IMPROVING ROAD SAFETY IN DEVELOPING COUNTRIES USING NETRISK: A ROAD NETWORK RISK MANAGEMENT APPROACH

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ABSTRACT

The aim of the NetRisk methodology is to provide road authorities with a simple yet comprehensive method to identify road safety issues across their networks, and ultimately develop a prioritised works program to address the concerns identified, within individual budgeting periods. In addition the process also aims to help address and document the legal obligations and responsibilities of the road owner. The NetRisk road network safety assessment process can be applied to any road environment in the world.

The process that has been developed includes:

1. A network level risk assessment (road network safety assessment) is completed to focus attention on high risk sections of road where the risk of crashes and the associated treatment of that risk is expected to provide the greatest return.

2. The high risk sections are then investigated in greater detail to locate specific hazards and possible treatment options. Specific software modules include an engineering toolkit and a road safety audit toolkit, provided as expert decision making tools to assist in the selection and costing of engineering treatments.

3. The individual treatments are then analysed using the ARRB Road Safety Risk Manager to assess all potential treatments to ensure the highest safety value for money projects are completed first. This will help ensure road authorities obtain the greatest reduction in road trauma from the total available funding.

The NetRisk approach is now being actively used throughout Australia and it has wide application in many regions around the world including Europe, America, Asia and the Middle East.

INTRODUCTION TO NETRISK

Road safety is a significant issue for all road asset owners across the globe. The growing focus on the financial and social consequences of road trauma has indicated a need for a 'fresh' look at current approaches to the issue of road trauma and at the optimal investment of inevitably limited road safety improvement resources.

The ARRB Group (ARRB) has researched and developed a suite of risk assessment tools designed to optimise road authority safety activities in relation to road safety works expenditure. These tools are designed to provide a comprehensive and defensible framework to compliment existing road safety inspection and assessment activities. Utilising the latest

research findings, and integrating Benefit Cost Ratio calculations, NetRisk is designed to enable road authorities to rapidly assess the safety condition of any road network. Only the most hazardous sites are highlighted for detailed investigation according to the road authority's available resources and local considerations.

NETRISK BACKGROUND

The NetRisk process has been designed to minimise the demand on resources whilst still ensuring that high risk locations are identified and treated. The following key principles have guided the development of NetRisk:

- consistency in approach between users
- a simple, easy to use tool that can be tailored to the available resources
- the ability to assess low volume unsealed and sealed rural roads, in a comparable way with urban and rural town environments
- inspection of the entire road network with the rating process focussed so as to ensure the optimum use of resources
- focus on engineering features or latent defects and not routine maintenance issues that should be managed through the normal activities of the network manager (e.g. pot-holes, edge breaks, sign condition)
- ensure the capability to extend the assessment process if desired
- integrate the NetRisk process within an overall project prioritisation process
- a focus on problem road elements or sites, and not road segments

