RAILWAY LEVEL CROSSING INFRASTRUCTURE COUNTERMEASURES

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ABSTRACT

Collisions between trains and road vehicles, although rare, can have catastrophic consequences. In particular, where high speed roads meet rail lines there is potential for tragic outcomes as evidenced by the deaths of 11 people on 5 June 2007 at Kerang in the State of Victoria, Australia.

Victoria has approximately 2000 railway level crossings of which over half are controlled with stop or give way signs. The cost of upgrading all crossings to active control (boom barriers and flashing lights) is in excess of $A300 million. Thus, there is a need for cost-effective methods of reducing the risk of crashes at railway level crossings.

Road and rail authorities in Victoria are trialling and investigating a range of level crossing treatments including ITS solutions.

In recent years treatments that have been installed on the road approaches to railway level crossings include lower speed limits, rumble strips to ensure that drivers are alert and Active Advance Warning Signs (particularly on roads with many heavy vehicles).

Investigations are being undertaken to determine the feasibility and cost-effectiveness of treatments as diverse as perceptual countermeasures to modify road user behaviour, the illumination of rural crossings, lower cost active warning devices and radio break-in technology.

1. INTRODUCTION

Collisions between trains and road vehicles, although rare, can have catastrophic consequences. In particular, where high speed roads meet rail lines there is potential for tragic outcomes as evidenced by the deaths of 11 people on 5 June 2007 at Kerang in the State of Victoria, Australia.

Road and rail authorities in Victoria are trialling and investigating a range of level crossing treatments including ITS solutions to reduce the likelihood of crashes, particularly those that could be expected to have very severe consequences.

2. BACKGROUND

The State of Victoria, Australia has a railway system which has a large number of road level crossings. A road level crossing occurs where a road intersects railway tracks at ground level.

Victoria currently has almost 2000 road level crossings on active train lines. The form of control at the crossings varies with approximately 20% having flashing lights, bells and boom barriers, 20% having flashing lights and bells without boom barriers and the remainder having passive controls (Give Way or Stop signs). The cost of upgrading all crossings to full active control (boom barriers and flashing lights) is estimated to be more than $A300 million.

While crashes at level crossings in Victoria have reduced quite dramatically since the 1950's, they have tended to plateau in recent years (See Figures 1 and 2). In addition, the crash at Kerang in 2007 between a truck and a passenger train in which 11 people in the train died, highlighted the potential for high consequence crashes at level crossings.

