



Transport
Roads & Traffic
Authority



RAILWAY CROSSING SAFETY SERIES 2011

Assess:

Applying risk tolerance and risk assessment
criteria to railway crossings



Contents

Section 1	2
Introduction	2
1.1 Purpose	2
1.2 Background	2
1.3 Outline of this guideline	3
1.4 How to use this guideline	3
Section 2	4
The risk assessment procedure, risk tolerance and risk assessment criteria	4
Section 3	5
The role of ‘so far as is reasonably practicable’ (SFAIRP) principles in risk tolerance and risk assessment criteria	5
Section 4	6
Risk tolerance at railway crossings	6
Section 5	7
The risk assessment criteria for railway crossings	7
5.1 Risks at a railway crossing	7
5.2 Incidents	8
5.3 Likelihood ratings	8
5.4 Consequence ratings	9
5.5 The risk level matrix	10
Section 6	11
Managing risks at a tolerable level	11
Section 7	12
Application of risk tolerance and risk assessment criteria in risk assessment	12
7.1 Risk analysis	12
7.1.1 Crash and ‘near miss’ incidence rates	12
7.1.2 ALCAM model outputs	13
7.2 Risk evaluation	14
APPENDICES	16
Section 8	17
Appendix A: Crash and fatality rates and traffic management measures at railway crossings	17
Appendix B:ALCAM	18
Appendix C: Principles of risk evaluation for railway crossings	20
Section 9	21
Glossary	21

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Section 1

Introduction

Assess: Applying risk tolerance and risk assessment criteria to railway crossings is a technical reference guideline for RTA planners. This guideline is to be used by planners when they undertake risk assessments for railway crossings (RCs) on the State road network. The guideline provides advice on how to apply risk tolerance and risk assessment criteria during key phases of the risk assessment procedure. Risk assessment is required whenever a railway crossing safety management plan is developed or when an upgrade of road infrastructure at an RC is planned.

1.1 Purpose

Assess: Applying risk tolerance and risk assessment criteria to railway crossings outlines the risk tolerance and risk assessment criteria adopted by the RTA in its risk assessment procedure for RCs on the State road network. These risk tolerance and risk assessment criteria create a reference framework for the comparison and evaluation of risks at RCs.

1.2 Background

RCs are an integral part of the State road network. Their existence and operation present a risk to the safety of road users within New South Wales.

Despite RCs posing a risk, a comparison of crash and fatality data for RCs and intersections within the State road network in New South Wales illustrates the overall success of the RC management measures implemented at RCs. Given the exposure to train traffic and the frequency of road use at RCs this successful minimisation of risks is especially notable.

While the number of crashes at RCs is low compared to other crash types, the consequences of a crash at an RC is potentially severe. In general, a crash at an RC can lead to fatalities and serious injuries to road users, as well as extended delays to the operation of the road and rail networks.

In recognition of the safety risks and the potential consequences of crashes at RCs, the RTA has included this infrastructure type within its overall safety risk framework.

The NSW *Rail Safety Act 2008*, Division 3 Interface Co-ordination legislates that the roads authority and rail infrastructure manager must jointly develop and agree on an interface agreement for an RC under their control. The purpose of the interface co-ordination provision is to ensure that the roads authorities and rail infrastructure managers:

- Identify risks to safety arising from RCs.
- Determine measures to manage, so far as is reasonably practicable, those risks.
- Seek to enter into interface agreements to manage safety risks and the safety management measures implemented to reduce those risks.

The RTA has as a matter of policy, determined to enter into, or be a party to a safety management plan for every RC on State roads. In addition, the RTA should generally be a party to a safety management plan where an RC is connected to traffic control signals or a railway crossing not on a State road affects safety or the operation of a State road.

A railway crossing that is not on a State road but has infrastructure on a State road provides additional challenges for the parties responsible for safety at the railway crossing. In the spirit of cooperation and collaboration promoted in the Rail Safety Act, the RTA may choose to be involved in the safety management plan for the RC, or may provide acknowledgement to the parties responsible that the RTA will maintain traffic control devices on the State road to the standards required in the Australian Standard AS1742.7.

1.3 Outline of this guideline

This guideline is divided into seven sections and three appendices.

Section 1 (this Section) outlines the purpose of the guideline, provides background information explaining the RTA's involvement in the safety management of RCs, and provides advice on how to make the best use of the guideline.

Section 2 describes how risk tolerance and the risk assessment criteria are used in the risk assessment procedure.

Section 3 outlines the role of 'so far as is reasonably practicable' principles in risk tolerance and the risk assessment criteria.

Section 4 provides a description of risk tolerance and the RTA's policy position for risk tolerance at RCs.

Section 5 provides a description of the risk assessment criteria, including the consideration of incidents, likelihood, consequences and the determination of the overall risk level relevant to a safety risk at an RC.

Sections 6 provides directions on the desired risk rating for an RC.

Section 7 provides directions on how to apply risk tolerance and the risk assessment criteria in the risk assessment procedure.

Figure 1: The risk assessment procedure – a schematic interpretation on page 15 illustrates the RTA's risk assessment procedure and shows how risk tolerance, the risk assessment criteria, risk analysis and risk evaluation work within this process.

1.4 How to use this guideline

This guideline is a technical reference document for planners. It outlines the RTA's position on the level of risk posed by RCs and explains how this position is incorporated into the risk assessment procedure.

Those planners who are new to the process of planning and managing safety risks, or to safety management measures and safety management plans, should review the whole guideline carefully. Planners with more experience may only need to read Sections 1, 2, 6 and 7.

Section 2

The risk assessment procedure, risk tolerance and risk assessment criteria

The RTA uses a five step risk assessment procedure to identify, assess, evaluate and manage safety risks and safety management measures at railway crossings (RCs). These risks are managed so far as is reasonably practicable (SFAIRP) (see Section 3). The risk assessment procedure is based upon the International Standard AS/NZS NZS ISO 31000:2009 – *Risk Management – Principles and Guidelines*. The risk assessment procedure is an essential part of planning and managing railway crossing safety management plans.

The five steps of the risk assessment procedure are outlined below.



For more information on the risk assessment procedure see Appendix A of *Plan: Establishing a railway crossing safety management plan*.

Risk tolerance principles provide planners with the RTA's current position on the level of risk RCs present when objectively compared to all other risks managed by the RTA. This information is important when undertaking steps 3 and 4 of a risk assessment.

The risk assessment criteria provide the likelihood, consequence and risk rating tables for use in steps 3 and 4 of a risk assessment.

This guideline provides advice on how to apply risk tolerance and the risk assessment criteria during the risk assessment procedure.

Section 3

The role of 'so far as is reasonably practicable' (SFAIRP) principles in risk tolerance and risk assessment criteria

The *Rail Safety Act 2008* permits the application of 'so far as is reasonably practicable' (SFAIRP) principles in the risk assessment of a railway crossing.

