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RISK ASSESMENT FOR ROAD NETWORKS AND BRIDGES

George J Giummarra

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RISK ASSESMENT FOR ROAD NETWORKS AND BRIDGES

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Abstract

The purpose of this paper is to present the findings of recent research and development at ARRB Transport Research that can provide Local Government with a total solution to managing risk of road networks and bridges. The two main components of the approach involve a network level risk assessment to determine high priority sections or bridges that then links closely with the local assessment, prioritisation and tracking of individual safety hazards and potential remediation projects.

The Queensland Main Roads and Local Government Alliance has recently commissioned ARRB to establish a similar risk assessment system for road networks and bridges. Together the network level tools and the Road Safety Risk Manager will allow Local Government to better understand and manage the relationships between risk and road safety.

Risk assessment, road safety, road networks, bridge risks, and prioritisation of risk

Introduction

Throughout Australia there is a growing need amongst road agencies responsible for road assets to implement effective risk management practices relating to many aspects of the road network.

Risk Management can be defined as *"the systematic identification, analysis and control of the broad range of risks, which have the potential to lead to injury of road users"*.

The purpose of this paper is to present the findings of recent research that can provide Local Government with a total solution to managing risk of road networks and bridges. The two main components of the approach involve a network level risk assessment to determine high priority sections or bridges that then links closely with the local assessment, prioritisation and tracking of individual safety hazards and potential remediation projects.

The Queensland Main Roads and Local Government Alliance has recently commissioned ARRB to establish a risk assessment system for road networks and bridges.

Network Level Risk Management

The proposed methodology developed for the Department of Natural Resources and Environment, (DNRE) Victoria is based on establishing practical and easily applied systems that field staff can readily understand and apply to achieve meaningful outcomes. Training of staff on the methodology and its application will be required. During the development, the methodology was tested on a representative sample of the road network and bridges based on existing safety audits to validate and verify the effectiveness of the methodology and results obtained.

Risk Factors

The methodology proposed allows calculation of a relative risk score index for each homogeneous road segment and bridge, based on a number of risk factors that have been identified as relevant to the risk profile of DNRE's roads and bridges. Some of these factors are common to both and some are specific to either roads or bridges. Each of the risk factors is listed below. In the interest of practicality the data collection requirements have been limited to measurements that can be readily taken by field staff. Where possible, the measurements required to enable the generation of a risk profile are based on those already collected for maintenance purposes, as detailed in Giummarra (2001).

The crash severity assigned to each of the factors, where possible, has been based on real accident data, as obtained from FEDERAL OFFICE OF ROAD SAFETY (1999). The relative risk score assigned to each level of risk within each risk factor, where possible, has been derived from a compilation of Australian accident research obtained from McInerney, R. & White, M. (1999). Where accident data has not been available, as is the case with many of the bridge risk factors, values have been allocated on a subjective basis using engineering judgement and feedback from DNRE staff.

Common Factors	Road Factors	Bridge Factors
Road Class Factor	Rutting	Age
Weather Factor	Skid Resistance	Stringer Material
Commercial Vehicle Factor	Loose Material	Inspection Frequency
	Table Drain	General Bridge Condition
	Culverts	Road Approach
	Trees >300mm Diameter	Skid Resistance
	Trees 100 – 300mm Diameter	Barriers
	Slope	Pedestrian Guardrails
	Embankment (Cut)	Bridge Drop-off
	Carriageway Width	Bridge Width
	Vertical Grades	Sight Distance
	Horizontal Curve Radius	Guideposts and Delineation
	Superelevation	
	Sight Distance	
	Vehicle Roll over Potential	
	Y-Junctions	
	T- Intersections	
	Cross Intersections	
	Guideposts	

A software package has been prepared that facilitates calculation of a relative risk score. This is a Microsoft Excel based application with a Visual Basic for Applications (VBA) engine. Two separate programs have been developed one for road segments and the other for bridges. Each allows for up to 100 records to be entered, analysed and reported.

Risk Scores – Roads

Each of the component risk factors for roads are split into three elements as shown below. These are multiplied together to give a Component Factor (CFr) for each component.

- **Crash Severity - CS (Relative Consequence)**

Crash Severity refers to the relative severity of the type of crash likely to result from a particular deficiency (eg,

head on crash caused by poor sight distance) based on Australian crash data.

- **Relative Risk Score - RRS (Relative Probability)**

Relative Risk Score represents the relative probability of a crash occurring due to a particular deficiency being present on the road network, based on Australian and international research.

