Australasian Transport Research Forum 2018 Proceedings
30 October – 1 November, Darwin, Australia
Publication website: http://www.atrf.info

# Addressing the cause of the problem and not its symptom: Road congestion at Railway Stations

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## Abstract

The research investigates the impact of railroad level crossings closures on traffic congestion at crossings in close proximity of railway stations. It is proposed that congestion at station level crossings is not caused by the level crossing intersection closure operation, but rather by train arrivals or at platforms, forcing the intersection to remain closed for long intervals. The research presents the theory that making alterations to the infrastructure of the station can derive a reduction of intersection closure periods, resulting in mitigating road traffic congestion at the location.

To test the theory, named Departure Side Platforms (DSP), the station environment of a station on the Melbourne rail network was simulated using computer road traffic simulation software. The simulation process was conducted in two phases: one to emulate the current environment and the other to emulate the proposed environment; results were derived by comparing the outputs and performance of both simulated environments.

Simulation results testing the intersection level crossings closures by single trains, two-trains and multiple-trains (up to 6 trains) arrivals and departures at both environments (within the same intersection closure), confirmed the infrastructure alterations approach of the new theory results in mitigating road traffic congestion at railway station locations.

## 1. Introduction

Vehicular traffic congestion is increasing in most urban areas (SKM et al., 2008; Taylor and Crawford, 2010; VicGov, 2013; VAGO 2013). One area where vehicular traffic congestion is prevalent is at railway level crossings (Hall and Somers, 2012; Lucas, 2010; Taylor and Crawford, 2010; VicGov, 2009; Webb and Gaymer, 2009; Fitzgerald, 1950; VAGO, 2013). There are approximately 9,400 level crossings in Australia (Henley and Harrison, 2009; RISSB, 2009; Wallace, 2008). According to VAGO (2017), Metropolitan Melbourne is home to the largest number of level crossings in metropolitan areas in Australia, 178 level crossings (VAGO, 2017).

According to VAGO (2017), there were a number of grade separations completed in Melbourne by the Metro Level Crossing Blitz program managed by VicRoads (VAGO, 2017). A new authority (LXRA), under the Level Crossing Removal Project (LXRP) program, has so far completed 17 grade separations in metropolitan Melbourne (LXRA, 2018).

This is an abridged version of the paper originally presented at ATRF 2018. For further information about this research please contact the authors

# 2. Literature Review - Intersections Level Crossings

The introduction of rail and road land transport modes, particularly when the modes cross each other's path at the same grade or level, continue to present a dilemma today. The legacy of a large number of level crossings has had detrimental impact on road transport networks, more so in capital cities urban areas, such as Melbourne, contributing to accidents and road traffic congestion (COAG, 2006; Edquist et al., 2009; Lucas, 2010; Maslen, 2010; Fitzgerald, 1950).

The issue of platform positioning has only come to light in recent years and its implications have not been fully researched or understood until now (Guzman, 2008; Guzman, 2011; Guzman et al., 2014c; Guzman, 2014; Guzman et al., 2015). The platform positioning is considered to be exacerbating motor vehicle traffic congestion at level crossings adjacent to, or in the vicinity of, railway stations (David, 2009; Guzman, 2008; Guzman, 2012; Guzman et al., 2014b; Higgs, 2009; Guzman et al., 2015; Guzman, 2014; VAGO, 2017). The impact of the platform position relates to the long periods of intersection closures being experienced at level crossings locations (Cooper, 2012; Guzman, 2012; Guzman, 2011; Hall and Somers, 2012; Guzman, 2014; Guzman et al., 2015).

# 3. Analysis of Current Solutions

The first option in addressing the level crossing problem should always be the closure of the crossing (NCHRP, 1999; RSC, 2008). Crossing closures can be achieved by: a) closing the crossing to road traffic; b) closing the crossing to rail traffic; or c) by way of grade separation (Glennon, 2005; Wallace et al., 2008).

Grade separation is the name given to the engineering process of separating both traffic modes, by way of building a tunnel or a bridge. Grade separation eliminates the problem altogether; it separates both modes of transport, rail and road, from each other's path (McNamara and Cox, 1979; VicGov, 2009). Grade separation can be achieved by one of the following engineering solutions: (a) lowering the rail line by tunnelling under the road; (b) lowering the road by tunnelling under the rail line; (c) building a road bridge over rail line; and (d) building a rail bridge over road (NewAustralia, 2010; VicGov, 2009; Wallace, 2008). This last option, of building a rail bridge over a number of roads, has recently been implemented in Victoria and has been named Sky Rail by LXRA in Melbourne, to remove several level crossings with some level crossings in close proximity of each other (LXRA, 2018).