The National Transport Commission (NTC) provides the following information concerning 'so far as is reasonably practicable' (SFAIRP):

SFAIRP is a legislative qualification that is well known to the law and found in a number of statutes both in Australia and overseas. In essence, it requires weighing the risk against the resources needed to eliminate or reduce the risk. It does not require every possible measure to be implemented to eliminate or reduce risk, but it places the onus on the person holding the duty to demonstrate (or be in a position to demonstrate) that the cost of additional measures to control the risk (over and above those risk controls already in place) would be grossly disproportionate to the benefit of the risk reduction associated with the implementation of the additional risk control.

Source: *National Rail Safety Guideline – Meaning of Duty So Far As Is Reasonably Practicable (SFAIRP)* National Transport Commission, June 2008.

The risk tolerance and the risk assessment criteria for RCs have been developed incorporating SFAIRP.



Section 4

Risk tolerance at railway crossings

The RTA must manage risks at RCs within the context of its responsibility to manage all other risks on the State road network and, where delegated, other roads.

Risk level can never be reduced to zero. Risk tolerance is the amount of risk that the RTA is obliged to accept (that is, prepared to accept, tolerate, or be exposed to at any point in time) in the context of the whole road environment, a finite budget and statewide crash management before it judges action to be necessary. Risk tolerance is a major factor in the development of the risk assessment criteria that are used in the risk assessment procedure.

The RTA's risk tolerance for RCs on the State road network is:

Safety risks created by a railway crossing are low when considered in relation to all other known significant contributing safety risks to road crashes and fatalities on the State road network.

In this context, the RTA's ongoing focus will be to minimise safety risks at existing RCs with a combination of maintenance, operation and the implementation of traffic engineering safety management measures and road user behavioural campaigns, as well as by working with police on enforcement, based on a realistic application of SFAIRP principles. Grade separation and the closure of RCs are options: however, due to their high financial cost and impacts on community access, they will typically only occur through major road improvement projects.

The RTA's current risk tolerance for RCs on the State road network has been developed based on a consideration of:

- Historical crash and fatality rates at RCs on the State road network.
- RC safety management measures used in New South Wales.

An assessment of the crash and fatality rates and RC management measures used in New South Wales is provided in Appendix A on page 17.

Section 5

The risk assessment criteria for railway crossings

Risk assessment is the overall process of risk identification, risk analysis and risk evaluation. The risk assessment criteria enumerated in this guideline operate as a reference point or standard rule for the comparison and evaluation of risks at railway crossings (RCs).

In assessing risk at an RC, four sets of risk criteria are important:

- The kinds of risks that may be present at an RC.
- The kinds of incidents that may occur at an RC.
- The likelihood of these incidents occurring.
- The consequences of these incidents, should they occur.

These four criteria are brought together in the risk level matrix. This matrix is used to determine the level of risk present at an RC, taking into account the existing safety management measures. On the basis of the risk level, planners are able to determine whether any further safety management actions at an RC are required.

The following sections explain the risk assessment criteria listed above.

5.1 Risks at a railway crossing

Risks that occur at RCs can be classified into groups according to the behaviour of a road user as they traverse an RC. These groups are called 'risk categories'¹. The following risk categories have been adopted for RCs:

- Road user fails to stop while a train is approaching.
- Road user fails to keep clear while a train is approaching.
- Road user fails to stay within travel lane, carriageway or path.
- Failure of traffic control signals or active control.
- Road user fails to observe other road user during operation of railway crossing.

As they stand, these risk categories are too broad to be applied in the risk assessment of a specific RC, because the controls and other characteristics of RCs vary.

Therefore, to enable planners to identify and evaluate risks at specific RCs, design and operation 'risk types' have been developed. These risk types are more specific than risk categories in that they consider both driver behaviour and the control, design and operational elements at an RC. The risk types identified for railway crossings are provided in *Evaluate: Applying the railway crossing cause consequence bow tie models* in Table 1 and Appendix 2.

The presence of a hazard or hazardous event at an RC will result in a 'risk type'. *Identify: The railway crossing safety hazard checklist* is a reference tool to assist planners in identifying hazards and hazardous events at RCs.

¹ The RTA has adopted the term 'risk category' in place of the term 'hazard'.

5.2 Incidents

An incident is a crash at, or as a result of the operation of, an RC. They occur where safety management measures either fail or are not present when required.

An RC safety risk could lead to the potential for one of the following incidents to occur:

- A road user crashes with a train at an RC.
- A road user crashes with rail infrastructure at the RC.
- A crash occurs between road users during the operation of the RC.

These incidents are to be used in the assessment of risks at RCs in the risk assessment procedure. For more information on the use of incidents and consequences in the risk assessment procedure see Appendix A of the *Plan: Establishing a railway crossing safety management plan*.

Please note that while 'near-misses' involving a road user failing to stop at an RC, or failing to keep an RC clear while a train is approaching are both undesirable incidents and illegal acts that may occur, they have not been included as incidents in the risk assessment procedure as the data collected for these incident types is not yet reliable.

5.3 Likelihood ratings

The RTA has adopted likelihood ratings of Negligible, Low, Medium, High and Extreme for the incidents outlined in the previous section. These likelihood ratings have been developed based on a consideration of risk tolerance and SFAIRP principles, as discussed in Sections 4 and 3 respectively.

The frequency of an incident that results in a crash (crash rate) by a road user with a train, with road or rail infrastructure, or with another road user has been adopted as the primary criterion in determining likelihood ratings. This risk assessment criterion has been chosen as data is available and reliable (it is provided by the NSW Centre for Road Safety) and provides a 'worst case' situation.

Table 1 below describes the likelihood ratings.

TABLE 1: LIKELIHOOD RATINGS

Likelihood rating	Description	Frequency of road user* crashes at, on approach and departure, or during the operation of a railway crossing
Extreme	The event is expected to occur in most instances.	One incident occurs at least once a month.
High	The event will probably occur in most instances.	One incident occurs between once a month and once in three months.
Medium	The event might occur at some time.	One incident occurs between once in four months and once in a year.
Low	The event could occur at some time.	One incident occurs between once a year and once in three years.
Negligible	The event may occur in exceptional circumstances.	One incident occurs less than once in three years.

* Road users include all categories of motor vehicles, pedestrians and cyclists. Assessment of motor vehicles should be undertaken separately from pedestrians and cyclists.

5.4 Consequence ratings

Consequences are the outcomes of incidents. The failure or absence of a safety management measure may lead to an incident, and an incident may have a consequence or consequences.

These consequences may include:

- Fatalities and injuries to rail or road users.
- Delay to road users, passengers and freight.
- Delay to rail users, passengers and freight.
- Damage to property and the environment.
- Secondary crash into crash site, or resulting from damaged safety management measures.

The RTA has adopted consequence ratings of Negligible, Low, Medium, High and Extreme for the consequences of the incidents presented in Section 5.2. These consequence ratings have been developed based on consideration of risk tolerance and SFAIRP principles, as outlined in Sections 4 and 3 respectively. The consequence ratings have been determined on the basis of RTA road safety and road network operational efficiency objectives.

