

## **Implementing the Australian Level Crossing Assessment Model (ALCAM) in Victoria**

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### **1.0 Introduction**

In Australia each state and territory is responsible for road and rail transport regulation in its jurisdiction. Each state and territory has a level crossing strategy committee comprising high-level management representation from both road and rail entities. These state based committees are chartered with the continuing improvement of safety at level crossings within their jurisdiction. Prior to the Australian Level Crossing Assessment Model (ALCAM) various methods of level crossing analysis were utilised involving basic risk allocation combined with predetermined warrants (exposure based levels of control, eg upgrade from flashing lights to booms at a road / rail exposure of 100,000 VT (vehicle/train) quantities). These methods did not encompass sufficient detail to adequately address some of the more critical / complex safety risks such as queuing, short stacking<sup>1</sup> and visibility constraints. The major difficulty in addressing risks at level crossings is the determination of how to achieve the optimal results with the available resources. A tool, which consistently assesses the characteristics at each level crossing, was required to effectively determine priorities when addressing safety risks at these sites. A project team was formed to establish such a tool, which has now undergone a variety of improvements to reach the stage it is at today. See table 1 (p.10). This paper has been prepared to demonstrate that ALCAM provides a safety assessment tool to be used to assist in the prioritisation of railway level crossings according to their comparative safety risk. It provides a rigorous defensible process to assist with decision making for road and pedestrian level crossings as well as a method to help determine the optimum safety improvements for individual sites. A total data management system is provided (the Level Crossing Management System – LXM) to allow for the effective management of ALCAM data as well as other important information (such as incident/accident history and digital photographs) which assists in the overall decision making process.

The main benefits of ALCAM and the LXM system, include the:

- Ability to rank level crossings within a jurisdiction using a consistent basis according to a detailed level of comparable risk, exposure and consequence
- Identification of potential accident causal factors and overall effects of proposed treatments
- Provision of a level crossing warehouse inventory/ asset management database (including digital photographs)

Through the Australian Transport Council of Ministers (ATC) and the Standing Committee of Transport (SCOT) all state and territory transport ministers agreed to adopt the Australian Level Crossing Assessment Model. ALCAM is overseen by a committee (the national ALCAM Group) of representatives from these states and territories to ensure its consistency of development and implementation.

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<sup>1</sup> (Short stacking is where the road conditions require a long heavy vehicle to stop after passing over a railway crossing, with the rear of the vehicle remaining foul of the railway lines.)

## **2. Implementing ALCAM in Victoria**

The Victorian Railway Crossing Safety Steering Committee (VRCSSC) adopted ALCAM during 2006 to identify public risk and risk mitigation treatments at all Victorian railway crossings and to objectively prioritise upgrades across Victoria. In October 2005 the Department of Infrastructure awarded a competitive tender to Ernst & Young in partnership with Forensic Collision Investigators, to carry out ALCAM risk assessment field surveys at all 3132 road and pedestrian public railway crossings in the State. ALCAM field surveys will take until December 2007 to complete.

Victorian ALCAM field surveys do **not** currently include “**occupation or private**” railway crossings, which will be undertaken in 2008/09. They do include the three (3) Victorian main line rail networks. These networks comprise the **Connex Melbourne Limited** (CML), (Victorian **Metropolitan** Rail Network). The **V/Line Passenger Pty Ltd**, (Victorian **Intrastate** Rail Network, including those rail lines which are part of the Victorian branch line rail network extending into southern NSW). The **Australian Rail Track Corporation** (ARTC), (Victorian **Interstate** Rail Network to the South Australian border at Wolsley and the New South Wales border at Albury, via Southern Cross). The ALCAM field surveys also include the ten (10) accredited Heritage/Tourist rail lines throughout Victoria, which have been identified as having public road/rail and pedestrian level crossings.

ALCAM is replacing the 1990's VicRoads Railway Crossing Prioritisation model, which was a simple excel spreadsheet which was ‘accident history’ and ‘overly’ cost benefit biased and which has become outmoded for a railway crossing safety risk management application today and which is not considered appropriate to accommodate the more appropriate and cost effective ‘so-far-as-is-reasonably-practicable’ risk reduction requirements of the new risk based Victorian *Rail Safety Act 2006* and the *NTC (Model) Rail Safety Bill 2006*.

### **2.1 The current status of ALCAM implementation in Victoria**

As at 31 August 2007 a total of 2365 ALCAM field surveys had taken place, or were in progress, including 652 metropolitan road and pedestrian crossings on the Connex ‘electrified’ rail network, 1642 on the Victorian regional rail lines, and 71 on four Heritage/Tourist rail lines.

Initially, all of the project attention was very much focused on the project ‘Quality Assurance’ process associated with the tender scope of works. This has been to ensure that Victorian railway crossing field surveys are being conducted strictly and accurately in accordance with the National ALCAM Crossing Assessment Handbook - Field Survey Guidelines and that both field survey teams are accurately and consistently collating field survey data between themselves. The project is now finalising planning for the tender scope of work items No’s 5, to 8 (below).