# 4. Research Methodology

Computer simulation modelling was used to assess the benefits of the proposed solution. Computer simulation is said to be one of the most powerful tools available for modelling and simulation activities, as it allows and simplifies the methods used to study, analyse and evaluate conditions that could not be studied under normal circumstances (Ingalls, 2008; Shannon, 1998). Computer simulation aims at understanding and finding solutions to complex phenomena (Winsberg, 1999) and in that process, satisfy the three tenets of qualitative research: describing, understanding and explaining (Yin, 2003; Tellis, 1997; Law and McComsa, 1991; Law, 2008).

VISSIM, a multi-modal microscopic traffic flow simulation software, was deemed the most appropriate of the packages available, as it allows the simulation of all types of road traffic and specifically heavy rail (trains). VISSIM provides more flexibility than the other contenders because of its ability to model unusual sites, for example railroad crossings, as well as providing powerful 3D and movie capture facilities (Fontaine 2012).

The research methodology was developed using Law's design model and expanded to fit the specific requirements of this research, incorporating two simulation processes, ensuring that this new design model incorporated into its design, the validity, reliability, and replicability features from Law's method (Law, 2008).

# 5. Current Platform Arrangement

The industry-based terminology used to depict the platforms location at railway stations is either the *up-line* platform (to the city) or *down-line* platform (from the city). This terminology, though, is not indicative of the position of platforms in relation to the level crossing. In this research, platforms at a station are classified as either Departure Side Platform (DSP) or Arrival Side Platform (ASP); this classification is dependent upon the relative position of the platform in relation to the level crossing intersection. Appendix A illustrates the current station DSP – ASP platforms infrastructure.

# 6. Proposed Platform Arrangement

This research extends previous work on platform positioning (Guzman, 2008; Guzman 2014) and proposes that congestion at station level crossings is not caused by the level crossing intersection closure operations, but rather by train arrivals or at the platform, forcing the intersection to remain closed for long intervals. This new arrangement presents a level crossing congestion-calming alternative not otherwise investigated or implemented previously.

## 6.1 Proposed Operation of two DSP Platforms

The proposed arrangement of the station infrastructure supports two-Departure Side Platforms (DSP) (instead of one DSP platform and one ASP platform). The current Arrival Side Platform (ASP) is decommissioned. The proposed arrangement, presenting both DSP platforms, is a mirror image of the current DSP platform. Appendix B illustrates the proposed station DSP – DSP platforms infrastructure.

# 7. Computer Simulation Modelling

Computer simulation models were used to emulate both the current operation and the proposed approach of the level crossing arrangement. The aim of these models was to test the effect of platform arrangements on level crossing closures and its impact on motor vehicle traffic congestion at a railway station level crossing intersection. The current operations were simulated using the level crossing closure activation and signals data, collected at one railway station of the Melbourne train network.

## 7.1 Data Collection Process

The rail line traffic data was assembled and analysed from the train timetables for the corridor and visual observations during the data collection effort. Also, as part of the the data collection effort, the intersection road signal system operations were recorded on-site using video recording equipment. The road vehicular traffic data was obtained from VicRoads, the roads traffic authority of Victoria. These figures were used to derive to 3 different estimated road traffic used in the simulations. These figures allow for mid and longer term growth.

## 7.2 Computer Simulation Process

All of the above mentioned data was used and the model tested many times over during the simulation process, ensuring the operational validity and replicability of the simulation design model created. These validation testing events required many, and in some cases hundreds of simulation runs, until the desired validation results were achieved to meet each development process set of predetermined criteria. Once this were achieved, a new model was created by the repositioning of the infrastructure of the station, modifying the station to the new platform specifications; the new model was a replica of the current model.

## 7.3 Simulation of the Current Environment

In the simulation model of the current arrangement, the environment initially simulated the operation of the level crossing, the closure of the main arterial roads to motor vehicle traffic, activated by a single train. Complexity was then added to the simulation, by having two trains, an arriving train in one direction when another was at, or leaving, the platform in the opposite direction. Further complexity was then added to the simulation, requiring it to support and operate multiple trains within a single intersection level crossing closure.

## 7.4 Simulation of the Proposed Environment

In the simulation model of the proposed arrangement, the current ASP up-line platform was decommissioned and a new platform, a DSP up-line platform, was built about 200 metres further away from the current position, but immediately after the intersection level crossing. This new platform environment for the up-line train represents a true or mirror image of the current platform environment for the down-line platform environment. The proposed station platform structure and operation of the new DSP – DSP station platform arrangement, supporting two Departure Side Platforms, was simulated and tested accordingly.