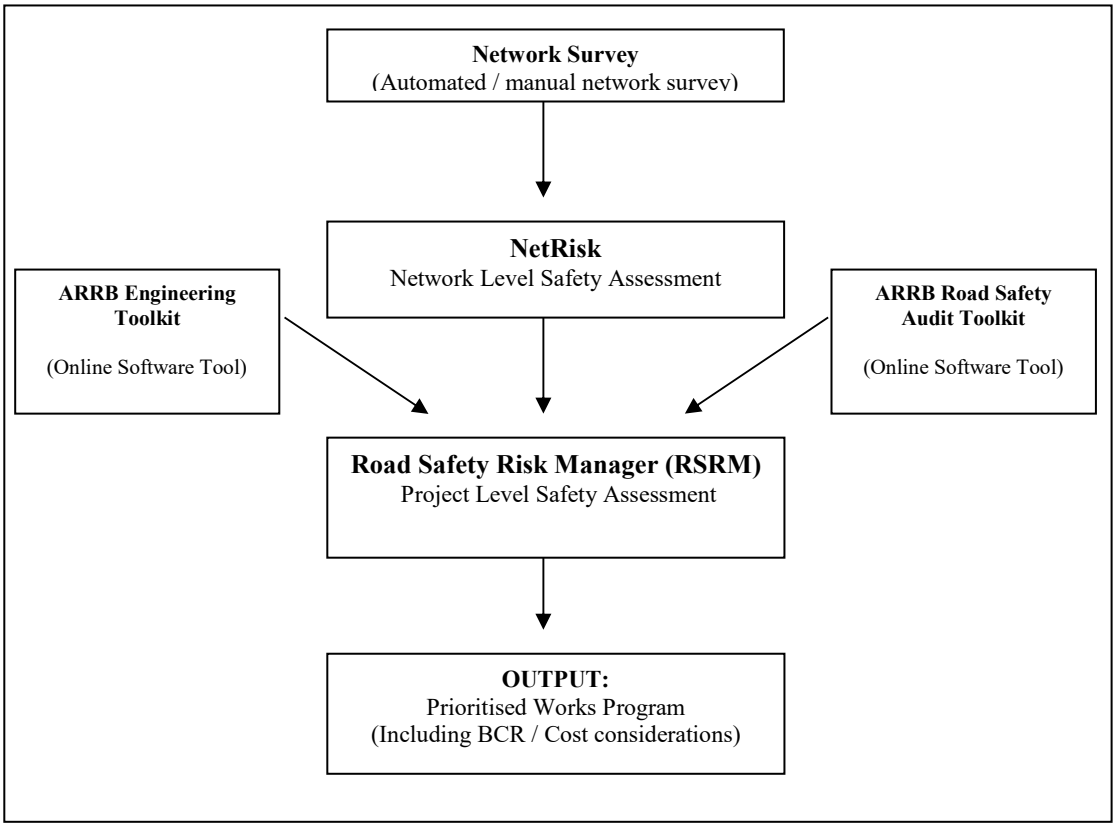


Figure 1 The NetRisk Process

THE NETRISK ROAD NETWORK SAFETY ASSESSMENT

The aim of the NetRisk methodology is to provide a sound basis to highlight the highest priority road safety issues across their network, and ultimately develop a prioritised works program to address the concerns identified. The process serves two main purposes:

- to assist the road authority to ensure investment is directed in a way that saves the maximum number of lives, and maximises the reduction in injury crashes
- to assist the road authority in meeting its duty of care in relation to legal responsibilities and obligations.

The entire road network is assessed using the Network Level Assessment Tool according to a set of predetermined road safety parameters, known as triggers or intervention levels, that prompt road authorities to investigate further. Detailed investigations of sites are triggered only when values of relevant parameters exceed certain preset minimum safety intervention levels. A process of customisation is required in order to reflect local preferences and conditions in different countries and regions. Trigger setting for the jurisdiction at the network level allows authorities to highlight and manage only the most hazardous sites on their network. This filtering process ensures that jurisdictions are not overwhelmed by vast numbers of work requests and can manage their road safety issues effectively and efficiently.

NetRisk is superior to its predecessors because it employs a proven risk management approach to road safety treatments at the network level. Traditional crash data based reactive 'blackspot' type approaches are effective for identifying and treating specific sites at the project level that have experienced high levels of road trauma. Reactive programs do not, however, identify or treat sites that are potentially dangerous but have no crash history. Do road users have to die at an unsafe site before it is treated?

NetRisk identifies and ranks hazardous sites across the network providing road authorities with a previously unavailable 'safety snapshot' of their network. The snapshot allows authorities to direct resources to addressing sites identified as the most hazardous on their road network, determined according to a site's potential risk, rather than just based on its crash history. Although the approach can draw upon crash data where it is available it is not a requirement.