### **2.2 Victorian regional ALCAM field surveys - prioritisation**

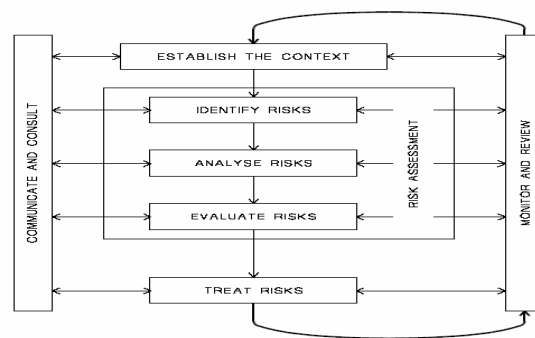
Prioritisation of non-metropolitan rail crossing ALCAM field surveys are being conducted on a risk based priority basis as follows;

1. Connex ‘Electrified’ Metropolitan rail network.
2. 143 Road/Rail Authority Nominated ‘Interim Priority’ Locations (Completed December 2006)
3. Non – Regional Fast Rail (RFR) Passenger Rail lines.
4. RFR lines

5. Heritage/Tourist Rail lines.
6. Metro Freight Lines
7. ARTC Interstate Rail Lines.
8. Regional Freight Lines.

### **3. Risk**

Risk (the chance of something happening that will have an impact on objectives) is widely known and accepted as the combination of both the likelihood (probability or frequency) of the occurrence of an event and the resulting consequence (outcome or impact) of that event once it has taken place. The risk management process as outlined in the Australian Standard and New Zealand Standard (AS/NZS 4360:2004, which is similarly represented in other international standards, follows a simple series of steps as outlined below (Figure 1):



**Figure 1 – Risk Management Process – AS/NZS 4360 : 2004 Risk Management Standards**

ALCAM and the ALCAM process considers all elements outlined in AS/NZS 4360:2004. It involves communication and consultation with a wide range of technical experts as well as the local stakeholders at individual sites. The context is well established as the safety risks relating to the potential of a collision at the at grade intersection of a roadway and railway. It identifies, analyses and evaluates the risks inherent at level crossings as well as giving determination of the adequacy of proposed treatments for the risks. Finally the model and the results produced from the model are regularly monitored and under a process of continual review and improvement.

In line with safety risk modelling principles ALCAM looks at risk from the viewpoint of consideration of loss (negative consequence) only as opposed to risk and reward (loss and gain).

The model considers both qualitative and quantitative characteristics (see Appendix A & B) as well as assessing the impact of physical properties (characteristics and controls, see Appendix C & D) including consideration of the related common human behaviours. It looks at the likelihood of a collision as well as the consequential effects resulting from that collision. The model allocates weightings to each characteristic in relation to how it would contribute to a collision and assesses what impact the existing controls would have on these characteristics. (See Section 4.8 – Treatment).

## **4. ALCAM mechanics**

In simple terms ALCAM is a mathematical tool which considers physical characteristics and controls in existence at both road and pedestrian level crossings. It considers these elements as well as the common motorist/pedestrian behaviour at the site to provide a “Risk Score” and “Total Risk Exposure Score” for each level crossing which enables the comparison of relative risk across all level crossings within a given jurisdiction. The ALCAM Mechanics as outlined on the following pages have been illustrated as examples in Appendix A & B (on pages 12 and 13).

### **4.1 Accident mechanisms, characteristics & controls**

The main calculation engine within ALCAM involves a matrix of weightings relating to how much the nominated characteristics at the level crossing influence the potential accident causal factors (accident mechanisms). The model also determines the impact the existing controls would have on these accident mechanisms. Significant and practical accident mechanisms, characteristics and controls have been considered and included through a process of seeking expert opinion through a series of workshops and interviews, involving almost 100 experts in road and rail crossing safety in Australia. The full listing of characteristics, controls and accident mechanisms for both road and pedestrian level crossings can be found in Appendix C and D respectively (on pages 14 & 15).

Mechanisms may be broadly grouped into the following categories:

- Mechanisms where the level crossing user is **unaware** of the dangerous situation.
- Mechanisms where the level crossing user is **unable to avoid** the dangerous situation.
- Mechanisms where the level crossing user is **unwilling** to recognise the dangerous situation.

Each of these mechanisms is then weighted based on a six by six responsibility and likelihood matrix. A mechanism’s weighting is calculated as the product of the responsibility rating and the likelihood rating (weighting score between 1 and 36).

- **Responsibility** - is the extent to which the road or rail infrastructure owner is responsible for the mechanism occurring.
- **Likelihood** - is an assessment of how likely it is that the mechanism causes an accident.

A characteristic is defined as a physical feature of a roadway or railway, or of a level crossing user (motorist or pedestrian), which may to some degree contribute to each of the accident mechanisms occurring. Characteristics include items such as sighting, speed of trains, potential for queuing or short stacking.

Controls are devices installed or implemented to improve the safety risk profile of the site and can include devices such as flashing warning lights, boom gates, signage, improved road alignment and through the effects of education and law enforcement campaigns.

### **4.2 Matrix**

A matrix has been constructed to represent the effect each characteristic would have on each accident mechanism. Some characteristics may have no causal effect on a particular accident mechanism, where some may have a partial effect. If a Characteristic is the only contributor to a

given mechanism then the percentage weighting will be 100%. The total percentage effect for each mechanism must be 100%.

