVRs.

Transfund New Zealand is currently applying this rationale in the development of a new Road Infrastructure Safety Assessment system (RISA). One of the aims of this work is to develop a more objective and evidence-based safety assessment system that can be applied to all sealed roads, irrespective of traffic volume. The RISA methodology is still under development and this paper provides a general description of the new methodology only.

This work builds on Transfund's "Safety Audit of Existing Roads" (SAER) that was started in 1995. The success of the SAER process has been limited to some extent by the subjective nature of these audits.

A key outcome for the RISA project team is to develop a system that will assist Road Controlling Authorities (RCAs) in identifying where safety gains can be most easily achieved. It is also intended that the system will provide a suitable tool to measure the safety performance of RCAs.

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1. Background

Safety Auditing of Existing Roads (SAER) was initially developed by Transit New Zealand (Transit) in 1995. Following the formation of Transfund New Zealand (Transfund) the SAER procedure has been refined and used consistently by Transfund as part of its responsibility to review the safety performance of Road Controlling Authorities (RCAs).

The development of the SAER process followed on from early work done in Australia by the Road and Traffic Authority of New South Wales (RTA) and the Queensland State Roads Authority. Transit (and later Transfund) used these procedures and processes as a basis to develop a New Zealand system.

The procedures were primarily designed to allow Transfund to review the provisions of traffic services, road maintenance and levels of safety being provided by RCAs, primarily from a road user point of view.

The key objectives were:

- To identify potential safety problems for road users.
- To seek consistency across the roading network.

The key outcomes were:

- To help minimise the risk and severity of crashes that may be attributed to road infrastructure.
- To improve awareness of safe maintenance practices.
- To help Transfund determine the effectiveness of its resource allocation for safety.
- To identify from a road user perspective issues and features that give misleading or confusing messages.

The audit methodology involved physical inspection during the day and at night. This included the use of survey (or check) sheets and the driving of road sections at normal driving speed with each team member noting issues as prompted by the survey sheets.

Road sections were surveyed in this manner in both directions of travel and then a slow 3rd drive-over was undertaken and the opportunity taken to stop and inspect particular features. Sample sections of approximately 10 to 15km were surveyed in this way for various road types.

The team then reviewed the results of each observer's notes and a subjective judgment made as to the safety impacts (risk ranking) of the features on the network. As the risk ranking is a combination of the probability of a crash and the likely severity of the outcome and as crashes are random events (with poor reporting rates on LVRs), it was often difficult to deal with the issue of 'exposure'. Also, because traffic volume was not a direct input, different auditors from different traffic backgrounds and environments, had different perspectives of 'busy' roads. Over time it became clear that this process, whilst valuable, was inherently driven by the emphasis of the individual team members.

The SAER reports gave RCAs guidance about both the 'good' and 'not so good' safety features of their networks. This usually encouraged RCA's to develop medium to long-term programmes for safety improvement works.

During the period 1995 to 2002 approximately 40 audits were completed and a database used to store the results. In part it was this database that started to show the inadequacies of the comparability of the data being collected.

Between 2000 and 2002, research and investigation showed that due to the subjective nature of the SAER process, it may not be the best tool to give an accurate relationship between on-road features and actual risk to road users. The actual crash effects of some of the issues being raised during the audits were often unknown and/or highly unreliable.

2. Identifying the need for change

In June 2000 Transfund commissioned two independent Safety Audits of the same road network. Both audits followed the audit methodology set out in the Transfund publication "Safety Audit Procedures for Existing Roads" (SAER) (December 1998).

Detailed comparisons were made between the findings Team A and Team B in the following areas:

- Sample selection, size and road type;
- Commonality of issues by rural/urban speed environment and by type of issue (positive/negative);
- Commonality of risk level assessment for common issues;
- Commonality of risk level assessment for common issues on commonly sampled routes; and
- Any obvious departures from the standard audit methodology, or other anomalies.