Table 2 outlines the consequence rating in terms of road safety. Although there are other potential consequences of an incident, the *NSW Rail Safety Act 2008* requires assessment based on safety. Other consequence types such as network operational impacts, and property and environmental damage could be considered when determining post incident management measures.

TABLE 2: CONSEQUENCE RATINGS

Consequence rating	Road Safety ²
Negligible	No medical treatment required for road users.
Low	Medical treatment required for road users.
Medium	Serious injury occurs for road users.
High	Single fatality occurs for road users.
Extreme	Multiple fatalities occur for road users.

² Although other consequences may result from a crash, the purpose of the risk assessments undertaken to conform with the *Rail Safety Act 2008* from the roads authority perspective are targeted at road safety.

5.5 The risk level matrix

The likelihood and consequence ratings are brought together in the risk level matrix to determine the risk level of a risk. The RTA has adopted risk level ratings of Negligible, Low, Medium, High and Extreme for the risk level assessment of RCs. The risk level ratings have been developed based on consideration of risk tolerance and SFAIRP principles, as outlined in Sections 4 and 3 respectively.

Table 3 presents the risk level matrix and illustrates how likelihood and consequence ratings are merged to determine risk level.

TABLE 3: RISK LEVEL MATRIX FOR RAILWAY CROSSINGS

		RISK LEVELS				
		Consequence				
		Negligible	Low	Medium	High	Extreme
Likelihood	Extreme	M	H	E	E	E
	High	L	M	H	E	E
	Medium	N	L	M	H	E
	Low	N	N	L	M	H
	Negligible	N	N	N	L	M





Section 6

Managing risks at a tolerable level

After determining the risk level of an RC, inclusive of the existing safety management measures, and using the risk level matrix outlined in Section 5.4, it can be decided whether additional safety management measures are required at that RC. This decision will be based on the RTA's goal of managing safety risks at a no greater than Low level, SFAIRP.

The following Section outlines the procedure for applying the risk assessment criteria, determining the risk level and managing the risk at a Low level at an RC.

Section 7

Application of risk tolerance and risk assessment criteria in risk assessment

The risk tolerance and the risk assessment criteria discussed in this document are used in two key phases of the risk assessment procedure: risk analysis and risk evaluation. These two phases match up with steps 3 and 4 of the risk assessment procedure and are outlined in more detail below. Risk tolerance and the risk assessment criteria are integral to the development of a railway crossing safety management plan.

The RTA uses qualitative analysis to assess risk. Qualitative analysis makes use of comparative scales permitting risk to be described by the terms Extreme, High, Medium, Low or Negligible, such as those applied in the risk level matrix outlined in Section 5.5. The risks at a railway crossing (RC) are described according to the risk assessment criteria detailed in Section 2 during steps 3 and 4 of the risk assessment procedure. (Also see Appendix A of *Plan: Establishing a railway crossing safety management plan* for more detailed information on the risk assessment procedure).

See Figure 1: The risk assessment procedure – a schematic interpretation (page 15) for an illustration of how risk analysis and risk evaluation fit into the overall risk assessment procedure.

7.1 Risk analysis

Risk analysis involves the assessment of the likelihood and consequences of a risk eventuating, taking into account the existing safety management measures implemented in the RC area of influence. The risk analysis determines the current risk level of the RC.

Risk analysis takes place during Step 3 (Analyse existing railway crossing risks) of the RTA's risk assessment procedure.

Detailed descriptions of the information sources drawn upon for risk analysis are provided in the following subsections.

7.1.1 Crash and 'near miss' incidence rates

Crash and 'near miss' rates provide data on the current safety performance of the RC. Crash data is used as an input into the 'likelihood' assessment of the risk analysis phase, while 'near-miss' data provides the planner with information on potential crash risks and should be considered when developing safety management measures.

7.1.1.1 Crash incidence rates

The following incidents are all indicators of potential safety problems relating to an RC: crashes between trains and road vehicles, pedestrians or cyclists at an RC; crashes between road users and rail/road infrastructure at an RC; and crashes between road users on the approach and departure to an RC (within the RC area of influence).

The data on crashes between road users and trains for the last five years is to be used in calculating the likelihood rating of an RC and should be sourced from the Independent Transport Safety Regulator (ITSR).

Crash data for road vehicles on the approach and departure to an RC within the RC area of influence should be sourced from the NSW Centre for Road Safety.

Note: ITSR and the rail infrastructure managers keep a record of 'incidents' at RCs. In this context 'incident' refers to any adverse occurrence at an RC and includes crashes, near misses, vandalism and equipment failure. This information may provide insights into a variety of issues at an RC.

7.1.1.2 'Near miss' incidence rates

The ITSr has defined a 'near miss' incident at a passive, active or unprotected RC between a road vehicle and a train as:

Any occurrence where the driver of a moving train takes emergency action or has insufficient time to take emergency action to avoid impact with a road vehicle at a railway crossing and **no collision occurs**. Emergency action includes continuous audible warning and/or brake application.

It is noted that some train drivers report any vehicle driving through an activated crossing as a near miss, and it is not always clear if they had to 'take emergency action'. As a result a near miss at an active crossing is typically a different class of event to near misses at passive crossings, which tend to be more serious.

'Near miss' data is not currently used by the RTA in the risk assessment process due to inconsistent reporting. Nevertheless, 'near miss' data provides an indication of potential problems at an RC and should be considered in the design and operational review for the road infrastructure upgrade of an RC.

7.1.2 ALCAM model outputs

The Australian Level Crossing Assessment Model (ALCAM) outputs provide a general indication of the comparative safety of an RC ranked against all RCs modelled by ALCAM in New South Wales. They also provide a list of risks at the RC as identified by the NSW Department of Transport, which owns the ALCAM model. ALCAM outputs can be used in the risk identification and risk analysis phases of the risk assessment procedure to provide basic data, but importantly any 'flags' raised in the ALCAM output must be assessed. However, the risk assessment must not be based on ALCAM data alone.

Outputs from the operation of the ALCAM model for an RC are:

- Likelihood ratings.
- Safety 'flags'.
- RC risks.
- Risk score.
- Risk rating.

The risk rating is a number used to rank the safety performance of an RC relative to all other RCs assessed by ALCAM in New South Wales. The ranking is based on a comparison of ALCAM risk scores. For example, an RC with a risk ranking of 10 would be considered to have a greater likelihood of a risk materialising than an RC with a risk ranking of 100. The ALCAM risk rating of an RC should only be used as a guide to its safety performance.

Risk 'flags' provide the key safety risks as assessed by ALCAM and must be considered in the risk assessment.

ALCAM risk scores generated for an RC are based on a review of its characteristics and controls. The effectiveness of a safety management measure can also be measured by how much it reduces an RC's risk score.

ALCAM also provides a list of risks that may be present at an RC. The risks are based on the assessment of data collected and used to support ALCAM.

Please note that while ALCAM outputs may help to guide the risk assessment process, the limitations of the model need to be taken into account. For instance, the model:

- May not capture all risks at a particular site.
- May be influenced by the accuracy of the site specific data used.