The final output from the Matrix is a Risk Score which is used to help determine whether or not a site will be recommended for safety improvement works. (See 4.6)

The current version of the matrix produces results, which have been shown to quite accurately reflect the current risk profile at each site. This has been determined through a detailed analysis of the results of a number of sample sites across each of the major Australian States in combination with ongoing review of model outputs.

### **4.3 Sensitivity**

A combination of both the weighted percentages and mechanism weightings formulated by a panel of road/rail experts result in each of the accident mechanisms having a different impact on the overall Risk Score at any particular level crossing. There are particular characteristics, which have a greater influence on the overall risk profile at each site. These characteristics include limited sighting of trains (at passive sites), limited approach sighting, queuing and short stacking, proximity to shunting yards and stations, high percentage of heavy vehicles and a hump or dip across the tracks. Steps are being taken to further validate the model including fault and event tree analysis and comparison of outputs with real incident information in several States.

It is these highly sensitive accident mechanisms which have the greatest influence on whether or not a site will be prioritised for safety improvement works.

### **4.4 Exposure rating (consequence / vehicles or pedestrians / trains)**

An exposure rating is calculated for each site made up of three factors. These factors being the Consequence Score (C) the actual road traffic volume (V) or the pedestrian volume (P) and train volume (T). The result of which is either a VTC for road level crossings or a PT for pedestrian level crossings.

Currently ALCAM utilises a relatively simple methodology for the determination of a Consequence. The Consequence Score (C) is determined as a relationship between an environmental factor and a train speed factor. The combination of these two elements result in a modification factor (Consequence), which is applied to the VT of a level crossing. For example, where there is a situation which involves very low train speeds and minimal exposure the VT would be reduced by a factor of 10 (Consequence factor = 0.1). At the other extreme where there are high train speeds and the potential for high exposure to human life (passenger train, or bus) the VT is increased by a factor of 10 (Consequence factor = 10).

The table below recognises and represents the likely outcome once a collision has occurred. It considers both a train speed factor and an environmental factor. The combination of these two elements result in a modification factor (Consequence), which is applied to the VT of a level crossing. For example, where there is a situation which involves very low train speeds and minimal exposure the VT would be reduced by a factor of 10 (Consequence factor = 0.1). At the other extreme where there are high train speeds and the potential for high exposure to human life (passenger train, or bus) the VT is increased by a factor of 10 (Consequence factor = 10).

Factors affecting Consequences		Speed				
		0 - 60	61 - 80	81 - 100	101 - 120	> 120
Environmental Factors	Index	1	2	3	4	5
Curve within stopping distance & Points in direction of travel	1	4	10	10	10	10
Road under bridge or river bridge	2	4	10	10	10	10
Steep embankment 3m +	3	4	4	10	10	10
Multiple track	4	3	4	10	10	10
School bus route	5	3	4	10	10	10
High proportion of heavy vehicles using the level crossing +10%	6	0.1	3	4	10	10
Tunnel within the stopping distance	7	0.1	3	3	10	10
Medium embankment	8	2	3	3	4	4
Curve within stopping distance & No other environmental concerns	9	1	2	3	3	3
Straight track + passengers	10	1	1	3	3	3
Straight track + freight only	11	0.1	1	1	3	3

Table 1 – Consequence table

Consequence effects are only relevant to vehicle level crossing incidents, as pedestrian incidents are limited in their range of effect to the pedestrian involved in the collision and there is no real likelihood of infrastructure damage. In the pedestrian matrix, the exposure rating is a factor simply based on the trains and pedestrian.

The system of consequence modifiers has been developed to have the effect of inflating or deflating the Exposure Score for the level crossing by up to a factor of 10, as a means of recognising the potential human life impact of a collision.

Work is currently under way through the national ALCAM technical Committee to utilise event tree modelling to better represent the potential outcomes of a collision at a level crossing. This will result in Consequence Factors, which more accurately reflect the potential outcomes of the collision, as they will be based on actual statistical data rather than the current expert opinion.

#### 4.5 Intervention & installation limits

The Intervention and Installation Limits in ALCAM are used to indicate a comparative level of safety risk at the site (High / Medium / Low) which is used to assist in the determination of whether treatment is or is not required at a particular site. To identify whether an existing level crossing is prioritised for treatment, or whether proposed controls at a level crossing are likely to be considered adequate, ALCAM compares the Risk Score with the following cut off limits:

- The **Installation Score** indicates a level below which the level crossing risk is *likely to be within acceptable limits*. The Installation Score is indicative of the Risk Score that should be achieved if a new level crossing was being installed at the particular location.
- The **Intervention Score** indicates a level above which there is *likely to be safety hazards* that require priority attention to mitigate the level of risk to road and rail users. This may require short-term and long-term actions to reduce the identified risks.

The diagram below (Figure 2) indicates at what point the comparative level of risk shifts from one category to the next in relation to the Intervention and Installation Limits. For an existing level crossing, where the Risk Score is greater than the Intervention Limit (High Risk), treatment

is generally considered as a high priority. Such treatment should be effective enough to reduce the proposed Risk Score to a level lower than the Installation Limit. For a new level crossing the Risk Score should be lower than the Installation Limit and should consider the future road/rail traffic volumes for the foreseeable future.

For a level crossing with a Risk Score between or equal to the Intervention and Installation Limits (Medium Risk), a further assessment should be carried out to determine if there are treatments which can be employed which are cost effective.