The key findings were:

- Teams A and B audited 6% and 9% of the total road network respectively.
- A total of 5 roads/routes were common to both audit samples.
- Team A audited a wider range of road types.
- Team B audited a greater length of roads, particularly those higher in the roading hierarchy.
- Approximately one third of issues identified during the audits were common to both teams' findings.
- For the general SAER findings, Team A and Team B identified and made recommendations and assessed risk levels for 14 and 10 issues respectively.
- Team A assessed a greater number of risks at marginally higher levels than Team B.
- From the general findings of the audit reports, there was a total of 11 common safety items identified by both teams that can be directly compared (These issues were not necessarily identified on the same routes). These results indicated that Team A generally assessed risk levels at a marginally higher level than Team B.
- For issues raised by both teams on the same audited roads/routes, where the teams' recommendations were the same (this comparison provides the most direct comparison), Team A generally assessed risk levels at a marginally higher level than Team B.

The detailed findings are shown in Tables 2,3,4 & 5 attached as Appendix A.

The relevant conclusions of this work are:

1. *That generally using a different sample of roads, both audit teams came to the same general conclusion regarding the safety performance of the road network being audited, that is: "…that the roads in the District were generally in good condition…"*
2. *That approximately 35% of all issues identified were commonly identified by both teams.*
3. *Each audit team assessed Risk Level Ratings slightly differently for issues commonly identified in both reports.*

The lack of common findings and the variation in assessing Risk Level Ratings raised concerns about a lack of repeatability and therefore robustness of the SAER system.

Transfund also commissioned a study into the relationship between the 'issues' raised by SAER auditors and actual traffic crashes. This work produced widely varying results and showed that while some of the assigned risk ratings were accurate, others were less accurate. Of particular concern was the finding that some issues that can be shown to contribute to crashes were not being identified during audits.

This work highlighted that the safety issues being identified were being compared against what was perceived as 'practical', rather than actual safety performance. Hence a winding road was being accepted as 'safe' if it was impractical to improve it. Therefore it was only the traffic signs and other delineation that was being rated.

Consequently it was concluded that the SAER process did provide a very useful independent, 'expert' opinion on the RCAs safety management of the road network. But it did not provide a good measure of the actual safety performance of the road network.

3. Developing a Road Infrastructure Safety Assessment (RISA) system

3.1 Outline

Once the need for a more robust, evidence-based system was identified, Transfund set up a project team. The objective of the team is to carry out the necessary research, system development, testing, implementation, promotion and professional training to have a trial system operational in 2003/2004.

The project team considers that the key outcomes of the RISA system are:

1. It must assist RCAs in identifying where safety gains can most easily be achieved.
2. It must be evidence-based and relate to quantifiable crash risks.
3. It must be practical and cost-effective to implement and use.
4. It must be applicable to LVRs.

In its simplest form, the aim of the project team is '*to develop a system that will be able to compare any road section with a 'standard' road section, in order to quantify the safety gains that could be made by the RCA.'*

Individual safety related features, such as roadside hazards, limited sight distance and the provision of traffic services, do not exist in isolation within the road environment. For this reason the project team considered that a fundamental component of any new process would be the amalgamation of existing research into a practical tool for quantifying the relative risk of multiple features.

3.2 Use of Existing Research

While it is not possible to reproduce in this paper all the research used in the ongoing development of the RISA system, development has included:

- review of existing road safety research carried out by various bodies and;
- adaptation to meet the needs of this assessment process.

This work was completed for Transfund by Opus Central Laboratories in conjunction with the project team and will be published in the future. An extensive literature search was undertaken on the classification of crash and road 'type' relationships, in order to help establish the necessary 'baseline' road standards. The search uncovered a wide range of literature that discusses the relationship between individual features within the road environment and the relative risk to road users as a result of those features. Much of this work has been New Zealand based or can be validated for New Zealand conditions.

The existing SAER database was used to identify the range of features (or deficiencies) that may be encountered during the physical assessment.