Should ALCAM data be found to be incorrect during the risk identification and assessment, the Policy Manager, Road User Priority and Access should be advised.

For further information on ALCAM please see Appendix B: ALCAM on page 18.

7.2 Risk evaluation

Risk evaluation involves taking into account the risk rating of an RC, the existing safety management measures, and the additional safety management measure options that need to be taken to reduce risk levels to Low.

Risk evaluation takes place during Step 4 of the risk assessment procedure.

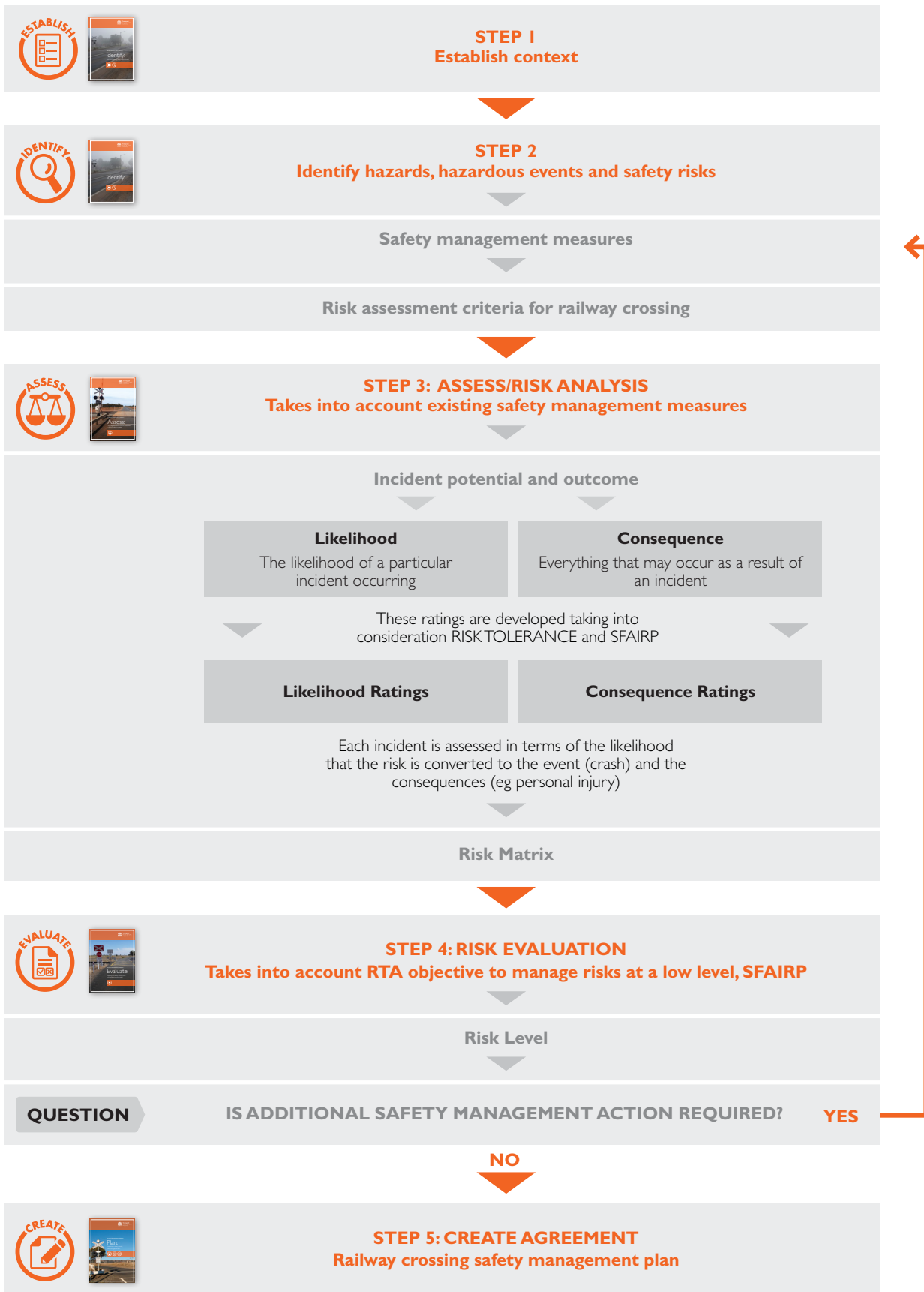
The aim of risk evaluation is to reduce risk levels at an RC which have been assessed Medium, High, or Extreme during risk analysis, so far as is reasonably practicable, through the application of a hierarchy of safety management measures. These measures include operations, behavioural and infrastructure initiatives. These measures are listed below. Please note that planning and managing safety management measures, so far as is reasonably practicable, requires planners to recognise that a balance is required between managing a safety risk and the time, effort, resources and costs involved.

Planners can use the following safety management measure options to minimise risks at, and on the approach and departure to an RC:

- Maintaining road components at an RC.
- Closing an RC.
- Upgrading an RC.
- Grade separating an RC.
- Building a new RC.
- Improving traffic management.
- Roadworks.
- Maintaining road infrastructure, traffic facilities, and road traffic control signals and systems on approach and departure to RC.
- Road user enforcement.
- Driver education and behavioural campaigns.
- Coordinating active RC control with adjacent road traffic signals.

The principles to be used by planners in the risk evaluation of an RC are outlined in Appendix C: Principles of risk evaluation for railway crossings on page 20.

FIGURE I: THE RISK ASSESSMENT PROCEDURE – A SCHEMATIC INTERPRETATION



Appendices

Section 8

Appendix A: Crash and fatality rates and traffic management measures at railway crossings

Crash and fatality rates at railway crossings

A comparison of crash and fatality rates at railway crossings (RCs) with those that occurred at intersections⁴ in New South Wales for the 10 years 2000 to 2009, reveal that the number of crashes and fatalities at RCs is very low compared to those at intersections. During this period there were:

- 22 fatalities at RCs, 17 of those fatalities were in crashes involving a train.
- 356 crashes at RCs, 73 of those crashes involved a train.
- 996 fatalities at intersections.
- 220,913 crashes at intersections.

The historically low number of crash and fatality occurrences at RCs supports the effectiveness of the current management approach used to minimise safety risks at RCs.

Railway crossing management measures

The RTA's safety management approach involves:

- Active participation in the Level Crossing Strategy Council (LCSC).
- The maintenance, operation and upgrade of RCs.
- The implementation of road user behavioural campaigns.
- Working with the NSW Police Force on enforcement at an RC.

Grade separation of RCs does occur but is typically as a result of meeting a combination of safety and efficiency objectives within a major road improvement project.

The RTA utilises the following approach in the provision of safety management measures on the State road network to manage traffic movements across RCs:

- Traffic control devices in accordance with Australian Standard AS 1742.7.
- The implementation of safety management measures on the road network⁵ on approach and departure to an RC.
- Statewide behavioural campaigns and site-specific enforcement campaigns to encourage safe driver behaviour in New South Wales.

⁴ Intersection crashes have been chosen as this crash type is the closest in nature to those that occur at RCs.