The primary output from the risk based model is a 'Network Risk Score' that provides an indication of the inherent risk to an individual road user at a particular location. The 'Network Risk Score' is based on the research behind the Road Safety Risk Manager (see Section 4.1) and includes components related to the following:

- road type (urban intersection, urban mid-block, rural intersection, sealed rural mid-block and unsealed rural mid-block)
- road elements impacting crash likelihood (e.g. horizontal alignment, lane width, shoulder width, delineation, skid resistance/surface condition, sight distance, turning provision, pedestrian provision)
- road elements impacting severity (speed, roadside environment, type of crash)

The location and assessment of the road network can be undertaken by either driving and visually assessing the road network or through the assessment of geo-referenced digital video or similar imaging of the road network. The use of video data provides a much safer alternative for the data collection phase, as practitioners are not exposed to 'field risk', and it improves time, cost and quality outcomes. Recent projects completed by ARRB using video technology have confirmed the suitability of this approach for network level assessments.

A software tool has also been developed to facilitate the assessment process (see Figure 2 below).

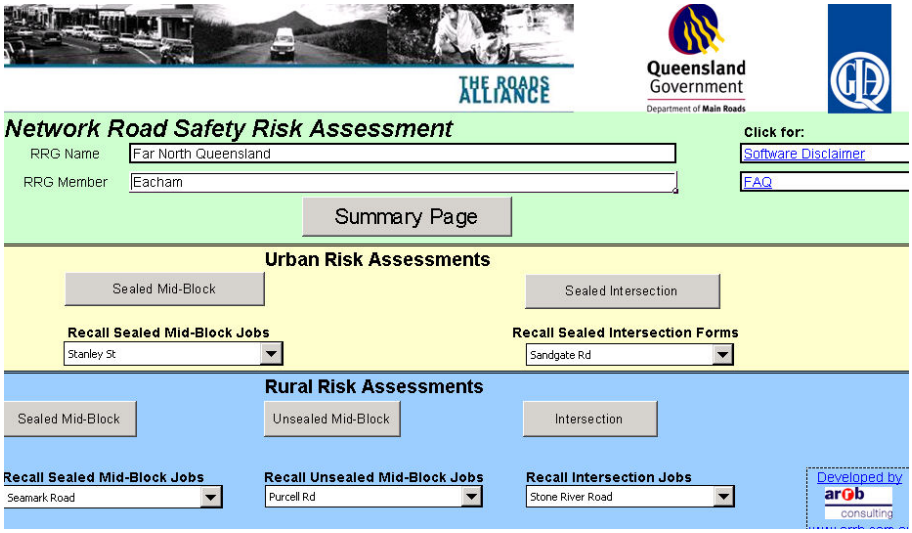


Figure 2: The NetRisk Risk Score spreadsheet

SAFETY TRIGGERS

While the entire network is inspected, the demand on resources is kept to a minimum by rating only those sections that include elements (such as those detailed above) that exceed a certain intervention or condition level. This is referred to as a 'safety trigger'.

The calculation of safety triggers and intervention levels within NetRisk flow from a comprehensive risk management program of Austroads funded research spanning over a decade.

The 'safety triggers' are set by the road authority at a level that allows identification of a manageable number of 'road safety hot spots'. This permits the authority to tailor the model based on their available resource and budget limitations. The triggers can be altered by the authority over time to enable continuous improvement in the safety performance of their network. For example, in relation to horizontal alignment, the safety trigger might be activated when the safe curve speed (e.g. the signed advisory speed of the curve) is less than 70 km/h, and the normal approach speed is estimated to be 80 km/h or greater (refer Figure 3).

Horizontal Alignment	Estimated approach speed		
Curve speed	100	80	60
straight/>130	1	1	1
100-130	2.2	1.8	1.4
70-100	3.5	2.6	2.2
<70	6	4.7	3.5

Figure 3: The safety trigger for horizontal alignment shown in pink

THE NETWORK LEVEL DATA COLLECTION

When undertaking the network level assessment every kilometre of the road network is considered. Network inspections can occur using traditional walk/drive over techniques or by utilising the output from a video survey to conduct network assessments 'in office'. Network assessments assist the road authority in proactively reviewing the entire network and ensuring they meet their duty of care. Only those points/sections where one or more safety triggers are activated need to be rated. When a trigger is activated, all engineering features at that location are reviewed taking into account the length of road that exceeds the trigger point.