# 8. Computer Simulation Results

The computer simulation process consisted of fourteen simulations. There were seven simulation covering the current environment and seven simulation covering the propossed environment. Each of these included simulation intersection closures initiated by: a) single train down line; b) single train up line; c) two trains; d) three trains; e) four trains; f) five trains; and g) six trains, amounting to fourteen simulations. The process was then replicated using the three different volumes of road vehicular traffic, providing a total of forty two (42) different simulations processes. These forty two individual simulations generated large amounts of data to be analysed, compared and reported. As part of the simulation output, there are 42 Audio Video Interleave (AVI) file format movies, one for each of the simulation performed. Appendix C presents an image captured during the simulation process.

VISSIM provided a variety of output reports and the results indicate road traffic queue differences, including differences in the average queue length, maximum queue length and number of stops within queues. Additional analysis of the current, proposed and differences of level crossing closures were also generated and reported. The simulation results confirmed that under the proposed platform environment, continual level crossing closures of more than two trains would no longer occur. Appendix D indicates the differences between the current and proposed railroad intersection closure periods recorded.

The current average closure activated by a single train on the down-line direction was recorded as forty six seconds (46s). Since no changes were introduced at this platform location, the forty six seconds (46s) recorded for a single train in this direction, continues to apply under the proposed environment.

The current average closure activated by a single train on the up-line direction, was recorded as one minute and forty one seconds (101s). Under simulated conditions, the closure period for a single train in this direction was the equivalent of the forty six seconds (46s) recorded for a single train that also applies under the proposed arrangement.

The current average closure activated by two trains was recorded at two minutes and seven seconds (127s). Under the proposed environments, the closure period for two-train activated closure will vary between a short closure period and a long closure period. The short closure occurs when both trains travelling in opposite directions, arrived at the detection activation trigger at about the same time. Under simulated conditions, the closure period for two-train was forty six seconds (46s), the same time as a single train closure. The long closure occurs when the first activating train is at the platform area and another train, travelling in the opposite direction, activates the track detection trigger. The longest closure for two-train was one minute and thirty two seconds (92s), equal to the sum of two single trains activation closures (46s + 46s = 92s).

Further, continuos closure of the level crossing by more than two trains will no longer occur; instead, a combination of singles train and two-trains closures will occur. Appendix D provides details of the intersection closure times expected for combinations of multiple train closures of more than two trains.

In addition, computer simulation comparison reports indicate and confirm considerable reduction of road congestion at level crossing intersection, where the average vehicular queue length, the maximum vehicular queue length and the total number of vehicular stops within the queues, all showed improvements under the proposed simulated condition arrangements. A sample of a VISSIM Simulation Queue Length Record report is attached Appendix E.

# 9. Conclusion

Computer simulation was used to test the effect of railway station platform arrangements and its impact on vehicle traffic congestion at a railway station level crossing. The processes conducted in this research contributes to theoretical knowledge by developing the Departure Side Platforms (DSP) theory. This new theory addresses the cause of level crossing problems and not the symptoms of the problems, mitigates railway station intersection closure periods, which in turn reduces and alleviates road traffic congestion at railway station intersection level crossings.

Under the new theory, intersection closure periods are shorter than currently experienced and the intersection open periods are longer than currently experienced, mitigating road traffic congestion. As a direct result, road traffic has the potential to flow through the intersection level crossing more efficiently and freely. This mitigates road congestion, reduces travel time and travel time costs, decreases environmental greenhouse gas emissions and pollution costs, reduces fuel consumption and costs, and minimises wear-and-tear and maintenance costs to vehicles, thus alleviating some of the burdens road congestion imposes on the community.

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# Appendices

**Appendix A**
**Current DSP – ASP Station Platforms**


Source: Target level crossing current DSP – ASP station platforms environment superimposed over Google™earth images

**Appendix B**
**Proposed DSP – DSP Station Platforms**


Source: Target level crossing proposed DSP – DSP station platforms environment superimposed over Google™earth images

**Appendix C**
**Simulation Video Animation Image Frame**

The image displays a frame of a simulation AVI file format video animation image of the target area, captured during the simulation process; the frame shows two trains arrivals at the train station.