One of the key elements of the RISA system is the exclusive use of relative risk factors for features within the road environment that have a known impact on road safety. Applicability to New Zealand roading conditions was a prerequisite for all data used. Relative risk factors for each feature have been determined on the basis of existing literature. In some cases, where it was not possible to quantify impacts, estimates of relative risk have been made.

3.3 The RISA Methodology

The basis of the RISA system is a two-stage methodology involving physical inspection and desktop analysis. The first stage involves comparing the safety performance of a road section against a baseline or 'standard' road section, with the presence and/or absence of various road features identified relative to the selected standard.

At this point, the resultant "road risk score" is exclusive of volume, terrain and road type effects. In the second stage of the process, the effects of road 'type', terrain and traffic volume are applied to allow a comparative assessment to be made.

3.3.1 Stage One – Physical Road Assessment

In a similar manner to that of the previous SAER methodology, a physical inspection of the road to be assessed is required. The road is divided into homogenous sections based on traffic volume and terrain type. Unlike the SAER process, intersections are identified and assessed separately for RISA.

An assessment score sheet (field sheet), similar to that presented below, is completed for each section. There are a total of 4 field sheets for each road section assessed, each covering a specific group of features under the broad headings - Cross Section; Surface; Alignment; Intersections.

Based on current trialing of RISA, a team of four people including the driver is ideal to carry out the assessment. Each team member, other than the driver, will complete one the first three field sheets. One or more of the team members will complete the 'Intersection' field sheet separately during a drive-over specifically for that purpose. It is important to note that the field sheets do not cover all features that comprise the road infrastructure, rather those that have a known impact on road safety.

Audit	Name	Date	Rd Name	Terrain	AADT	Length	Rd	F.TOTA

X SECTION Item		0 km – 1 – 2 – 3 – 4 – 5	Exposure Length	Relative Risk	Risk Score
Hazards within 6m	Point			20	
	Recoverable length			10	
	Non-recoverable length			15	
Unsealed Shoulder				5	
Shoulder width	Very Wide			-20	
	Wide			-10	
	Narrow (only RTs 2-6)			10	
	Very narrow (only RTs 3-6)			20	
Lane width	Narrow			10	
	Very narrow			20	
One Lane Bridge/One lane Culvert				60	
Lane width	Very narrow			20	
	Narrow			10	
Shoulder width	Very Narrow			20	
	Narrow			10	
	Wide			-10	
	Very Wide			-20	
Unsealed Shoulder				5	
Hazards within 6m	Point			20	
	Recoverable length			10	
	Non-recoverable length			15	
		5 – 4 – 3 – 2 – 1 – 0 km		Sheet Total	

ROAD TYPE STANDARDS

No.	Road Type	AADT	Lane Width	Shoulder Width	Street Lighting
1	Low Volume Rural	0-1000	3.5m	0.0m	no
2	Medium Volume Rural	1000-4000	3.5m	0.75m	no
3	High Volume Rural	4000+	3.5m	1.5m	no
4	Minor Urban	n/a	3.5m	1.5m	no
5	Major Urban	n/a	3.5m	1.5m	yes
6	Motorway	n/a	3.5m	1.5m	yes

The purpose of the physical assessment is to identify the presence or absence of individual features and to measure the approximate exposure length of each feature. For example, for a given road 'type' a certain shoulder width may generally be expected to meet the desirable levels of safety for the traffic volume as established from the research.

The RISA field sheets are used to record the length of road where the shoulder width fell above or below those expected values. Where the shoulder width fell below the expected width a safety *dis-benefit* will be assigned, where the shoulder width was wider than the expected width, a safety *benefit* will be assigned.

This information is then used to determine a Features Score (A) for each group of features (i.e. each field sheet), based on the sum of the risk scores for each feature.

The Features Score has a baseline of ‘1’. For example, a Features Score of 1.2 indicates that there are features on the road section that could be eliminated or modified to reduce the risk to road users by 20%.