Finally a level crossing with a Risk Score below the Installation Limit (Low Risk), in most cases, is likely to be within acceptable limits from an overall risk perspective to not require to be prioritised for remedial works. A review of the risk factors should be carried out on a regular basis on these sites to ensure there has been no significant change to the risk profile and that there are no specific individual risks which require urgent attention (such as standards compliance).

**Safety improvement required** - Risks have been identified that require priority attention and are likely to require risk mitigation works to be undertaken to return risk to an acceptable level.

#### Intervention Limit

**Safety improvement to be considered** - Risks have been identified that require further assessment by relevant road and railway entities. Remedial action may be required to address any unacceptable risks.

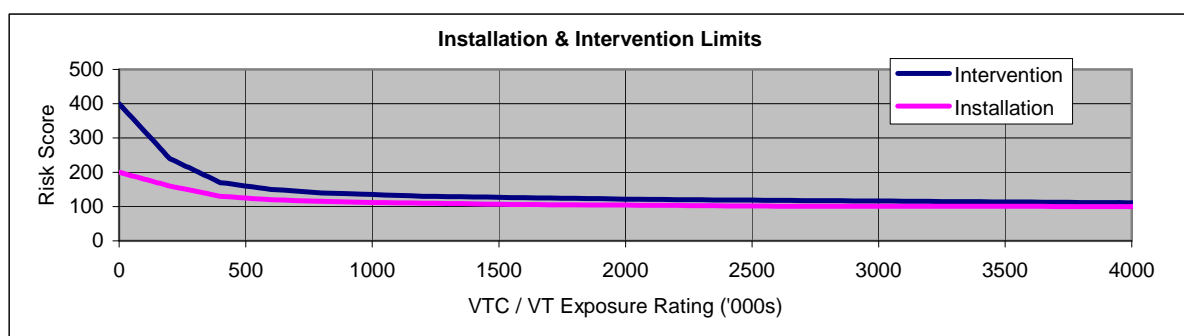
#### Installation Limit

**Safety at site to be monitored** - Indicative that appropriate protection is in place and that remedial action is not likely to be required. Ongoing monitoring by road and railway entities is required.

**Figure 2 – Risk Category**

In any case, pursuant with rail safety legislative requirements to reduce all railway operational risks in so-far-as-is-reasonably-practicable, 'any' risk which can be mitigated, should be mitigated, irrespective of the risk score or risk category.

These Limits are defined on a scale dependant on the risk exposure rating (VTC or PT). As the exposure rating decreases, the acceptable limits will increase. This recognises that where there is a higher level of exposure there is a greater sensitivity of site risk. Figure 3 illustrates the general shape of the Intervention and Installation Limit curves.



**Figure 3 – Intervention & Installation Limits**

Essentially the limits were developed as described in the original (pre-ALCAM) 'Queensland Risk Scoring Matrix System' manuals, as "These limits have been derived by selecting a target accident rate that is considered acceptable for Queensland public level crossings. A comparison of the current accident rate with this target rate has identified that a 35% reduction in accidents is desired. Accordingly, since risk exposure score is the strongest measure of accidents it is necessary to reduce the total risk exposure score for the state by 35%. By using a test sample, the limits have been iteratively varied until a reduction of this order is achieved. The rest of the ALCAM stakeholders have accepted these principles

The Intervention and Installation Limits for risk scores were therefore established to ensure that this target of 35% reduction in risk score could be achieved for the sample

#### **4.6 Total risk exposure score**

The final overall comparative score which is produced by ALCAM is called the "Total Risk Exposure Score" (TRES). This figure is a combination of the Exposure Rating and Risk Score, and is the figure used to compare each level crossing against all other level crossings within a given jurisdiction. By sorting level crossings in relation to their TRES a priority listing is created which can then be used to develop safety improvement programs.

#### **4.7 Flags**

There are particular risks at sites which are identified regardless of the sites overall level of risk (H/M/L). This is to highlight risk areas which although having a low likelihood of occurrence may result in a level of risk which is considered intolerable (eg queuing and short stacking). ALCAM flags such areas of concern to allow further assessment to ensure they are not left unconsidered. A compliance flag is also included in relation to the requirements of the relevant Australian Standard (AS1742.7).

#### **4.8 Treatment**

Once a sites particular risk profile has been calculated for a site the suitable treatments / safety improvement works options can be determined. ALCAM allows the user to run various proposed solutions to the highlighted safety risks and consider the theoretical reduction in overall and specific risk.

It must be understood that active controls are not always the answer. The proposed risk treatment must address the specific risks particular to each site. For example, at a site where queuing has been identified as a risk factor, the introduction of active controls such as boom gates may reduce the overall risk at the site, however, it may not address the queuing risk, and may actually add to the risks associated with vehicles queued on the tracks. A more suitable solution may involve changes to road infrastructure on the departure side of the level crossing or interfacing with adjacent road traffic signals.

It is also very important to ensure that all stakeholders associated with the particular level crossing are involved with the determination of the final recommended treatment. Although ALCAM is a comprehensive tool for the assessment of level crossing risks, it cannot make assessment of unique risks particular to each site. An on site meeting of all relevant stakeholders is recommended at each site to ensure any unique risks are identified and treated



as required. A sites incident history should also be considered at this stakeholder meeting and addressed as required.