For example:

- A narrow bridge may activate the lane width/shoulder width triggers. The length of the bridge is then assessed rating all factors on the assessment form (see figure 4)
- A section of road 3 km long with sharp horizontal curves with safe speeds of 60 km/h may activate a trigger. The required road features are then assessed for that section of road
- A 20 km section of unsealed road triggers because it is in poor condition. The section of road can be assessed as one 20 km section if relatively homogenous over that length. If, for example, the roadside condition is clear for the first 15 km and hazardous for the last 5 km, assessing as two separate sections would be appropriate.
- An urban intersection may activate a trigger due to poor right turn provision. The entire intersection is then assessed using the appropriate assessment form.

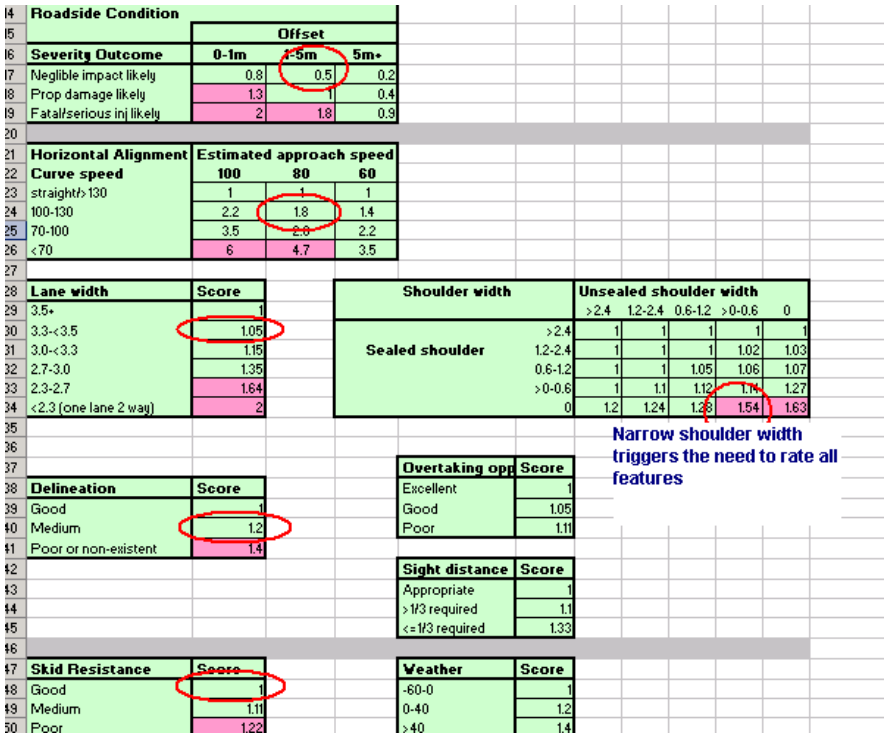


Figure 4: The narrow shoulder at a bridge structure may trigger the need to assess the site

For the majority of authorities the triggers are set in such a way that only 5-10% of the network will exceed an intervention level for rating and further investigation. Application of

this process results in the detection of a manageable volume of sites to be treated within each budgeting period, allowing the road authority to focus resources on the most hazardous aspects of their network. In practice some authorities have chosen to rate their entire network (as opposed to just those sections that trigger) to provide a risk score for each kilometre of road within their control.

The network level survey is generally only required every 2-3 years depending on the rate of change in deterioration, demand and / or project investment over the period.

CALCULATION OF NETWORK RISK SCORE

Upon completion of the network assessment, the results for each section triggered can be entered into the NetRisk Risk Score model. The model will then automatically calculate the relevant risk scores, severity values (based on roadside condition) and the 'Network Risk Score' (refer Figure 5).