The sum of the Features Scores (minus 3 plus 1) for each road becomes the Road Risk Score (B) for the entire section of road assessed.

3.3.2 Stage Two – Factoring for Road Type, Terrain and Use

This stage of the methodology ensures that comparative measures can be made. To develop an overall measure of safety performance it is necessary to adjust the Road Risk Score to account for Road Type, Terrain Type and Traffic Volume. Once again the derivation of Road Type and Terrain Factors come from existing literature including the Transfund Project Evaluation Manual and the Transit Geometric Design Guide draft version. The resultant score is the Factored Score (C) and because of its ‘exposure’ component, provides for the best overall measure of safety performance.

3.4 Initial Trials

The Project Team is now carrying out field trials of the RISA system. The first trial, in late 2002, focused solely on Stage 1 of the methodology, in particular the ability of the team to gather the necessary data during the physical assessment.

As a result of the first trial, changes to the methodology were recommended and were incorporated into the system prior to the second trial in February 2003. The second trail focused on Stages 1&2 and in particular, the method by which the data can be interpreted and outputs presented in a meaningful way for RCAs.

At the end of the second trial there was a level of confidence within the team that the system was beginning to produce useful results. In particular the relativity the outputs for the various test sections were beginning to match the expectations of the individual assessors. Results achieved during the second trial are shown in Table 1:

Table 1: Results of Second RISA Field Trial

Features Scores (A)				Total Road Score (B)	Road Score Ranking from RISA system*	Road Score Ranking from Team expectation	Factored Score (C)
Road	Cross-Section	Surface	Alignment				
Rd 1	1.23	1.26	1.05	1.54	1	1	5.78
Rd 2	1.62	1.02	1.00	1.64	2	2=	1.32
Rd 3	1.50	1.03	1.26	1.79	3	4	1.52
Rd 4	1.88	1.01	1.18	2.07	4	2=	7.95

(* Total Road Score ranked from best to worst)

As an example, the Road 1 Features Scores for 'Surfacing' indicates that the RCA could improve road safety (i.e. reduce risk to the road user) by approximately 26% by addressing the identified surfacing issues.

These results also highlight the difficulties in subjectively assessing exposure. The road that appeared to be the safest in terms of subjective opinion, was in fact the second least safe, due to terrain and high traffic volumes and therefore a high degree of exposure for the road user to the identified cross section and surfacing issues.

The RISA process acknowledges that exposure is a significant component of risk and one that is difficult to assess on a subjective basis. The RISA methodology has been developed on the basis that exposure is a combination of traffic volumes exposed to identified hazards and the frequency and/or length of those hazards.

4. The Future of Road Infrastructure Safety Assessment

The project team considers that it is well on the way to delivering a crash/safety performance related 'Road Infrastructure Safety Assessment' that will be able to be used to:

- clearly indicate the areas where RCAs can focus their efforts to gain the greatest safety performance benefit for road users;
- rationally compare RCAs in relation to the safety performance of their road infrastructure.

- provide a better measure of road safety on LVRs than random event road crash data.

The RISA process will be a very useful tool because it removes a large degree of the subjectivity that existed with the previous SAER process. This is due to its origins based in existing research of features within the road environment that have a known impact on road safety and their comparison with a 'desirable base line standard'.

A further four trials are currently programmed during 2003. The aim of these will be to further refine the processes and to develop the appropriate software to automate the data processing phase.

It is important to note that the skill and experience requirements of 'Assessors' are quite different from that which was required for the SAER process. Future training will be selective and targeted towards people who will be able to represent Transfund in undertaking RISA on a regular basis.

While the project team is currently focusing on rural roads, it is intended to progress to urban roads in the near future. A draft procedures manual for rural roads is currently being developed in parallel with the field trials.

The current draft programme for refinement and rollout of the RISA system is as follows:

- 2003 – development of a procedures manual and the completion of approximately 4 trial assessments.
- Late 2003 – RISA presented to the Transfund Board with recommendations on the process and an implementation strategy.
- 2004 – subject to necessary approvals, implementation preceded by consultation with RCAs.