It is important to ensure that if an identified risk can reasonably practicably be mitigated then action should be taken to ensure this risk is addressed.

#### **4.9 Cost benefit**

As a part of the determination of the optimal treatment to be implemented at an individual site ALCAM provides an analysis of the reduction in risk of a proposal verses the estimated cost of that treatment. This then allows the comparison of a number of options in relation to their cost benefit, based upon the 'so-far-as-is-reasonably-practicable' cost effectiveness measure for each option. This information is then used at the stakeholder meeting to assist in the determination of the optimal solution.

### **5. ALCAM process**

The ALCAM process involves the collection of data through a combination of site surveys and train and vehicle information from the respective rail and road authorities. Each level crossing must be assessed uniformly using a standardised procedure to gather level crossing data. This requires a simple yet explicit process for the determination of quantitative information in combination with detailed instructions on the determination of qualitative information. Once the data is collected and entered into ALCAM, reports can be run to produce a priority listing, which can be used as the basis for safety improvement programs. A total data management system is provided (the Level Crossing Management System – LXM) to allow for the effective management of ALCAM data as well as other important information (such as incident history and digital photographs) which assists in the overall decision making process.

Proposed treatment options are pre-determined through the use of ALCAM and a treatment report is prepared. The proposals as outlined in this report are then discussed at an on-site stakeholder meeting, where the highlighted risks and proposed treatments are combined with any site specific risk and treatments. This process ensures that sites are both addressed on a consistent priority basis and that all safety risks have been addressed.

The ALCAM process is represented graphically in Appendix A & B. These diagrams show the flow of information through from data collection, input, the model calculations, road and rail volumes, Consequence and Limits through ALCAM itself and on the outputs and how these feed into the stakeholder review and eventually to the finalisation of proposed safety improvement works.

### **6 The history of ALCAM**

1999	A project team was formed, part of its role was to establish a tool and technical guidelines for the assessment and treatment of level crossings and oversee the development of a database for level crossings. Prior to this project there was little evidence of a standard process whereby all level crossings were assessed in a consistent manner. The processes included a search of existing level crossing assessment tools which found a number of simple formula methods (eg The Warren Henry Formula) which considered elements such as road / rail traffic
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	<p>volumes, number of tracks, road grade / curvature, adjacent intersections, sun glare, etc.</p> <p>Accordingly, the project team developed a risk scoring system referred to as the "Risk Scoring Matrix". This system provided a process for evaluating the Risk Score of a level crossing based on its existing characteristics and controls. It also enabled the identification of improvements to the Risk Score due to the implementation of selected controls and changes to characteristics.</p>
2002	<p>The project team identified that some modifications were required to improve the outputs of the Risk Scoring Matrix.</p> <p>A national committee was established to ensure that the Risk Scoring Matrix was used consistently and uniformly across the nation. The matrix was re-named the Australian Level Crossing Assessment Model (ALCAM) and the committee as the ALCAM Group. Part of this committee's brief was also to develop a database that would enable the model to be used by all ALCAM members in the risk assessment of their level crossings.</p> <p>The ALCAM Technical Committee was commissioned as an ALCAM Group sub-committee of the ALCAM group to further develop and improve the current risk assessment tool and to produce the first version of a national level crossing assessment tool.</p>
2003	<p>The ALCAM Group initiated major reviews of both the vehicle and pedestrian assessment matrices by the ALCAM Technical Committee. In February an independent review of the processes used to review ALCAM took place.</p> <p>During 2003 Australian Transport Council (ATC) and SCOT (Rail Group) sanctioned that the ALCAM be adopted nationally. In addition, the Australian Railway Level Crossing Safety Implementation Group (ARLCSIG) was authorised to overview the ALCAM process of setting the standard for the Vehicle and Pedestrian matrices within ALCAM.</p>
2004	<p>Following a number of enhancements a new version of the ALCAM was released in May 2004. A Micro Soft Access database was developed (Level Crossing Management System – LXM) as a useful tool for maintaining data and running assessments. It was adopted formally by the ALCAM Group.</p>
2005	<p>A Pedestrian level crossing matrix was added to ALCAM and issued in May 2005 and was incorporated in the LXM system.</p>
2006 +	<p>Development of ALCAM is continuing with further updates expected on an ongoing basis.</p>

**Table 2 – The history of ALCAM development**

## **7 Conclusions and ALCAM Directions**

ALCAM continues to be developed with fine-tuning of weightings, introduction of new level crossing control technology and most recently the commencement of refinement of the Consequence Factor. The development occurring in relation to the Consequence Factor is incorporating the principles of Cause – Consequence modelling through the use of event trees. An event tree is used to analyse a sequence of possible events which will result in a certain outcome. Each final outcome in the tree can have a value allocated to it and a corresponding likelihood of it occurring.

ALCAM is regarded as the best available (good practise) risk assessment tool for level crossings in Australasia. It is essentially still under development and will continue to be improved

over time in a dynamic environment. The outputs from ALCAM are accepted by road and rail crossing safety experts in each state and territory of Australia and New Zealand, as very valuable and extremely representational of the actual level of risk at each rail crossing site.