⁵ The need for safety management measures is based on the identification of risks, hazards and hazardous events at the RC that can be minimised with these measures. The type of safety management measure used will depend upon the design and operational conditions at an RC.

Appendix B: ALCAM

Australian Level Crossing Assessment Model (ALCAM)⁶

The Australian Level Crossing Assessment Model (ALCAM) is an assessment tool used to identify key potential risks at RCs and to assist in the prioritisation of railway level crossings according to their comparative safety risk. It provides a quantitative method for assessing and prioritising safety risks.

ALCAM is a complex scoring algorithm which considers each RC's physical properties (characteristics and controls) including consideration of the related common human behaviours, to provide each RC with a 'Likelihood Factor' score. This score is then multiplied by the RC's 'Exposure' score (a factor taking into account the volumes of vehicles, pedestrians and trains) and finally multiplied by the 'Consequence' score to give the ALCAM Risk Score. The ALCAM risk score enables the comparison of the relative scores across RCs within a given jurisdiction. This provides an overall risk rating for the RC however each individual hazard needs to be considered in its own right.

ALCAM produces both an overall comparative risk score for each RC as well as highlighting where specific potential hazards exist. It utilises likelihood bands as a preliminary means of determining the potential level of likelihood of an incident (High/ Medium/Low) at an RC. ALCAM is then used in the determination of proposed treatments to address these hazard areas. A total data management system is used (the Level Crossing Management System – LXM) to allow for the effective management of ALCAM data as well as other important information (such as accident history) which assists in the overall decision making process.

It is important to note that ALCAM is only one of the tools used in the safety assessment of RCs. Consideration also needs to be made to address other elements, such as full social and economical impact, as well as RC specific safety factors. While ALCAM does produce various outputs, this does not preclude the need for sound engineering, operational and human factor judgment. ALCAM should be used in conjunction with stakeholder level crossing assessments, standards and other risk mitigation strategies. ALCAM should be applied by road and/or railway safety engineers or other similar professionally qualified staff who have been trained by approved ALCAM instructors in the proper application of ALCAM. This needs to be combined with appropriate expertise and experience in RC safety risk management and knowledge of the applicable RC standards.

The ALCAM likelihood factor score, in conjunction with the ALCAM likelihood band, is used to indicate the likelihood of an incident at the level crossing (High/Medium/Low) based on the exposure of each individual rail vehicle, road vehicle or pedestrian, which can then be used to assist in the determination of whether treatment is likely to be required at a particular level crossing. To identify whether the controls at an RC are likely to be considered adequate, ALCAM compares the likelihood factor with likelihood bands.

Figure 2 (following page) illustrates the three Likelihood Bands and action most likely to be required for each.

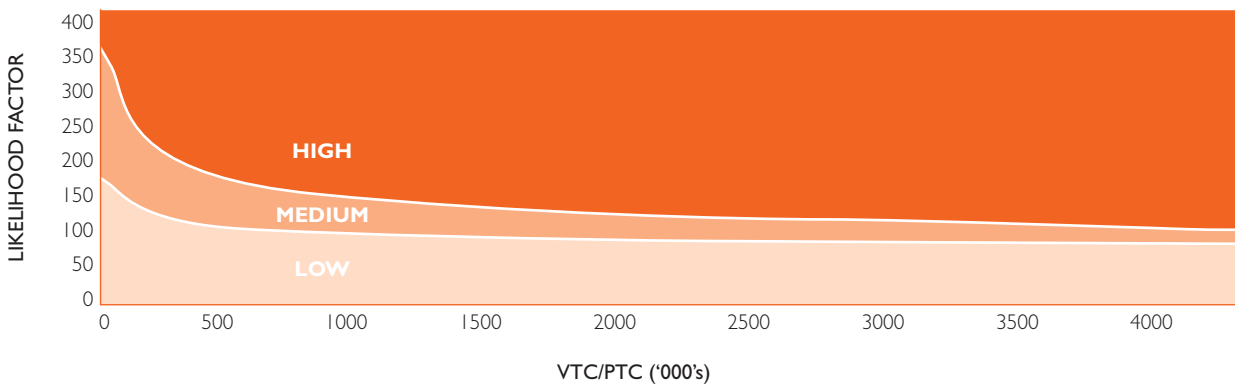
⁶ Australian Level Crossing Assessment Model – ALCAM in Detail. Department of Transport, February 2010. www.transport.nsw.gov.au/sites/default/file/levelcrossings/ALCAM_In_Detail-NSW.pdf.

FIGURE 2: ALCAM LIKELIHOOD BANDS AND 'INTERVENTION' AND 'INSTALLATION' LIMITS

High	Safety improvement highly likely – factors have been identified that may require priority attention and are likely to require mitigation works to be undertaken to return to an acceptable level.
Medium	Safety improvement to be considered – factors have been identified that may require further assessment by road and railway entities. Remedial action may be required to address hazards.
Low	Safety at site to be monitored – indicative that appropriate control is in place and that remedial action may not be required. Ongoing monitoring by road and railway entities is required.

These likelihood bands are defined on a scale dependant on the exposure and consequence rating ($V \times T \times C$ or $P \times T \times C$ where V = road vehicle volume, P = pedestrian volume, T = train volume, C = consequence factor)⁷. As the exposure increases, the acceptable likelihood level will decrease. This recognises that where there is a higher level of exposure there is a greater opportunity for an incident to eventuate and therefore a lower tolerable level of likelihood. Figure 3 illustrates the general shape of the likelihood bands.

FIGURE 3: LIKELIHOOD BANDS (GRAPHIC REPRESENTATION)



It is important to note that the output from ALCAM's risk assessment of a level crossing may not always align with the RTA's risk assessment using the risk tolerance and risk assessment criteria in this report.

⁷ The calculation of the 'likelihood bands' in ALCAM does not align with the RTA's method of determining likelihood. 'Consequence' is not included in RTA likelihood considerations, but introduced later in the procedure as a separate factor in determining 'risk level'.

Appendix C: Principles of risk evaluation for railway crossings

The following principles must be used in the risk evaluation of a railway crossing (RC). The use of these principles will facilitate a consistent approach by RTA planners.

- The minimum safety risk control treatment for an RC is the provision of infrastructure in accordance with Australian Standard AS 1742.7 for the existing type of control at the RC. Please note that the infrastructure does not need to be the same as that required in the current standard; it must, however, be in accordance with the standard in place when the RC was last upgraded.
- Active control, including bells, lights and boom gates, should be provided as a minimum at all RCs on State roads.
- It is mandatory that the RTA undertake maintenance and operation of road infrastructure, traffic facilities and road traffic control signals and systems under its control in accordance with RTA policies and procedures.
- In some instances providing the solution with the highest risk reduction capability is not feasible. In this context, incremental risk reduction through the provision of more realistic safety improvements is acceptable. As an example, an enforcement regime may be a realistic safety management measure in the short-term while approval of funding for infrastructure works is obtained.
- The origin of risks, hazards and hazardous events are diverse and include road and train use, design and environmental factors. The management of risks at an RC may require the application of only one or of multiple safety management measures.
- The RTA's *Evaluate: Applying the railway crossing cause consequence bow tie models* should be used in determining safety management measure options for an RC risk type.
- The intent of railway crossing safety management plans is to assess the appropriateness of existing safety management measures and to determine if additional measures are required. Safety management measures requiring RC and road network changes, including closing an RC, upgrading an RC, the provision of a new RC, the grade separation of an RC, traffic management improvements or roadworks, will necessitate further detailed planning in order to assess their feasibility, impacts and benefits.
- Inclusion of road closure and grade separation as safety management measure options will require approval by the Network Management Directorate.