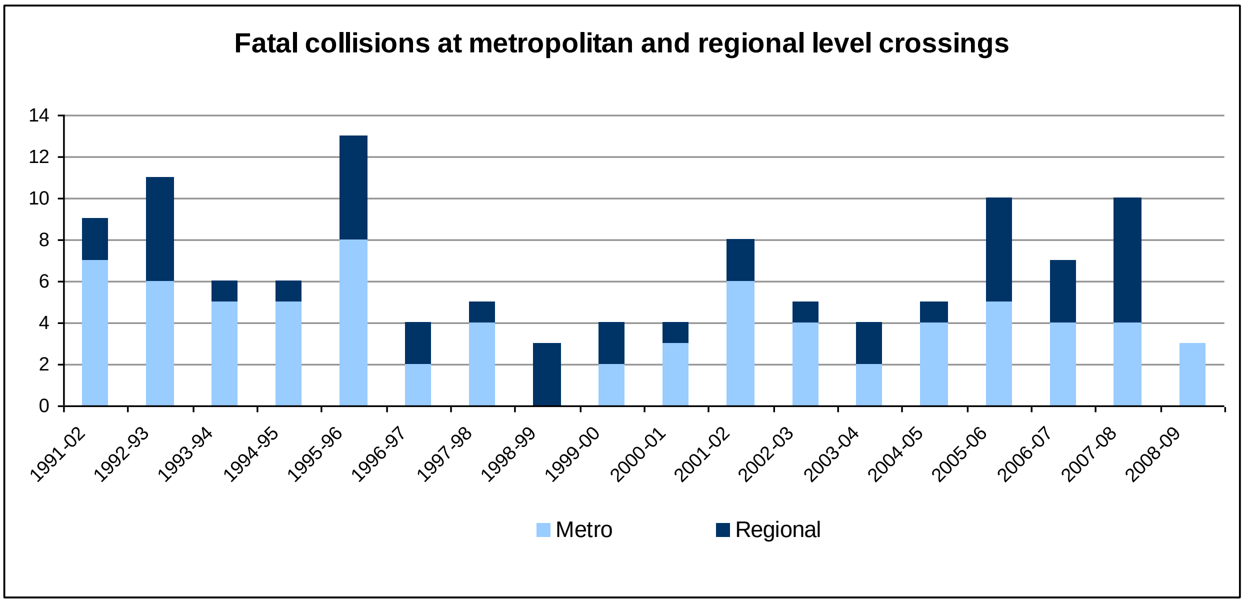

Figure 1 – Fatal collisions at railway level crossings in Victoria [1]

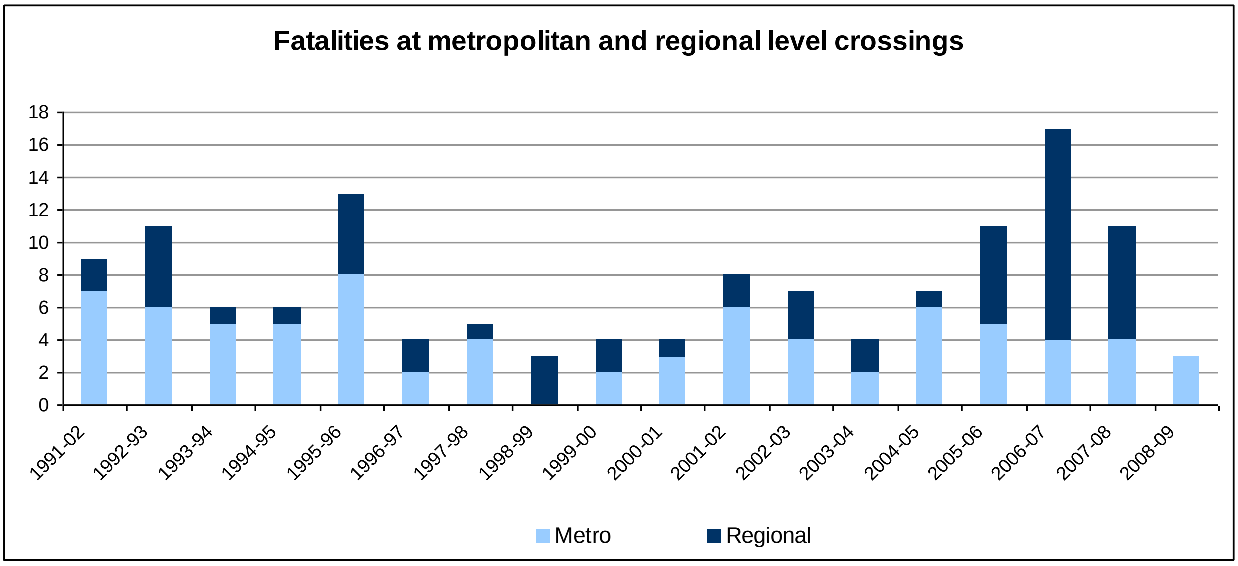

Figure 2 – Fatalities at railway level crossings in Victoria [1]

In has been argued that this potential for high consequence crashes has increased due to the growing number and mass of heavy vehicles on the roads as the volume of freight increases. In addition, there is increasing use of Diesel Multiple Unit (DMU) rail vehicles which travel at higher speeds and, because they are of lighter construction, leave their passengers more vulnerable in a crash with a heavy vehicle than passengers in a train pulled by a locomotive.