With the exception of the Victorian implementation component, this paper has been developed as a collaborative effort by several members of the ALCAM National Committee, who have kindly given their permission for its presentation at the 30<sup>th</sup> Australasian Transport Research Forum.

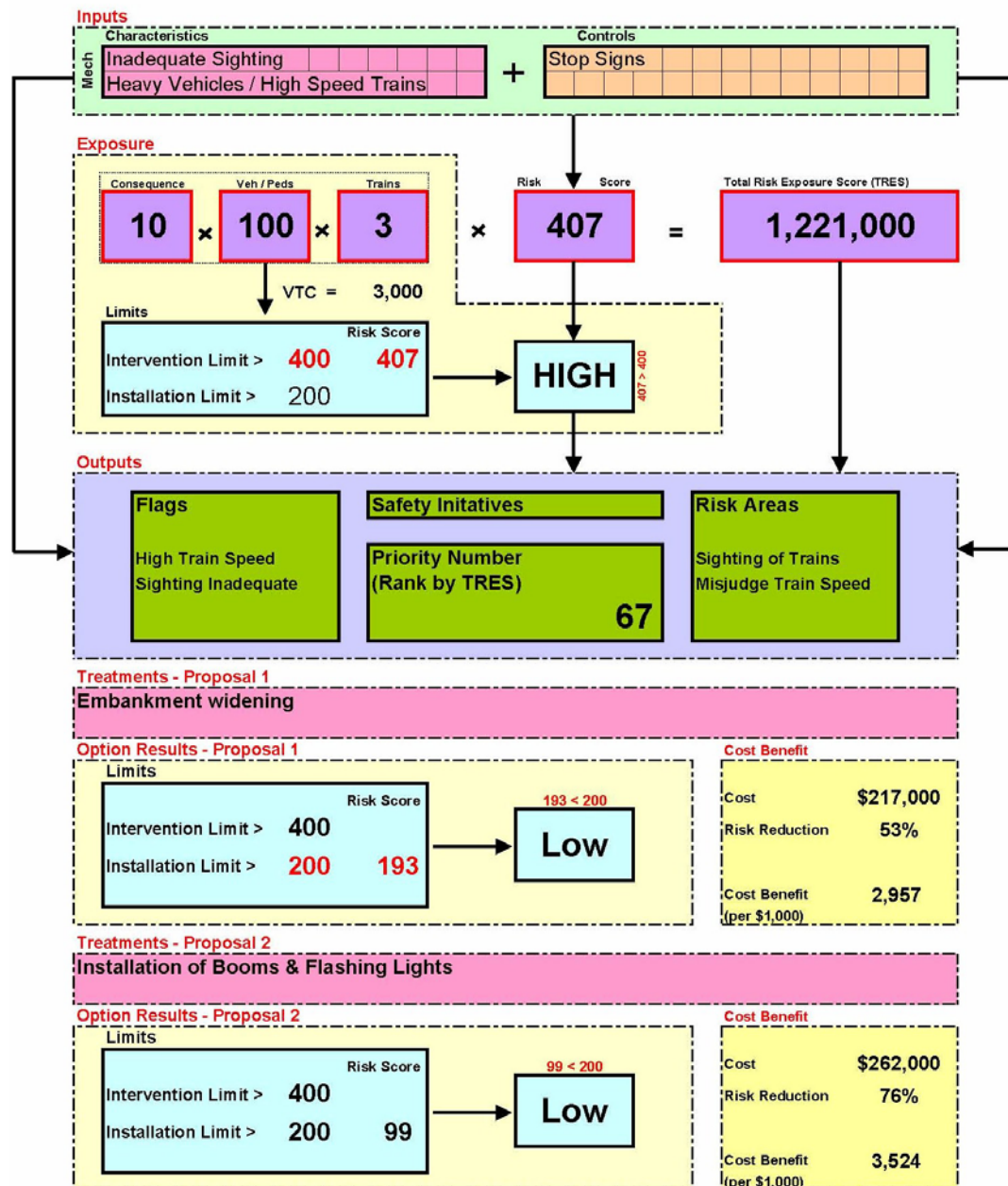
## **8. References**

ALCAM National Committee (2007) 'ALCAM IN DETAIL'.

## APPENDIX A

The diagram below illustrates the flow of information for a typical passive level crossing site. It shows a selection of the main inputs and outputs of the site as well as the critical figures which make up the comparative Total Risk Exposure Score. It also shows 2 proposals and their effects on the ALCAM outputs as well as their cost benefit. The diagram follows the process as described on pages 3 to 7 of the main text.