Section 9

Glossary

- **Active advance warning sign:** a sign that provides advance warning of the impending or current operation of flashing signals at a railway crossing through the use of flashing yellow signals within the advance warning sign. These comprise the RX-11 assembly provided in AS 1742.7.
- **Active control:** controlling the movement of vehicular or pedestrian traffic across a railway crossing using devices such as flashing signals, gates or barriers (or a combination of these), where the device is activated prior to, and during, the passage of a train through the crossing. These comprise the RX1, RX2 and RX5 assemblies as defined in AS 1742.7. See also the glossary entry for 'passive control'.
- **ALCAM:** the Australian Level Crossing Assessment Model. A quantitative risk assessment and risk ranking tool used to assess and prioritise railway crossing risks across New South Wales. See www.transport.nsw.gov.au/sites/default/file/levelcrossings/ALCAM_In_Detail-NSW.pdf.
- **Barrier:** an alternative term for a safety management measure.
- **Bow tie model:** a qualitative risk assessment technique that 'links' the relationships between the causes of crashes ('risks'), the initiatives or controls designed to mitigate the potential for a crash ('safety management measures'), the crashes ('incidents'), the initiatives or controls designed to reduce the negative outcomes of an incident ('post-incident management measures'), and the outcome of an incident despite the initiatives and controls ('consequences'). The bow tie model is an integral part of the RTA railway crossing risk assessment and management procedure.
- **Broadly acceptable:** a level of risk deemed to be Low or Negligible and, when considered in the context of all risks being managed by the organisation, requiring no further action to comply with the 'so far as is reasonably practicable' principle.
- **Clear zone:** the area adjacent to the traffic lane that should be kept free from features that would potentially be hazardous to errant vehicles. The decision of whether or not to include a clear zone is based on the consideration of the recovery area for every errant vehicle, the cost of providing that area, and the probability of an errant vehicle encountering a hazard. The clear zone should be kept free of non-frangible hazards where economically and environmentally possible. Alternatively, hazards within the clear zone should be treated to make them safe or be shielded by a safety barrier (Austroads, 2008).
- **Consequence:** the outcome of an incident that has arisen from a risk. In the context of a railway crossing, a consequence may involve the injury and/or death of road or rail users, delays to people and freight on the road or rail networks, and property and environmental damage. Note that:
 - There can be more than one consequence from one incident.
 - Consequences can be expressed qualitatively or quantitatively.
 - Consequences are considered in relation to the achievement of RTA objectives, especially those related to road safety.
- **Coordination provisions of the NSW Rail Safety Act 2008:** the purpose of these provisions is to ensure that rail infrastructure managers and roads authorities identify risks to safety arising from rail or road crossings, so far as is reasonably practicable, determine measures to manage, so far as is reasonably practicable, those risks, and seek to enter into agreements to manage those risks.

The provisions are intended to ensure that risks arising from rail or road crossings are identified and that the accountabilities for risk control measures are clearly articulated.

- **Crash:** see the glossary entry for 'incident'.
- **Design for safety:** design that uses a safe systems approach. See also the glossary entry for 'safe systems approach'.
- **Frangible:** Roadside furniture designed to collapse on impact. The severity of potential injuries to the occupants of an impacting vehicle is reduced, compared to those that could occur if the furniture was unyielding.
- **GIS database:** see the glossary entry for 'Railway crossing GIS database'.
- **Hazard or hazardous event:** a source of potential harm or a situation with a potential to cause harm (as defined in AS 4360: 2004). A hazard is anything that may cause a risk – here 'risk' includes physical risks (eg, objects), environmental conditions (eg, fog) and road user behaviour (eg, crossing the centre line). See also the glossary entry for 'risk'.
- **Hazard identification:** the process of identifying and characterising hazards that exist or potentially exist.
- **Hierarchy of control:** a legal and logical preference of treating or controlling risk. For example, using the principles of SFAIRP and incremental road safety to spread limited resources across many demands.
- **Incident:** a crash at, or as a result of the operation of, a railway crossing. Incidents occur where safety management measures either fail, or are not present, when required. Incidents can include: a vehicle or pedestrian being struck by a train; a vehicle or pedestrian being struck by a vehicle; and railway crossing infrastructure being struck by a vehicle.
- **Infrastructure:** the network and devices used to carry or display the information, services and equipment required for the operation of railway and road systems. These include railway crossing control systems and equipment, such as flashing lights, boom gates, signal huts or culverts to clear stormwater.
- **Interface agreement:** an agreement in writing regarding the management of risks to safety that are identified and managed under Division 3 of the *NSW Rail Safety Act 2008*. An interface agreement includes provision for:
 - The implementation and maintenance of measures to manage those risks.
 - The evaluation, testing and (if appropriate) revision of those measures.
 - The respective roles and responsibilities of each party to the agreement in relation to these measures.
 - A process for reviewing and revising the agreement.
- **ITSR:** the Independent Transport Safety Regulator. See www.transportregulator.nsw.gov.au
- **LCSC:** the Level Crossing Strategy Council. See www.transport.nsw.gov.au/levelcrossings
- **Level crossing:** the area where a road and a railway meet at substantially the same level. Please note, however, that a level crossing does not include the road related area, such as the road shoulder, the dividing strip and pedestrian paths (see Rule 120 of the *NSW Road Rules 2008*). 'Level crossing' is used colloquially as an alternative term for a railway crossing.
- **Likelihood:** a general description of probability or frequency. In the context of a railway crossing, likelihood refers to the probability of an incident occurring.
- **Local road:** an administrative category of roads in NSW. Local roads are under the care, control and funding of local governments. See www.rta.nsw.gov.au/doingbusinesswithus/downloads/lgr/reg_table_for_internet_31jan11.pdf for a list of roads classified as regional or State (local roads can be identified as those not appearing on the list).
- **May:** 'may' is used in this document to make *recommendations* of good practice.
- **Must:** 'must' is used in this document to give mandatory directives.
- **Near miss:** a failure by a safety management measure that does not result in a crash. In the operation of a railway crossing, the Independent Transport Safety Regulator defines a near miss as "Any occurrence where the driver of a moving train takes emergency action, or would have if there was sufficient time, to avoid impact with a person, vehicle or other obstruction, and no collision occurred. Emergency action includes continuous audible warning and/or brake application."