3. RAILWAY LEVEL CROSSING STRATEGY

In recent years strategies have been developed and a number of inquiries undertaken. These, along with other proposals from a range of sources, have led to a range of infrastructure treatments to improve railway level crossing safety being implemented, trialled or investigated. These have included:

3.1 Kerang Package

Following the crash at Kerang a package of measures with a total cost of $A33 million was implemented and included the following infrastructure elements:

- Installation of rumble strips on the approaches to 200 road level crossings on sealed roads that were controlled by Stop or Give Way signs;
- Works to improve sight distance at level crossings, particularly those at crossings controlled by Stop or Give way signs; and
- Installation of Automated Advance Warning Signs (AAWSs) on the approaches to level crossings at 53 locations on Highways in non-metropolitan areas. AAWSs are flashing lights which are triggered a few seconds before the flashing lights at the crossing. These mean that motorists will always be able to stop at the crossing with no need to travel through the first few seconds of the crossing flashing lights.

3.2 Towards Zero

A strategy to improve level crossing safety in Victoria called *Towards Zero* [2] was developed by the Victorian Government. Infrastructure related actions in this strategy included:

- The continuation of a level crossing upgrade program where level crossings controlled by Stop or Give Way signs are updated to flashing lights and boom barriers;
- A program to install boom barriers at locations currently controlled by Flashing Lights only;
- A program to improve sight distances and signage at level crossings, particularly those controlled by Stop and Give Way signs;
- The reduction of speed limits to a maximum of 80 km/h at all level crossings on sealed roads used by passenger trains or scheduled bus services;
- Research and development for emerging technologies including innovative vehicle to vehicle and vehicles to infrastructure technologies, GPS, Dedicated Short Range Communication (DSRC), Wireless Activation in Vehicular Environments (WAVE), alternative low cost warning devices for lightly trafficked or remote crossings and the possible use of traffic signals at level crossings rather than current railway level crossing flashing lights.

3.3 Parliamentary Road Safety Committee Inquiry

In the State of Victoria, Parliamentary Road Safety Committees (PRSCs) are committees of Parliamentarians from all parties (both those in Government and others) which meet, receive submissions from stakeholders and interested parties and report on particular road safety issues. The Committee's report makes recommendations about actions that could be taken to address the issue and the Government makes a Whole of Government response which either accepts, rejects or accepts in principle the recommendations. In 2009 this Committee inquired into Safety at Level Crossings [3]. In responding to the Committee's recommendations the Government of the day indicated that it would:

- Lower speed limits on the approach to railway level crossings on all rural sealed roads to 80 km/h;
- Investigate the likely effectiveness of a number of low cost infrastructure treatments;

- Further investigate Intelligent Transport System (ITS) solutions.

3.4 Evaluation of Treatments

Evaluations of various treatments are an important part of the approach to level crossing safety in Victoria. The numbers of crashes at level crossings are too small to allow before and after studies of changes in the numbers of crashes at level crossings when a infrastructure treatment has been implemented or trialled. However, many of the treatments trialled have been the subject of evaluation studies to determine changes in motorist's behaviour, such as their average travel speed, which may indicate a reduction in the potential for crashes.

4. RECENT ACTIONS

4.1 ALCAM Surveys

Surveys have been carried out to record the infrastructure status at all level crossings in Victoria including details such as whether sight distances and signage are to current standards. The data collected is used in two ways. Firstly it is provided to the road and rail stakeholders to allow them to develop programs to address any deficiencies. Secondly, the data is used in the Australian Level Crossing Assessment Model (ALCAM) which estimates the relative risk of crashes at level crossings to assist prioritisation of upgrade works.

4.2 Sight Distance and Signage Improvements

The results of the ALCAM survey have been used by road authorities and rail managers to develop programs and prioritise works to address the deficiencies in sight distance and signage identified.