- **Condition Assessment – CA (Exposure)**

Condition Assessment refers to the extent of a deficiency along a section of road as a percentage (ie. deficiency occurs along 50% of road section) or the number of instances of the deficiency occurring (ie. 8 Y-intersections).

Risk Score – Bridges

Each of the component risk factors for bridges are split into two elements as shown below. These are multiplied together to give a Component Factor (CFb) for each component.

- **Crash Severity – CS (Relative Consequence)**

Crash Severity refers to the relative severity of the type of crash likely to result from a particular deficiency.

- **Relative Risk Score – RRS (Relative Probability)**

Relative Risk Score represents the relative likelihood of a crash occurring due to a particular deficiency being present.

Relative Risk Index Score

Roads

The relative risk score index for a particular homogeneous segment of road is calculated from a combination of the above risk factors as shown in Equation 1 below:

Equation 1

$$\mathbf{TRS_{Road} = (\sum CF_r) \times WF \times RF \times CVF}$$

$$\mathbf{CF_r = CS \times RRS \times CA}$$

Where:
TRS_{Road} = Total Risk Score for Road Segment
CF_r = Component Factors (Edge Drop Factor, Edge Break Factor, Etc)
WF =Weather Factor
RF =Road Class Factor
CVF =Commercial Vehicle Factor
CS =Crash Severity (component)
RRS =Relative Risk Score (component)
CA =Condition Assessment (component)

Bridges

The relative risk score index for a particular bridge is calculated from a combination of the above risk factors as shown in Equation 2 below:

Equation 2

$$\mathbf{TRS_{Bridge} = (\sum CF_b) \times WF \times RF \times CVF \times AF \times SMF \times IF}$$

$$\mathbf{CF_b = CS \times RRS}$$

Where:
TRS_{Bridge} = Total Risk Score for Bridge
CF_b =Component Factors (General Bridge Structure Factor, Skid Resistance Factor, etc)
WF = Weather Factor
RF = Road Class Factor
CVF = Commercial Vehicle Factor
AF = Age Factor
SMF = Stringer Material Factor
IF = Inspection Factor
CS =Crash Severity (component)
RRS = Relative Risk Score (component)

Field trials

The methodology has been successfully trialed on a sample of road sections and bridges in various DNRE regions, and risk profiles determined.

The data collection task for road sections proved to be achievable at a comfortable driving speed (approximately 40 km/h on unsealed

roads). Data collection for bridges took approximately 10 minutes per bridge.

The relative risk assessments were compared as much as possible to previously conducted audits, and found to give a consistent indication of relative safety of the road sections.

Project Level Risk Management

Following the establishment of network level risk priorities, an authority is interested in the identification of priority actions at the project or maintenance level. The Road Safety Risk Manager (RSRM) provides a tool to meet this need and manage, prioritise and track the status of individual road safety issues on the road network.

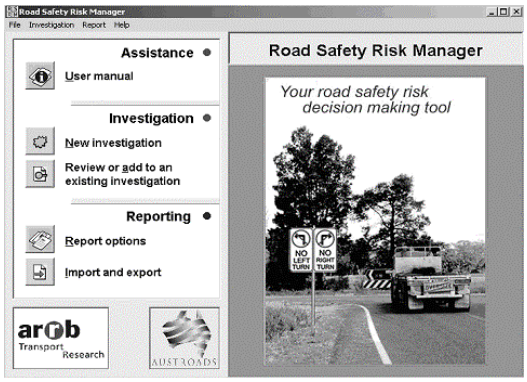
Released in October 2002 a number of local and state government authorities are now actively using the RSRM for a variety of needs including,

- Analysis of projects being submitted for state or federal funding programs,
- Prioritisation of maintenance activities and enquires from the public,
- Development of mass-action programs (eg guardrail, signage),
- Evaluation of road safety audit findings,
- Assessment of blackspot programs,
- Investigation of remedial treatments in response to fatal and serious injury crashes.
- Assessment of various design options and audit recommendations.

Why is prioritisation important?

In the changed legal environment since the High Court decision on non-feasance in May 2001 it is now as important for an authority to prioritise the works they can afford to do, and well as those they cannot afford or are unable to do.

The Road Safety Risk Manager



A difficulty faced by many authorities is the ability to determine the value of a potential remedial treatment when there is not an existing crash history at the location. The public will often ask, “Do we have to wait until a crash occurs before something is done?”