Source: www.rsrp.asn.au/files/publications/12_30..pdf

- **Operational issues:** events or potential events that may impact upon the safe and efficient movement of road or rail traffic.
- **Over Size Over Mass:** a category of heavy vehicle which includes vehicles that, either on their own or with their loads included, exceed a relevant mass or dimension limit of the *Road Transport (Vehicle Registration) Regulation 2007* or *Road Transport (Mass, Loading and Access) Regulation 2005*. Examples include special purpose vehicles (eg, mobile cranes), vehicles carrying an indivisible load (eg, a wind power generator blade), and agricultural vehicles (eg, tractors and airseeders). In such cases, authority to travel is provided by a vehicle permit system (see www.rta.nsw.gov.au/heavyvehicles/oversizeovermass/index.html or www.rta.nsw.gov.au/heavyvehicles/downloads/operating_conditions-oversize_overmass.pdf).
- **Passive control:** controls the movement of vehicular or pedestrian traffic across a railway crossing using signs or devices which rely on the road user detecting the approach or presence of a train by direct observation. In other words, in passive control the signs and devices are not activated during the approach or passage of a train. For definitions of crossing control types see page 15 of ITSR www.rsrp.asn.au/files/publications/12_30.pdf.
- **Person:** refers to a natural person, or a company, partnership, joint venture, the association or corporation of another body corporate, or any governmental authority.
- **Planner:** the officer responsible for the planning and management of a safety management plan at a railway crossing. The planner is normally appointed by the directorate delegated to deliver the project on behalf of the project sponsor; but in some cases the planner is appointed by the project sponsor.
- **Policy Manager, Road User Priority and Access:** the position responsible for the policy, strategy and program management of railway crossings in the RTA's Traffic Management Branch, Network Services Directorate.
- **Post-incident management measure:** any measure which aims to:
 - Limit the severity of an incident (crash) once it has occurred.
 - Reduce the likelihood of consequences (that is, injuries and fatalities to road and rail users) of that incident.
 - Reduce the likelihood of a secondary incident occurring (that is, a subsequent crash) as a result of the initial incident.
 - Reduce the likelihood of consequences occurring as a result of a secondary incident, should it occur.
- **Project Manager (railway crossings):** the RTA's Infrastructure Services, Road Safety and Traffic Management section officer responsible for the day-to-day management of railway crossings in their region.
- **Public road:** any road that is opened or dedicated as a public road, whether under the *Roads Act 1993* or any other law; and any road that is declared to be a public road for the purposes of the *Roads Act 1993* but does not include a Crown road.
- **Rail infrastructure manager:** the person who has effective management and control of the rail infrastructure of a railway, whether or not the person owns the rail infrastructure, or has a statutory or contractual right to use the rail infrastructure or to control and/or provide, access to it. In NSW rail infrastructure managers include:
 - The Australian Rail Track Corporation (ARTC).
 - The Rail Corporation New South Wales (RailCorp).
 - The Country Rail Infrastructure Authority (CRIA).
 - The Transport Infrastructure Development Corporation (TIDC).
 - Rail infrastructure managers of isolated lines and private sidings.
 (Source: Section 4 of the *NSW Rail Safety Act 2008*.)
- **Rail transport operator:** may be a rail infrastructure manager, or a rolling stock (train) operator, or a person who is both (*NSW Rail Safety Act 2008*). Typically, the term 'rail transport operator' is used to refer to any person who operates rolling stock on the railway.
- **Rail reserve:** the land dedicated for the operation of a railway.

- **Railway:** a guided system designed for the movement of rolling stock, which has the capability to transport passengers or freight on a railway track together with its infrastructure and rolling stock.
- **Railway crossing:** the area where a road and a railway cross at substantially the same level. This includes the land, features and infrastructure bounded by the rail reserve and prolongation of the road boundary.
- **Railway crossing area of influence:** in the roads authority context, this includes the railway crossing and an agreed distance along the approach roads that are considered to be essential to ensure the safe operation of both the railway crossing and the traffic which is affected by the operation of the railway crossing. The length of road agreed upon typically relates to the provision of traffic control devices such as warning signs. However, the area of influence may extend further along the road, as the length of vehicle queues may influence road safety further than the warning signs. For instance, a crash at the back of the queue of traffic might be associated with the operation of the railway crossing.
- **Railway crossing GIS database:** a spatial database used to store information regarding railway crossings. Among its uses is the mapping of railway crossings with other spatial information such as road crashes. This database is managed by the RTA's Road Information and Asset Management Technology section.
- **RC:** railway crossing.
- **RC Risk Register:** a list of those sites where risk is deemed to be above a 'broadly acceptable' level. These sites are prioritised for treatment when funds are available. The register is held by the Policy Manager, Road User Priority and Access, Traffic Management Branch. See also the glossary entry for 'broadly acceptable'.
- **Recovery measure:** another term for a post-incident management measure.
- **Regional road:** an administrative category for roads in New South Wales. Regional roads are roads under the care and control of local governments, with funding provided by local government and supplemented by the RTA under the 'block grant agreement'. For information on the block grant agreement see www.rta.nsw.gov.au/doingbusinesswithus/lgr/index.html. For a list of classified roads, including their administrative category, see www.rta.nsw.gov.au/doingbusinesswithus/downloads/lgr/reg_table_for_internet_31jan11.pdf.
- **RAV:** Restricted Access Vehicle. A vehicle that is larger than a general access vehicle, as defined in the *Road Transport (Mass, Loading and Access) Regulation 2005*. These vehicles are restricted to travel on specified (gazetted) routes in New South Wales. Common configurations include B Double and Road Trains. See also the glossary entry for 'Over Size Over Mass Vehicle' for another category of vehicle/load that is larger than the general access limits.
- **Risk:** the chance of something happening that will have an impact on RTA road safety objectives. A risk is:
 - Often specified in terms of an event or circumstance and the consequence that may flow from it.
 - Measured in terms of a combination of the consequences, their likelihood and exposure.
- **Risk analysis:** the assessment of the risks presented by an RC in terms of the likelihood and consequences of incidents that might arise from these risks, taking into account the existing safety management measures at that railway crossing.
- **Risk assessment:** the overall process of identifying, analysing and evaluating risks, hazards and hazardous events at a railway crossing. See also the glossary entries for 'risk analysis' and 'risk evaluation'.
- **Risk assessment criteria:** standards for the comparison and evaluation of risks at railway crossings. See *Assess: Applying risk tolerance and risk assessment criteria to railway crossings*, Section 5, for a discussion of these criteria.
- **Risk assessment procedure:** a five-step procedure used to identify, assess, evaluate and manage safety risks and safety management measures at railway crossings. This five step procedure is detailed in Appendix A of *Plan: Establishing a railway crossing safety management plan*.
- **Risk category:** a way in which risks at a railway crossing are grouped according to the different types of road user behaviour from which they arise. See *Evaluate: Applying the railway crossing cause consequence bow tie models*, Section 2.1.