5			Overtaking Opps	0	0-20		7.76	0.00
6			Sight Distance	0	0-20		4.85	0.00
7	**Surface**	20 20-40	**Skid Resistance**	50	30-50	1	8.82	3.53
8	**Condition**		**Weather**	50	30-50	1	8.82	3.53
9			Rutting	0	0-20		7.65	0.00
10			Roughness	0	0-20		7.65	0.00
12							**SUB-TOTAL**	16.48
14							**NETWORK RISK**	32.97
16	**Comments:**							
17								
18	No sealed shoulders with nasty roadside environment							
19								

Figure 5: Network Risk Score calculation

On completion of the rating for each section that has been triggered, users are able to map their risks across the network and identify those high priority sites for further investigation and potential treatment. An example is given in figure 6.

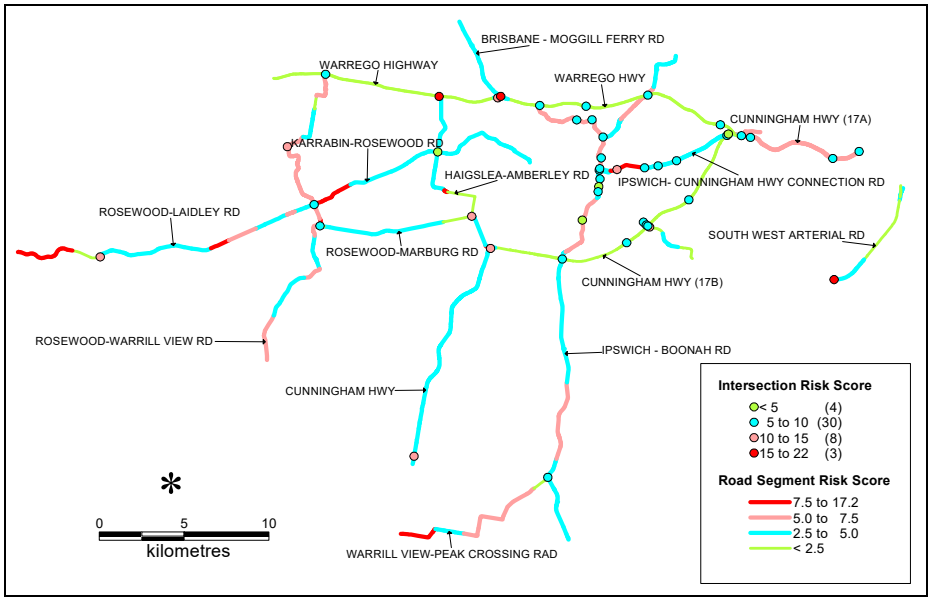


Figure 6: A network risk map detailing the intersection/road segment risk scores

Depending on the available resources the authority may choose to prioritise and stagger the investigation of the higher risk sites over a number of years.

An additional application of the NetRisk assessment method at the network level is the ability to assess the safety deficiencies along homogenous road segments and major intersections for comparison. This approach applies the network level screening process to proactively identify and measure the negative safety deficiencies along a road length. The tool allows for the fast, efficient and safe rating of safety performance of the road network through visual inspection of the road network either manually or via video assessment.

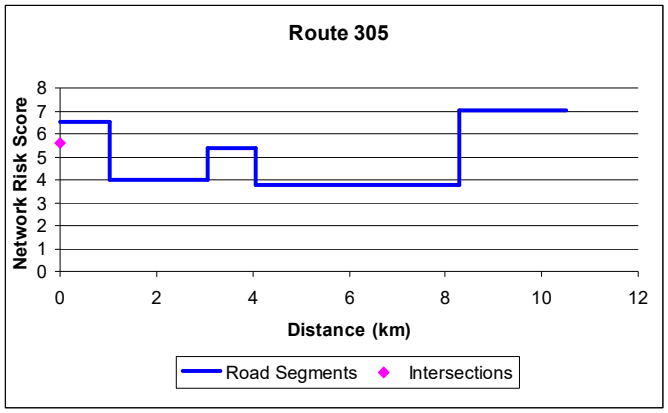


Figure 7 displays the network risk score along the length of route 305. The higher risk sections of the route are clearly identifiable, and can simply be scheduled for detailed investigation.