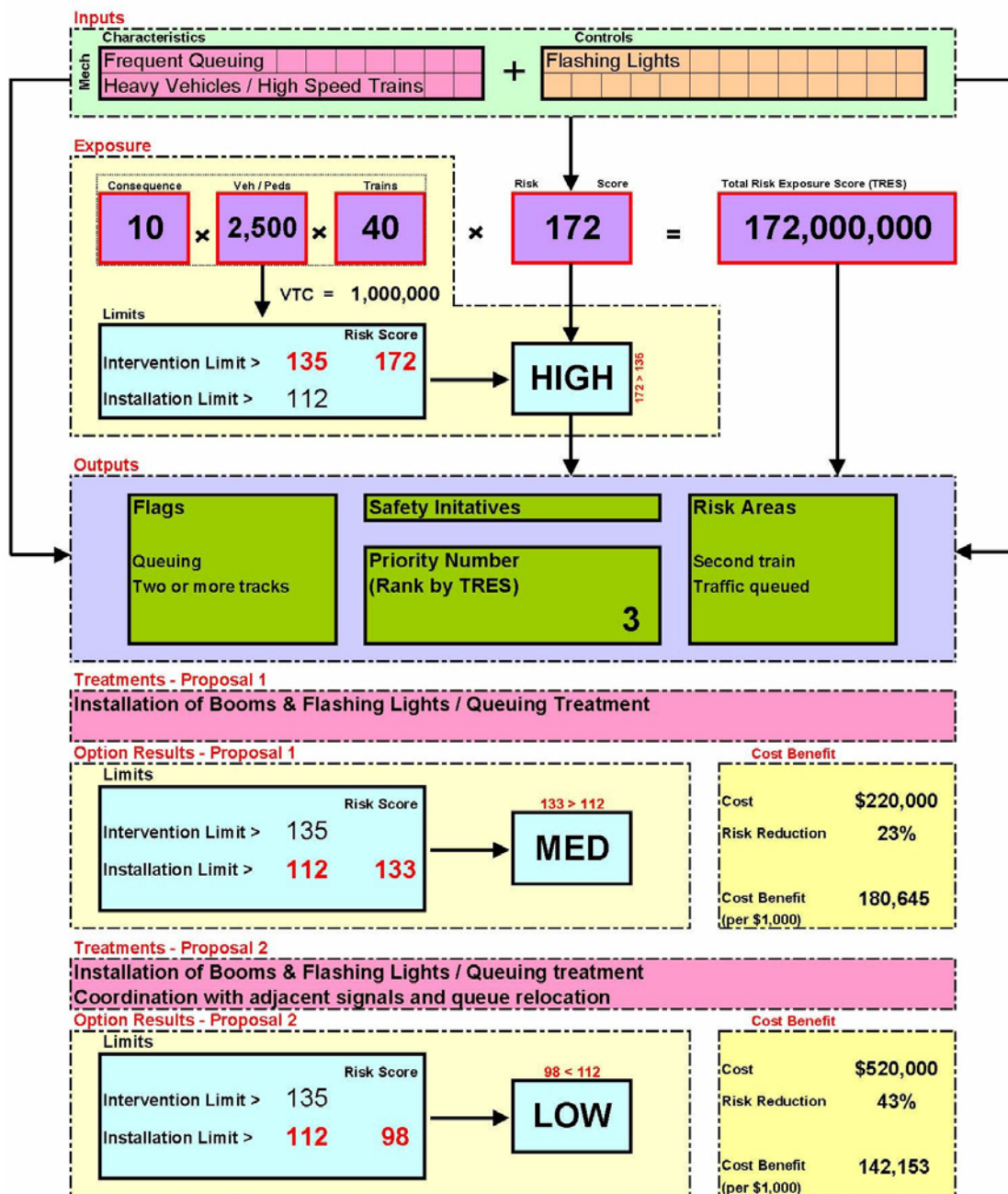
### ALCAM Example - Typical Passive Site



## APPENDIX B

The diagram below illustrates the flow of information for a typical active level crossing site. It shows a selection of the main inputs and outputs of the site as well as the critical figures which make up the comparative Total Risk Exposure Score. It also shows 2 proposals and their effects on the ALCAM outputs as well as their cost benefit. The diagram follows the process as described on pages 3 to 7 of the main text.

## ALCAM Example - Typical Active Site



## **APPENDIX C**

### **Road Level Crossings – Characteristics, Controls & Accident Mechanisms**

#### **Level Crossing Characteristics**

- Effectiveness of equipment inspection and maintenance
- Longest approach warning time
- Proximity to intersection control point
- Proximity to siding/shunting yard
- Proximity to station
- Possibility of short stacking and / or queuing from adjacent intersections
- Frequency of level crossings along the road
- Number of lanes
- Vulnerability to road user fatigue
- Presence of adjacent distractions
- Condition / Visibility of traffic control at level crossing
- Distance from advance warning to level crossing
- Conformance with Australian Standards (AS 1742.7)
- Heavy vehicle proportion
- Level of Service (vehicle congestion)
- Road traffic speed (approach speed 85<sup>th</sup> percentile)
- Train volume - two way (high / low)
- Seasonal / infrequent train patterns
- Slowest train speed at level crossing (typical)
- Longest train length at level crossing (typical)
- High Train Speed on approach to level crossing
- Number of operational rail tracks
- Condition of road surface on immediate approach/departure (not Xing panel)
- Level crossing panel on a hump, dip or rough surface
- S1 - advance visibility of level crossing from road
- S2 - approach visibility to train (vehicle approaching level crossing)
- S3 - visibility to train (vehicle stopped at level crossing)
- Road / Rail effected by sun glare
- Temporary visual impediments - sighting of level crossing / sighting of train