- **Risk control:** the part of risk management that involves the implementation of policies, standards, procedures and physical changes to eliminate or minimise adverse risks (AS 4360).
- **Risk evaluation:** the process of comparing the existing level of risk at a railway crossing with the new level of risk that would eventuate from the implementation of changes to risk management, should any be deemed necessary, arising from the risk analysis process. Risk evaluation therefore often involves a comparison of the effects of existing safety management measures with the effects of revisions to the existing safety management measures. Often a number of alternative revisions are considered during risk evaluation.
- **Risk level:** a qualitative measure that brings together the likelihood and consequence of a risk, on a scale from Negligible to Extreme, to allow the ranking of risks and the prioritising of mitigation or safety management measures where the level of risk is above the 'broadly acceptable' threshold. See also the glossary entry for 'broadly acceptable'.
- **Risk level:** this is determined taking into account the risk assessment criteria of likelihood and consequence, and assigned through use of the risk level matrix. See *Assess: Applying risk tolerance and risk assessment criteria to railway crossings*, Section 5.
- **Risk level matrix:** a matrix which uses the risk assessment criteria as they apply to a particular railway crossing to generate a risk level for that particular risk. See *Assess: Applying risk tolerance and risk assessment criteria to railway crossings*, Section 5.5.
- **Risk management:** an overall process of hazard identification, risk assessment and risk management, which includes the implementation, and active monitoring and review, of controls, policies, procedures and practises, to manage those risks, so that they are maintained at a level that is as low as is reasonably practicable.
- **Risk ranking:** An output of ALCAM which sorts the relative safety of public railway crossings throughout NSW from greatest risk to lowest. A railway crossing ranked 'one' is judged to have the highest risk.
- **Risk rating:** the overall risk level of a railway crossing.
- **Risk tolerance:** the amount of risk that the RTA is prepared to accept, tolerate, or be exposed to, before it judges that action is necessary to reduce or eliminate that risk. Decisions regarding risk tolerance take into account all the risks to the RTA in the context of exhaustible resources. Risk tolerance is a function of ranking a risk against all other assessed risks and determining at what risk level risk mitigation action should be taken, SFAIRP. For the purposes of railway crossing risk assessments, levels of Negligible and Low are considered to be broadly acceptable.
- **Risk type:** a way in which risks at a railway crossing are grouped which takes into consideration both road user behaviour and the control, design and operational elements at a railway crossing. Risk types are organised as sub-categories of risk categories. See *Evaluate: Applying the railway crossing cause consequence bow tie models*, Section 2.1.
- **Road carriageway:** the portion of a road or a bridge devoted particularly to the use of vehicles, inclusive of shoulders and auxiliary lanes (*Austroroads Glossary of Terms 2010*).
- **Road project:** a project funded or commissioned by the RTA that results in a new road or new traffic management infrastructure, or a physical change to the infrastructure of an existing road which, subsequent to this change, will become part of the State road network in NSW. Examples of road projects include:
 - A new motorway or improvement to an existing motorway.
 - A new arterial road or an upgrade to an existing freeway or arterial road, including road widening, traffic control signals, intelligent transport systems and traffic control facilities.
 - An enhancement to the road-based public transport network, such as a transitway or bus priority measure on an existing freeway or arterial road.
- **Road Safety Audit policy:** released as a Technical Direction by the NSW Centre for Road Safety TD 2003/RS03, Version 2 in August 2005. This provides an imperative to conduct road safety audits. See www.rta.nsw.gov.au/roadsafety/downloads/tds/td2003rs03-aug05.pdf.

- **Road Safety Audit process:** a formal examination of an existing road, or a future road or traffic project, in which an independent qualified team looks at the project's potential crash and safety performance. The process may be applied to an existing road network, to concept or detail designs prior to road construction, during road construction or before opening the road to traffic.
- **Road:** a private road or a public road that has, as one of its main uses, the driving or riding of motor vehicles, and includes any relevant road-related area within the meaning of the *NSW Road Rules 2008*.
- **Road user:** a driver, rider, passenger or pedestrian (*NSW Road Rules 2008*).
- **RTA:** the Roads and Traffic Authority of New South Wales.
- **Safe systems approach:** an approach that provides for safety to be considered throughout all phases of a road project, as all phases can be seen as contributing to the provision of a safer system. For example, a safe systems approach to a road project would include the following: designing the road, roadside areas and traffic management measures to provide a forgiving environment for all road users (safer roads); public education (safer people); and, vehicle safety standards (safer vehicles).
- **Safety control measure:** an alternative term for a safety management measure. See also the glossary entry for 'safety management measure'.
- **Safety management measure:** any measure (including legal measures, physical actions, engineering measures, educational measures and so on) that aims to prevent or mitigate an incident.
- **Safety management plan:** a railway crossing safety management plan is a contract between the RTA and other relevant parties which details how safety risks, safety management measures and post-incident management measures will be managed at a railway crossing, so far as is reasonably practicable.
- **Safety risk:** another term for 'risk'. See also the glossary entry for 'risk'.
- **SFAIRP:** see the glossary entry for 'so far as is reasonably practicable.'
- **Shall:** 'shall' is used in this document to give mandatory directives.
- **Should:** 'should' is used in this document to make *recommendations* of good practice.
- **So far as is reasonably practicable:** what is (or was at a particular time) reasonably practicable in relation to ensuring safety with regard to risk, taking into account:
 - The likelihood of a risk eventuating.
 - The degree of harm that would result if a risk eventuated.
 - What the person concerned knows, or ought reasonably to know, about a risk and any ways of eliminating or reducing a risk.
 - The availability and suitability of ways to eliminate or reduce risk.
 - The cost of reducing or eliminating a risk.

(Source: Section 6 (2), *NSW Rail Safety Act 2008*)

- **State road:** an administrative category for roads in NSW. The RTA takes responsibility for managing the primary traffic function of State roads, including funding and determining priorities. The RTA also regulates the activities of third parties – including local councils and contractors – on the road. This is to ensure that road safety and traffic efficiency are promoted and consistently applied across the major traffic routes throughout the State, and that the road asset is protected. Activities that are located outside of the primary traffic area do not relate to traffic control, such as footpaths, are generally the responsibility of local councils. See www.rta.nsw.gov.au/doingbusinesswithus/downloads/lgr/reg_table_for_internet_31jan11.pdf for a list of roads classified as State roads.
- **Unincorporated area:** the area in the far west of NSW that does not have a local government. The *Western Lands Act 1901* established the position of the Western Lands Commissioner who is responsible for administering the Act, subject to the control and direction of the Minister for Lands. The Unincorporated Area is managed by the NSW Department of Lands under direction of the Western Lands Commissioner. See www.edo.org.au/edonsw/site/factsh/fs02_6.php.

This document is part of the Railway Crossing Safety Series 2011, the documents that make up the series are:

- Plan: Establishing a railway crossing safety management plan (*policy number PN239G*)
- Identify: The railway crossing safety hazard checklist (*policy number PN241G*)
- Assess: Applying risk tolerance and risk assessment criteria to railway crossings (*policy number PN238G*)
- Evaluate: Applying the railway crossing cause consequence bow tie models (*policy number PN240G*)

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