Figure 7: Network Risk Scores – Route 305

Sample network length assessment output Route (305) analysed by ARRB Group

> *'Several engineering road elements were identified to have safety issues. The safety deficiencies included poor horizontal alignment, inadequate shoulder width, delineation and unforgiving roadside conditions. The first 3km of the road has inadequate shoulder width. There are no edge lines between chainage 1.0km and 3.1km. Hazardous roadside conditions are noted from chainage 0km to 1.0km and 8.3km to 10.5km. There are some sharp horizontal curves at chainages 0km to 1.0km and 3.1km to 4.1km. The three narrow bridges along this road also present some safety concerns (Note: the network model does not isolate minor point hazards such as bridges).*
>
> *The crash rate is low (i.e. crash rate is less than the average crash rate for similar types of road carrying identical traffic) along the entire length of this road.'*

NetRisk delivers a comprehensive yet transparent safety assessment that can compare, assess and prioritise hazardous road locations and lengths across an entire road network.

PROJECT LEVEL INVESTIGATION AND PRIORITISATION

Following the network level assessment the sites are assessed in priority order from highest network risk score to lowest network risk score. This activity is generally undertaken by a suitably qualified / trained engineer or technical representative, and includes a range of analysis such as:

- sourcing of crash records to identify any existing crash problems at the location / section of road
- review of the road features that triggered for that section of road as they may provide an indication of suitable remedial treatments. For example if shoulder width was the safety trigger, widening the shoulders would represent a potential treatment
- a detailed site assessment (or review of video data or photos taken during the network survey) should be completed to identify specific hazards. Key data to be collected includes the mix of traffic, road cross-section, traffic movements and conflict points

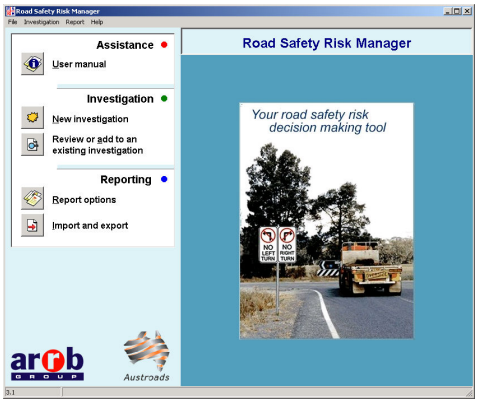
- Determination of appropriate treatment/treatments for the location. The Engineering Toolkit is a very effective tool that can be used to facilitate this process.

PROJECT LEVEL ASSESSMENT - ROAD SAFETY RISK MANAGER

The high risk sites that are triggered by the network level assessment are assessed in a more detailed manner using the Road Safety Risk Manager (RSRM) project level tool. The project level tool takes the user through the detailed hazard analysis, treatment and costing areas of the investigation process. All detailed project level assessments can be undertaken using the video data files, traditional walk over visual inspection techniques, or by using information from road safety audits of the sites.

The RSRM provides a consistent, scientifically based and well documented approach to assessing road safety hazards and treatments for the purpose of prioritising actions. Following the collection of site information, the tool allows the assessment of individual hazards and treatments in 5-10 minutes. With the reporting and budget analysis tools provided, the software can meet the specific needs of risk identification, risk management and the development of remedial treatment programs. The software also provides a simple way to track the status of any issue and to record any actions taken, allowing traceability and transparency in decision making, and assisting road safety managers to demonstrate a responsible approach to managing road safety risk.