The RSRM does not require crash histories to be able to determine the value of a project. The process is based on the measurement of risk as a function of exposure, likelihood and severity, and provides users with the ability to analyse the hazard risk and the treatment risk reduction for some 60 different types of deficiencies, across a variety of different road types and severity outcomes. Following inclusion of treatment costs, the derived risk reduction-cost ratio forms the basis of prioritising the proposed works.

The key components of the Road Safety Risk Manager

The key components of the software include recording and analysis of:

<u>Investigation Details</u>

- Information on the site, assessor and other project details

<u>Exposure</u>

- The number of vehicles that are exposed to the hazard and associated treatment

Likelihood

- Selection of the typical road environment at the location (eg intersection or mid-block)
- An assessment of the how bad the particular problem at the site is (and how the treatment will rectify the situation)
- An assessment of the degree to which other factors (eg weather, skid resistance) influence the risk at the site

Severity

- The severity of a crash if it does occur taking into account speed and crash type.

Risk Reduction Cost Ratio

- The initial and ongoing costs associated with the treatment
- Automatic calculation of the risk reduction cost ratio of the treatment

Action Taken

- Details on the status of the issue (eg pending / completed / no further action to be taken)
- Actual works planned or undertaken

Reporting and Budget Analysis

- A budget analysis tool to assess changes in treatment order
- Different reporting and ranking options suitable for technical review through to management summaries

Exporting and Importing

- The ability to transfer records between users for overall program management

A key design criteria throughout the research and development phase of the process was to ensure the process remained simple and efficient and utilised data readily available (or estimated) by the local authority. The resultant application allows the assessment of individual issues in less than 5-10 minutes, with comprehensive help files available to assist users.

Issues that can be assessed

The Road Safety Risk Manager allows the comparison and assessment of a large variety of engineering issues on an even basis. For example the installation of a right turn lane can be compared to a shoulder widening project; the sealing of an unsealed road can be compared to a street lighting project; the traffic calming project can be compared to a guardrail installation. Other key issues that can be assessed include a range of regulatory and advisory signing projects, delineation works, line-marking, lane and shoulder widening, skid resistance, roundabouts, alignment and sight distance issues, edge breaks, roughness, roadside hazards and pedestrian and cyclist issues.

Prioritisation of Works

With all the potential projects or maintenance activities assessed the program can be prioritised at the touch of a button and a works program suitable for submission to Council (or an alternative funding body) produced.

From a legal perspective, the listing of projects that are not funded is also valuable in assisting to demonstrate a responsible and reasonable approach to meeting the Council's duty of care.

More importantly a program of works that is designed to maximise risk reduction across a network will ensure that the investment by Council in road safety will achieve the maximum reduction in road trauma and crashes.

Alliance Proposal

ARRB Transport Research has been requested by the Alliance to assist in

the development of a staged road risk assessment methodology for road networks and bridges. The purpose of the methodology will be to guide regional road groups in establishing and monitoring their own small number of safety criteria of relevance to their region.

The proposed development will involve the establishment of a minimum common data set with the option to include additional safety factors. The proposal also includes the use of the RSRM, the production of a training package and the delivery of training to all regional groups.

Conclusion

The network level risk assessment project has established a practical way of assessing roads and bridges on a network basis to help identify those that have a high risk. The methodology proposed allows calculation of a relative risk score index for each homogeneous road segment and bridge, based on a number of risk factors that have been identified as relevant to the road safety. A software package has been developed to facilitate the calculation of the relative risk score and the ranking of road segments and bridges.

Once these high priority road segments and bridges have been identified it will be a separate task to identify the most cost-effective and appropriate risk mitigation options using the Road Safety Risk Manager (RSRM) package. The RSRM provides authorities with a tool to manage, prioritise and track the status of individual road safety issues on their networks. Released in October 2002 a number of road authorities are now actively using the Risk Manager with a summary of their experiences and potential applications to be discussed.

Together the network level tools and the Road Safety Risk Manager will allow Local Government to truly understand and manage the *relationships* between *risk* and *road safety*.

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At ARRB, George has been responsible for the establishment of research programs and technology transfer activities for Local Government and other agencies associated with local roads across Australia and overseas. George has been successful in providing a number of projects aimed directly at meeting the needs of local roads including innovative road safety measures.

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Rob McInerney moved into the role of Business Manager, Strategy in 2002 where he is responsible for the ongoing management and monitoring of the emerging issues and trends within the transport sector relevant to ARRB Transport Research. He is also the Project Manager of the Road Safety Risk Manager product, following extensive involvement in the research, development, ongoing training and support associated with the proactive road safety risk assessment tool.

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