## Appendix D

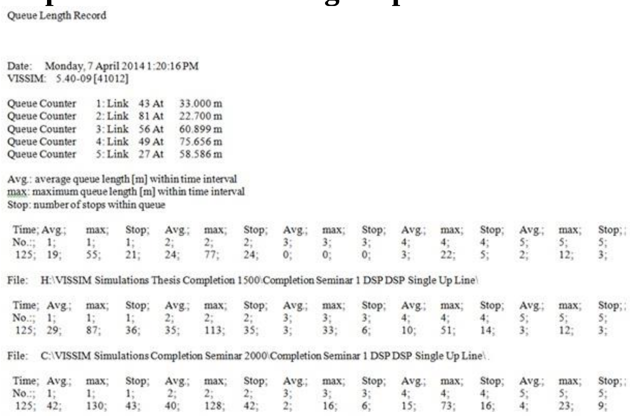
**Computer Simulation Intersection Closure Results**

| Closures per Trains Arrivals | Current Average Closure Periods (in sec) | Proposed Closure Periods (in sec) | Periods of Closure Differences (in sec) |
|---|---|---|---|
| **Single Down-Line Train Closure** | 46 | 46 | **0** |
| **Single Up-Line Train Closure** | 101 | 46 | **-45** |
| **Two-Trains Closure – Best Time** | 108 | 46 | **-62** |
| **Two-Trains Closure – Worst Time** | 153 | 92 | **-61** |
| **Three-Trains Closure – Average *** | 243 | 3x46 = 138 or 1x46+1x92= 138 | **-105** |
| **Four-Trains Closure – Average *** | 318 | 4x46 = 184 or 2x46+1x92= 184 | **-134** |
| **Five-Trains Closure – Average *** | 527 | 5x46 = 230 or 3x46+1x92= 230 or 1x46+2x92= 230 | **-297** |
| **Six-Trains Closure – Average * (longest recorded closure)** | 638 | 6x46 = 276 or 4x46+1x92= 276 or 2x46+2x92= 276 or 3x92= 276 | **-362** |

* = Indicates the operation will no longer occurs under the proposed environment; instead a combination of single trains or two trains operations will be involved (i.e. a three-train closure will be replaced by either 3 single trains closures or a combination of 1 single train and a two-train closures).

## Appendix E

## Proposed DSP – DSP Single Up-Line Train simulation result



Queue Length Record

Date: Monday, 7 April 2014 1:20:16 PM
VISSIM: 5.40-09 [41012]

Queue Counter 1: Link 43 At 33.000 m
Queue Counter 2: Link 81 At 22.700 m
Queue Counter 3: Link 56 At 60.899 m
Queue Counter 4: Link 49 At 75.656 m
Queue Counter 5: Link 27 At 58.586 m

Avg.: average queue length [m] within time interval
max: maximum queue length [m] within time interval
Stop: number of stops within queue

| Time; | Avg.; | max; | Stop; | Avg.; | max; | Stop; | Avg.; | max; | Stop; | Avg.; | max; | Stop; | Avg.; | max; | Stop;; |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No.:; | 1; | 1; | 1; | 2; | 2; | 2; | 3; | 3; | 3; | 4; | 4; | 4; | 5; | 5; | 5; |
| 125; | 19; | 55; | 21; | 24; | 77; | 24; | 0; | 0; | 0; | 3; | 22; | 5; | 2; | 12; | 3; |

File: H:\VISSIM Simulations Thesis Completion 1500\Completion Seminar 1 DSP DSP Single Up Line\

| Time; | Avg.; | max; | Stop; | Avg.; | max; | Stop; | Avg.; | max; | Stop; | Avg.; | max; | Stop; | Avg.; | max; | Stop;; |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No.:; | 1; | 1; | 1; | 2; | 2; | 2; | 3; | 3; | 3; | 4; | 4; | 4; | 5; | 5; | 5; |
| 125; | 29; | 87; | 36; | 35; | 113; | 35; | 3; | 33; | 6; | 10; | 51; | 14; | 3; | 12; | 3; |

File: C:\VISSIM Simulations Completion Seminar 2000\Completion Seminar 1 DSP DSP Single Up Line\.

| Time; | Avg.; | max; | Stop; | Avg.; | max; | Stop; | Avg.; | max; | Stop; | Avg.; | max; | Stop; | Avg.; | max; | Stop;; |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No.:; | 1; | 1; | 1; | 2; | 2; | 2; | 3; | 3; | 3; | 4; | 4; | 4; | 5; | 5; | 5; |
| 125; | 42; | 130; | 43; | 40; | 128; | 42; | 2; | 16; | 6; | 15; | 73; | 16; | 4; | 23; | 9; |

This report is presented as a sample of the types of report generated by the simulation software, and combines the output of three different runs of single up line train using the three different road traffic volumes measuring the average queue length, maximum queue length and the number of stops within the queue, queues created by the closure of the road intersection by the arriving train.