At this stage it is envisaged that the process will be available for RCAs to use on their own networks, possibly as part of their current or future Safety Management Systems.

Appendix A

Results of a comparison of Two Independent SAERs for the same RCA

Table 2: Audit Road Selection by Road Hierarchy		
Road Type	Number of Roads Audited	
	Team A	Team B
Regional Arterial	2	3
District Arterial	3	6
Collector	6	6
Local (Industrial)	1	-
Local (CBD)	1	-
Local (Residential) [inspection only - on Day 3]	[9]	-

Table 3: Risk Level Assessment – from General SAER Findings		
Risk Rating	Number of Each Rating	
	Team A	Team B
Urgent	0	0
High	2	0
Medium	9	4
Low	3	6
Total	14	10

<table>
<tr><th colspan="5">Table 4: Risk Level Comparison for Common Issues with Common Recommendations</th></tr>
<tr><th rowspan="2">No.</th><th rowspan="2">Item</th><th rowspan="2">Recommendation</th><th colspan="2">Assessed Risk Level Rating</th></tr>
<tr><th>Team A</th><th>Team B</th></tr>
<tr><td>1</td><td>Curve Warning</td><td>Review & Upgrade</td><td rowspan="2">Medium</td><td>Medium</td></tr>
<tr><td>2</td><td>Delineation - Roadmarking</td><td>Review & Upgrade</td><td rowspan="3">Low</td></tr>
<tr><td>3</td><td>Delineation – EMPs</td><td>Review & Upgrade</td><td>Low</td></tr>
<tr><td>4</td><td>Delineation – RRPMs</td><td>Review & Upgrade</td><td>No Risk</td></tr>
<tr><td>5</td><td>Roadside Hazards</td><td>Develop Policy & Programme</td><td>High</td><td>Medium</td></tr>
<tr><td>6</td><td>Intersections Signage – priority control</td><td>Develop Policy & Programme</td><td rowspan="5">Medium</td><td rowspan="3">Low</td></tr>
<tr><td>7</td><td>Intersection Signage – advanced warning</td><td>Review</td></tr>
<tr><td>8</td><td>Intersection Signage – SNS upgrade programme</td><td>Continue/accelerate implementation programme</td></tr>
<tr><td>9</td><td>Intersection Signage – Layouts</td><td>Review & Standardise</td><td>Medium</td></tr>
<tr><td>10</td><td>Consistency of Roadmarking</td><td>Review & implement, appropriate to hierarchy</td><td rowspan="2">Low</td></tr>
<tr><td>11</td><td>Consistency of Directional Signage</td><td>Review & Upgrade</td><td>Low</td></tr>
</table>

<table>
<tr><th colspan="5">Table 5: Risk Level Comparison for Common Issues with Common Recommendations on Common Routes</th></tr>
<tr><th rowspan="2">No.</th><th rowspan="2">Item</th><th rowspan="2">Recommendation</th><th colspan="2">Assessed Risk Level Rating</th></tr>
<tr><th>Team A</th><th>Team B</th></tr>
<tr><td>1</td><td>Pavement Width</td><td>Review & Upgrade</td><td rowspan="2">Low</td><td rowspan="4">Low</td></tr>
<tr><td>2</td><td>Delineation – Roadmarking</td><td>Review Frequency</td></tr>
<tr><td>3</td><td>Roadside Hazards – fence strainer posts</td><td>Review & remove, isolate or mitigate</td><td>Medium</td></tr>
<tr><td>4</td><td>Traffic Management – at one site</td><td>Review & Upgrade</td><td>Low</td></tr>
<tr><td>5</td><td>Delineation – Route Consistency</td><td>Develop Policy & Programme</td><td rowspan="2">Medium</td><td rowspan="2">Low</td></tr>
<tr><td>6</td><td>Delineation – Intersection Layout</td><td>Upgrade lane markings</td></tr>
</table>