The research behind the RSRM software forms part of a significant research program being funded by Austroads and delivered by ARRB. This ongoing commitment will ensure continuous improvement of the models and theory behind the software, and provides practitioners with practical and accessible research results.



The focus of road safety risk management methodology is to achieve the maximum road safety benefits for the budget available within any prescribed budget cycle. To ensure this outcome, the individual projects need to be assessed to evaluate their return on investment in terms of risk reduction.

The Road Safety Risk Manager developed by ARRB in association with Austroads is designed to assist authorities to proactively assess road safety projects. The software provides the following key advantages to practitioners:

- based on over eight years research and development with the research investment ongoing
- allows comparisons of over 70 different project types (e.g. install signals; install roundabout; guard-rail; seal unsealed road; shoulder widening)
- assessments completed in only 5-10 minutes each
- a photo of the site and local knowledge is generally enough to assess the location
- provides a method to assess the value of a project in an objective manner
- tracks the status of projects and assist an authority to meet their duty of care.

The Road Safety Risk Manager also includes a range of analysis tools to assist authorities to optimise their road safety works programs (see Figure 9 below). The budget analysis tool

allows users to quantify the positive and negative impacts of changes to the prioritised program, allowing informed decision making.

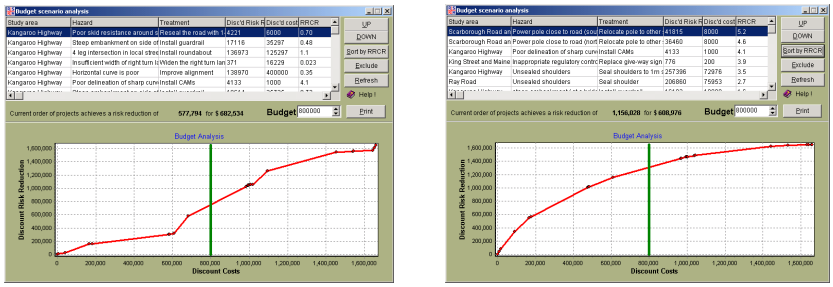


Figure 9: The budget analysis tool before and after optimisation

In addition the Road Safety Risk Manager also assists users in the following areas:

- Prioritisation of road safety audit findings
- Prioritisation of issues raised by the public, or authority inspections
- Prioritisation of mass-action programs (e.g. guard-rail, shoulder sealing)
- Assessment and prioritisation of road construction and maintenance programs
- Analysis of design options to determine the best value for money
- Development of broader safety related works programs

On the completion of the individual assessments the authority is able to generate a prioritised list of all the road safety issues on roads under their control (refer Figure 10 below). Some projects identified will represent good value for money, while some projects may represent a poor return on investment. This is equally important as it will help the authority firstly determine the projects to invest in, and provide a well documented assessment of their reason for not investing in low return projects. This can be important if, by chance, a crash unfortunately occurs at that location in the future.

Multiple Hazard and Treatment Report
Executive Summary

Report generated on 19 Jul 2005 22:35 **by** Rob McInerney

Road Name	The Hazard and ID	Hazard Location	Proposed Treatment	Initial Cost	BCR	Status
Safety Road	Slippery road - no signage	Chilly Hwy, Chainage: 8.500	Sign road as slippery when wet	$1,500	60	Action Complete
Safety Road	Poor advisory signing of approaching intersection (built-up)	Bushy Tree Blvd, Chainage: 8.200	Relocate sign in front of vegetation	$300	28.2	Action Pending
Safety Road	High angle parking	Main Street, Chainage: 0.000	Replace with 30 degree parking	$6,000	26.1	Action Pending
Safety Road	Poor edge lines	Gum Tree Road, Chainage: 342.000	Re linemark edge lines	$8,000	14.7	Action Pending
Safety Road	No CAMS around sharp curve	Slippery Bend, Chainage: 11.400	Install CAMS	$4,000	14.4	Action Complete
Safety Road	Traffic lights obscured by vegetation	Branch road near the weeping willow forest., Chainage: 11.300	Trim tree to make visibility 100%	$1,000	14.1	Action Programmed
Safety Road	4 leg intersection - Inappropriate layout. (local)	Cross Road, Chainage: 1.250	Install roundabout	$95,000	7.5	Partially Complete
Safety Road	No RRPMs - Poor delineation at night / wet	Reflection Road, Chainage: 6.300	Install RRPMs	$3,800	6.6	Action Programmed
Safety Road	Vehicles leaving road - fatigue expected cause	Rumble Hwy, Chainage: 18.200	Install profile edge lines	$18,000	5.1	Action Programmed
Safety Road	Poor skid resistance around corner	Slippery Bend, Chainage: 5.000	Treat flush patches and 10mm reseal	$3,800	3.6	Action Pending
Safety Road	No sealed shoulders	Pasture Drive, Chainage: 11.800	Widen and Construct 0.5m sealed shoulder	$180,000	3	Action Pending