4.3 Speed Limit Reductions (See Figure 3)

Speed limits have been reduced at level crossings on rural arterial roads (approximately 75 locations) to a maximum of 80 km/h. In general the underlying speed limit on these roads is 100 km/h. The reduced speed limit begins 400 metres before the crossing and extends for 100 metres after the crossing. A before and after evaluation of this type of speed limit reduction is planned to be carried out in the near future and expansion of these speed limit reductions to sealed local roads is also proposed. Speed surveys were undertaken at one level crossing for another purpose before and after the speed limit at the crossing was reduced from 100 km/h to 80 km/h. While other treatments, in addition to the speed limit reductions were also being installed at the crossing, the surveys indicated a significant reduction in average speed but to a level still significantly above 80 km/h.

Figure 3 – Speed limit and rumble strip signs

4.4 Automated Active Advance Warning Signs (See Figure 4)

The Australian standard for railway level crossings indicates that Automated Advance Warning Signs (AAWS) should be installed at locations where stopping sight distance is below the recommended standard. In these cases AAWSs warn motorists that they are approaching a level crossing and indicate whether a train is present in advance of when they are able to see the crossing.

AAWSs have also been installed at 53 locations on highways controlled by flashing lights or flashing lights and boom barriers where stopping sight distance to the crossing met the Australian Standard. The aim of these installations was to provide motorists, particularly heavy vehicles, with additional advance warning of the need to stop at a crossing and to enable them to stop with there never being a need for them to travel through the first few seconds of the flashing lights at the crossing.

Two studies were undertaken in relation to AAWSs. The first study compared road driver behaviour, as measured by vehicle speed, at two locations controlled by flashing lights and boom barriers, one with AAWSs and one without. The second study carried out a before and after analysis of vehicle speeds at a location where AAWSs were installed.

The results of the first study (Green, March 2009) [4] were not statistically significant due to low vehicle volumes but suggested that when AAWSs were active vehicle speeds dropped. The second study (Green, February 2010) [5] was confined to one location. This was because at all other locations boom barriers were installed at the same time as the AAWSs and the study would not have been able to separate the effects of each treatment. In this case again vehicle volumes were very low and no conclusive results were obtained.

The cost of installing AAWSs is significant and as the two studies did not demonstrate major changes in behaviour it is difficult to justify a further expansion of the use of AAWSs at locations where sight distance is adequate even though it could be expected that they would provide additional warning to motorists. AAWSs are currently only being installed at locations where a crossing is being upgraded to active controls and stopping sight distance on the approach to the crossing does not meet the required standard.

Figure 4 – Automated advance warning signs

4.5 Rumble Strips (See Figure 5)

Rumble strips were installed at level crossings controlled by Stop or Give Way signs on sealed high speed (80 km/h or above) rural roads. Three sets of rumble strips were installed on the approach to a level crossing at locations just before signs warning of the level crossing. The first rumble strip was installed between 400 and 350 metres from the crossing and the last one between 270 and 210 metres from the crossing. The objective is to ensure drivers are alert as they approach the signs warning them of the level crossing ahead. A before and after study (Hore-Lacy, 2008) [6] was carried out of speeds at locations 50, 200 and 500 metres from the crossing. The study indicated that after the installation of rumble strips there was a small (in the order of 3-6 km/h) but statistically significant reduction in the speed of vehicles at all measuring points. There was also some suggestion of increased driver alertness as shown by vehicles braking earlier at locations with rumble strips. These changes in driver behaviour suggest that driver alertness has been enhanced.

Figure 5 – Rumble strips

4.6 Installation of Active Controls

There has been a continuing program of upgrading passively controlled crossings to active control. Since 2008 all upgrades have included boom barriers as well as flashing lights. Over the 3 financial years to 30 June 2010 approximately 60 passive level crossing were upgraded to active control.