#### **Level Crossing Controls**

- Active control - Half boom, flashing lights / Half boom, flashing lights (Duplicated)
- Active control - Full boom, flashing lights
- Active control - primary flashing lights / primary flashing lights (Duplicated)
- Passive control - stop signs / stop signs (Duplicated)
- Passive control - give way signs / give way signs (Duplicated)
- Passive control - position markers only
- Rail operated gates at level crossing
- "Keep Clear" signs and cross hatching of level crossing
- Backing boards / LED lights
- Hump / dip advisory sign to road user
- R6-25 signage (confederate flag)
- Train speed advisory sign to road user
- Overhead mounted (mast arm) traffic control
- SINGLE / DUPLICATED train activated advance warning (eg. flashing lights)

#### **Level Crossing Controls (cont)**

- SINGLE / DUPLICATED large passive advanced warning
- STANDARD passive advanced warning (W7-4, W7-7)
- Vehicle activated advance warning (eg. strobe lights)
- Passive tactile advance warning (eg. rumble strips)
- Rail-X pavement marking
- Localised public education strategies / enforcement
- Red light camera
- CCTV surveillance
- Hand signallers (flagmen)
- Public response phone number
- Reschedule train to avoid conflict
- Whistle board / location board for train
- Reduce train speed sign (to achieve S2 & S3)
- Street lighting at level crossing
- Maintenance program for vegetation etc
- Create extra lanes over level crossing - to address queuing
- Central barrier posts/median on road approach
- Address short stacking – infrastructure / alternate access
- Vehicle escape zones
- Control of level crossing (CCTV or on-site)
- Queue clearance / queue relocation (Coordinate with adjacent traffic signals)
- Sign (active) for second train
- Detectors in level crossing conflict zone
- Healthy state monitoring
- Queue relocation

#### **Accident Mechanisms**

- Competing stimuli (at the level crossing)
- Could not see traffic control
- Could not see train from road approach (S2)
- Could not see train from at level crossing (S3)
- Vandalism
- Failure (wrong side) of active control
- Failure (right side) of active control
- Shunting
- Simultaneous trains from both directions
- Level crossing control is ambiguous
- Fatigue
- Road standard / road driver expectation
- Unable to stop in time
- Vehicle stuck on tracks (infrastructure)
- Vehicle stopped on tracks (vehicle / driver behaviour)
- Traffic queued on tracks
- Long vehicle overhangs on tracks
- Racing train or misjudged train speed
- Driving through passive control without looking
- Driving through flashing lights
- Driving around boom gates

## **APPENDIX D**

### **Pedestrian Level Crossings – Characteristics, Controls & Accident Mechanisms**

#### **Level Crossing Characteristics**

- Effectiveness of equipment inspection and maintenance
- Longest approach warning time
- Shortest approach warning time
- Presence of adjacent distractions (visual)
- Proximity to intersection control point, siding/shunting yard, station
- Proximity to licensed establishments / special event venue
- Proximity to school, playground aged care facility
- Ambient noise level / Audibility of alarm
- Conspicuity / Visibility of traffic control at level crossing
- Volume of pedestrians
- Percentage of cyclists / wheelchairs
- Percentage of children
- Percentage of physically / sensory / intellectually impaired
- Train Volume
- Seasonal / infrequent train patterns
- Highest Train Speed at level crossing (typical)
- Longest train length (typical)
- Number of operational rail tracks
- Pathway surface type
- Angle of level crossing / width of flange gap
- Condition of level crossing (fencing / path surface)
- Trains stand across level crossing
- gradients, widths and manoeuvring space of pathway/maze
- Path approach alignment
- Conformance to Australian Standards
- Visibility of train from level crossing
- Trains effected by sun glare
- Temporary visual impediments - sighting of train
- Masking of trains

#### **Level Crossing Controls**

- Swing gates
- Boom gates
- Manual Gates
- Maze
- Path only
- Visual alarm
- Audible alarm
- Visual and Audible alarm
- Signs only
- Adjacent boom gates and audio
- Adjacent visual and audio
- Adjacent boom gates and lights
- Adjacent lights
- Emergency egress with latch
- Emergency egress without latch
- No emergency egress
- Hand signallers

#### **Level Crossing Controls (cont)**

- Control of level crossing (CCTV or on-site)
- Healthy state monitoring
- Police enforcement
- Public education strategies
- Public response phone number
- Supervision of children
- CCTV monitored
- Signage advising train speed
- "Do not stop on tracks" sign
- Signage "Level Crossing unsuitable for mobility devices"
- Sign (active) for second train
- Holding line (painted only)
- Delineation line marking (painted only)
- Tactile ground surface indicators (TGIS)
- Path lighting of level crossing
- Maintenance program for vegetation etc
- LED's / Target boards
- Whistle boards
- Pavement marking of level crossing
- Wing / funnel / guide fencing
- Funnel pathway
- Adjacent corridor fencing / four quadrant booms
- Advanced warning signs
- Change pathway alignment
- Increase path width and trafficability
- Train lights
- Reduce train speed sign to achieve sighting requirements

#### **Accident Mechanisms**

- Distracted
- Did not see train
- Did not hear train
- Incapable of recognition
- Did not see level crossing
- Vandalism
- Failure (wrong side) of active control
- Failure (right side) of active control
- Simultaneous trains from both directions
- Misjudge where train would stop
- Shunting of trains
- Unable to stop in time
- Skylarking
- Caught in tracks
- Unable to cross quickly enough
- Trapped between automatic gates
- Racing train or misjudged train speed
- Ignoring warning signals / signs
- Crawling under / over wagons