Figure 10 – RSRM multiple hazard and treatment report

NETRISK IMPLEMENTATION REQUIREMENTS

The risk models that underpin the NetRisk method are currently designed for application within Australasia. A process of customisation will be required for use in other regions of the world in order to accurately reflect local operating conditions and practices, to enable road authorities to derive the maximum safety benefits from implementing the system.

In order to facilitate the successful implementation of NetRisk the following customization will be required:

Core Products:

- Customisation of network triggers to reflect local conditions, approaches and priorities
- Customisation of RSRM project level risk models to reflect local conditions

Online Support tools:

- Customisation of Engineering Toolkit to reflect local preferences regarding countermeasure options, costs and selection
- Customisation of Road Safety Audit Toolkit to incorporate local standards, methods and practices

Software support

- Support arrangements including help desk, online user forums and online training can be customised in order to assist authorities to derive the maximum benefit from the NetRisk method.

NETRISK IMPLEMENTATION

The use of NetRisk in combination with automated data collection services (such as a video based network surveys) provides the ultimate road safety assessment tool. The system is intrinsically efficient as the safety triggers can be calibrated to reflect the needs of the individual road authority, in such a way that only a manageable number of sites need be considered for treatment in each budgeting period, allowing for local resource allocations and network management priorities. The use of video assessments also provides significant safety benefits for practitioners as they are not exposed to field risks when conducting site inspections / assessments.

Use of the tool provides a defensible position in relation to legal obligations and responsibilities as the works prioritisation process undertaken is research proven, and the process of decision making is well documented, traceable and transparent.

The use of functional online tools such as the Engineering Toolkit and Road Safety Audit Toolkit within the NetRisk process provide additional benefits for road authorities. Not only do these modules perform specific roles within the process, they act as a quality control mechanism ensuring that a comprehensive assessment approach is applied that considers all available treatment options and considerations including road authority preferences and policies.

NetRisk has been implemented in numerous environments at all levels of government. The NetRisk method has also been deployed by numerous private road network operators including national parks and within mine site environments. The NetRisk process has been presented as a potential working model for the International Road Assessment Program (iRAP) and is currently being utilized in the iRAP pilot project in Malaysia. It has also been

presented to the World Bank and World Health Organisation for potential application in developing countries. NetRisk offers benefits for both the developed and developing world as the approach is flexible enough to focus upon jurisdictional priorities while delivering real benefits at the operational level.

NetRisk is the only road network safety assessment product of its kind in the world. The NetRisk approach is the culmination of many years of road safety research, resulting in a process that delivers the research findings to practitioners, via an easy to use, logical interface that provides scope for local knowledge and expertise. Proper implementation of the NetRisk method across a road network will result in the proactive identification and reduction of high risk sites across road networks. It has the potential to deliver numerous safety benefits to road users as well as the community at large.

NetRisk is an ideal road network safety assessment tool for road authorities in developing countries. Proper implementation and correct application of NetRisk will save lives, improve safety and reduce the impact of road trauma on the community.

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