4.7 Installation of Boom Barriers

The *Towards Zero* strategy indicated that there would be a program to reduce the likelihood of high consequence crashes which would include installing boom barriers at crossings on lines with high volumes of passenger trains which were currently controlled by flashing lights only. Overall, in the 3 financial years to 30 June 2010, when the installation of boom barriers that occurred as part of the AAWS program, above, are included, boom barriers were installed at approximately 100 locations which were previously controlled by flashing lights only.

4.8 Signal Linking

In metropolitan areas one of the major crash risks involves vehicles queuing back onto a level crossing from a nearby road intersection. Electronically linking the signals at the road intersection with the signals at the rail crossing enables the queue to be dissipated when the rail signals are activated as a train approaches. The ALCAM survey identified locations where queuing over the rail tracks tended to occur and these locations on arterial roads where signal linking was not present were prioritised for treatment and six locations have been treated in recent years.

4.9 Grade Separations and Crossing Closures

In addition to the low cost treatments a grade separation was installed in 2009/10 on a major metropolitan route at a location which had the highest number of near misses. A number of further grade separations are proposed. In general, while the risk of crashes between trains and road vehicles is eliminated with grade separations, the justification for these treatments is primarily based on reducing congestion. The possibility of eliminating level crossings by closing the road is the focus of attention of the Victorian program. Although the closure of roads can be difficult to achieve because of access for adjoining land owners, in recent years a number of crossings have been eliminated in this way.

5. CURRENT DEVELOPMENTS

5.1 Review of Low Cost Infrastructure Measures

The Government's response to PRSC recommendations indicated that investigations would be carried out into the potential of the following low cost infrastructure measures:

- Yellow Box Marking on the road pavement across level crossings;
- Perceptual countermeasures such as line markings with the aim of slowing the speed of vehicles approaching level crossings;
- Tactile stimuli including speed bumps, coloured raised pavement markers and changes to texture of the pavement surface on the approach to level crossings;
- Solar powered lights to improve the conspicuity of passive level crossings;
- Low-cost warning devices.

In addition the Government supported PRSC recommendations for:

- Carrying out an assessment of enforcement cameras as a viable level crossing safety management countermeasure where other appropriate countermeasures are not deemed as appropriate;
- Further developing Intelligent Transport Systems infrastructure.

At this stage the following investigations have been undertaken.

5.2 Yellow Box Markings (YBMs)

An initial study indicated that YBMs were effective at some locations and not at others. A further study investigated the circumstances when YBMs were effective and found that this was more likely under the following conditions:

- The departure side of the crossing is visible (i.e. there is not a crest in the road which limits visibility to the departure side of the crossing);
- The width of the crossing is not too great;
- The boom barriers are not usually down for a long time before the train arrives;
- There is a departure side escape area;
- There are a large number of trains per hour.

In addition the YBM is obviously likely to have a greater impact if queuing occurs regularly at the site.

5.3 Other Low Cost Measures

There are a significant number of studies that have been undertaken for the use of low cost devices such as perceptual countermeasures and tactile stimuli for road safety purposes. In general, these studies indicate that the use of these devices lead to minor changes in road vehicle speed. A desktop assessment is currently being undertaken to determine whether these devices are likely to be cost effective at level crossings and whether their use would lead to any benefits not obtained by the rumble strips currently installed at passive railway level crossings. A similar assessment is being carried out in relation to the use of solar powered lights to determine whether these would provide any benefits not currently obtained by existing rail infrastructure.

Low cost warning devices are devices that warn motorists of an approaching train using technology which is much cheaper than traditional level crossing systems. Usually the low cost is a result of the use of technologies for train detection which are cheaper than traditional rail signal systems (such as radar or road detector type loops to detect trains) but which may not be considered “fail-safe” in the traditional manner. Some limited trialling of such a low cost device has been conducted in recent years and more comprehensive trials are now being proposed.

5.4 Enforcement Cameras

A trial has been also conducted by the Victorian Department of Justice to assess the technical capability of automatic enforcement cameras to enforce red light, speeding and queuing over the railway track violations at level crossings. The trial confirmed the capability of using cameras to enforce red light and speeding violations and these are now being enforced at one location. It was determined that to enforce queuing on the railway track violations video evidence would need to be available. The technical and practical feasibility of this is now being investigated.

5.5 Traffic Signals at Level Crossings

The possible use of traffic signals rather than standard level crossing flashing lights at level crossings was investigated using the Monash University Accident Research Centre (MUARC) driving simulator. It was felt that drivers might be more likely to stop at traffic signals however the simulator study (Lenne, Rudin-Brown, Navarro, Edquist, Trotter, Tomasevic, 2009) [7] did not suggest that this would be the case.

5.6 Radio Break-in

Radio break-in systems are used to broadcast messages to local vehicles to warn them of hazards, approaching emergency vehicles or approaching locomotives at railway level crossings. With this technology a radio transmitter is fitted to a vehicle or locomotive, or to roadside infrastructure, such as a railway level crossing and broadcasts a local signal. Receiver units are fitted to sound systems of vehicles and the warning message is played over the vehicles sound system regardless of whether the system is turned on or off, or set to radio, CD or MP3. Specialised GPS technology can also be fitted to locomotives to enhance the overall technology solution.

Initially two companies were asked to undertake three month feasibility studies and one of these companies was selected to move to a Proof-of-Concept phase of the project. The Proof-of-Concept phase which is now in progress, involves the construction of prototypes with tests, trials and human factors studies. Live tests are planned to be undertaken as part of this phase.

Implementation of radio break-in technology across either the heavy vehicle fleet or all vehicles would be a major project requiring significant funding. Based on the feasibility study and the outcome of the Proof-of-Concept, VicRoads will prepare a business case for Government funding consideration.

6. SUMMARY

Road and rail authorities in Victoria are trialling and investigating a range of level crossing treatments including ITS solutions to reduce the likelihood of crashes between trains and road vehicles.

In recent years treatments that have been installed on the road approaches to railway level crossings include lower speed limits on high speed rural roads, rumble strips to ensure that drivers are alert and Active Advance Warning Signs (particularly on roads with high heavy vehicle volumes). In many cases evaluations have been carried out to investigate the effectiveness of the treatments. While the low number of crashes means that it is not possible to compare crash numbers before and after the installation of the treatments, other measures such as road vehicle speed have been measured as an indication of the likely impact of the treatment.

Investigations are being undertaken to determine the feasibility and likely cost-effectiveness of treatments as diverse as perceptual countermeasures to modify road user behaviour, the illumination of crossings in rural areas, lower cost active warning devices and radio break-in technology.

REFERENCES

1. Victorian Auditor – General's Report, Management of Risks at Level Crossings (March 2010), Figures 3C & 3D (Data provided by Public Transport Safety Victoria)
2. Towards Zero Victorian Crossing Safety Steering Committee (November 2009)
3. Parliamentary Road Safety Committee Inquiry into Improving Safety at Level Crossings (December 2008)
4. Green D. (March 2009), Evaluation of Active Advance Warning Signs (AAWS) using existing installations, ARRB Group for VicRoads on behalf of Victorian Railway Level Crossing Safety Steering Committee
5. Green D. (February 2010), Before and after evaluation of active advance warning signs (AAWS) installed at the Cressy railway level crossing, ARRB Group for VicRoads on behalf of Victorian Railway Level Crossing Safety Steering Committee
6. Hore-Lacy W. (2008), Rumble strip effectiveness at rural intersections and railway level crossings, ARRB Group for VicRoads
7. Lenne M. G., Rudin-Brown C. M., Navarro J., Edquist J., Trotter M. and Tomasevic N. (August 2009), Driver behaviour in response to flashing red lights versus traffic signals at railway level crossings, Monash University Research Centre