Contract Report

Compliance with traffic signals at railway level crossings

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for VicRoads

VC73922-1 August 2009

arrb consulting

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for VicRoads

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Summary

Background

On behalf of the Victorian Railway Crossing Safety Steering Committee (VRCSSC), VicRoads engaged ARRB to investigate whether drivers of road vehicles showed better compliance with crossing requirements at active level crossings when traffic lights were used as part of the display. Road user compliance at conventional level crossing treatments, conventional level crossing treatments plus traffic lights and intersection traffic lights on the road newtwork was to be compared.

This was to be achieved by comparing violation rates at:

- rail level crossing controlled by flashing lights only in 60 and 80 km/h speed zones
- rail level crossings controlled by flashing lights and boom barriers in 60 and 80 km/h speed zones
- rail level crossing controlled by flashing lights, boom barriers and traffic lights in 60 km/h speed zones
- traffic light controlled intersection in 60 km/h and 80 km/h speed zones.

Sites investigated

Railway crossing sites were chosen to include crossings which had flashing lights only, flashing lights and boom barriers, and flashing lights, boom barriers and traffic lights, and to include sites in 80 km/h speed limit zones and in 60 km/h speed limit zones.

Intersection sites were chosen in 80 km/h speed zones and 60 km/h speed zones.

For four of the sites, the data used was collected during an earlier investigation of the effects of a pilot program of enforcement and education measures to improve compliance at railway level crossings.

The study included sites on the metropolitan rail network, and sites outside it. Sites outside the metropolitan rail network were chosen to maximise train numbers and traffic flows to provide an adequate number of crossing operations for analysis.

As far as possible, sites were chosen to ensure there were no features which may have affected the results, e.g. curves close to the crossing or side roads entering the main road close to the crossing.

Measurements

Traffic counters were used to monitor traffic at the sites. The traffic counters used accept input both from:

- pneumatic tubes laid across the road to detect the passage of vehicles
- a non-electrical (fibre optic) connection from the traffic light or level crossing controller.

This enables the logger to record traffic movements in relation to the level crossing or intersection phase.

Findings and conclusions

The main findings and conclusions were:

- Compliance varied markedly across the different level crossing controls. Sites controlled by boom barriers had a higher number of violations of the flashing red lights compared with level crossings controlled by flashing lights only. The non-compliance at sites with boom barriers occurred in the period when the lights were flashing before the boom came down or after the boom rose. Motorists tend to treat the boom barrier as the control and the violations are either well before or after the passage of a train.

- Compliance was better at railway level crossings provided with traffic lights in addition to flashing lights and boom barriers compared to sites with flashing light and boom barriers only. This may be because they provide a clear cue as to when entering the crossing is no longer permitted, reducing the number of vehicles entering towards the beginning of the red period. It may also be because the green signal provides a clear indication of when entering the crossing is permitted after the passage of the train.

- Compliance at railway level crossings with traffic lights is not as good as it is at road intersections controlled by traffic lights. This may be because some drivers use the position of the boom barrier as an indication of when entering crossing is no longer permitted, and of when it is permissible once more. This study has some limitations and in order to fully understand the effect of providing traffic lights, before and after studies should be carried out at a number of sites where traffic lights are added to the existing ensemble of rail level crossing control devices and are not used in conjunction with pedestrian facilities or signalised intersections. Only by using a study design of this type can it be determined that the effects are due to traffic lights rather than other influences.

This study has some limitations and in order to fully understand the effect of providing traffic lights, before and after studies should be carried out at a number of sites where traffic lights are added to the existing ensemble of rail level crossing control devices and are not used in conjunction with pedestrian facilities or signalised intersections. Only by using a study design of this type can it be determined that the effects are due to traffic lights rather than other influences.

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1 Introduction

Investigations of recent level crossing crashes in Victoria have led to a re-examination of ways of controlling road user behaviour at railway level crossings. It has been suggested that traffic lights might encourage better compliance than the flashing light assemblies currently used because:

- all drivers are familiar with traffic lights, but not all are necessarily familiar with railway crossing lights
- at traffic lights, the red stop signal is preceded by a yellow signal, providing time for drivers who cannot stop to clear the intersection, warning drivers approaching the intersection that the lights are about to change and providing a clear 'break point' after which entering the crossing would be a violation.

On behalf of the Victorian Railway Crossing Safety Steering Committee (VRCSSC), VicRoads engaged ARRB to investigate whether drivers of road vehicles did in fact show better compliance with crossing requirements at active rail level crossings when traffic lights were used as part of the display, along with flashing lights and the usual warning and regulatory signs.

1.1 Objectives

The specific objectives of the investigation were to determine:

- whether driver compliance with stopping requirements at rail level crossings provided with traffic lights in addition to the usual railway crossing controls is better than at rail level crossings with only the usual controls
- how driver compliance with stopping requirements at rail level crossings provided with traffic lights compares with compliance at signalised intersections.

The scope of the project does not extend to assessing specific conditions at level crossing sites which may influence compliance (e.g. placement of lanterns or length of time of railway operation).

2 Method

2.1 Sites investigated

Railway crossing sites were chosen to include crossings which had flashing lights only, flashing lights and boom barriers, and flashing lights, boom barriers and traffic lights, and to include sites in 80 km/h and 60 km/h speed limit zones. Intersection sites were chosen in 80 km/h and 60 km/h speed zones. The characteristics of the sites included in this investigation are outlined in Table 2.1.

Four of the level crossing sites (Queen Street in Colac, Dawson Street in Stratford, Rooks Road in Nunawading and Webster Street in Dandenong), used data collected during an earlier investigation of the effects of a pilot program of enforcement and education measures to improve compliance at railway level crossings (Cairney, Knightly, Casey and Wishart 2008).

This previous investigation involved comparing compliance of stopping behaviour, measured in the same way as it was measured in the present study, before and after an education and

enforcement program was introduced. Only the 'before' data from the earlier study is used in the present study. Sites from the earlier study are have been shaded in Table 2.1.

Sites outside the metropolitan rail network were chosen to maximise train numbers and traffic flows to ensure an adequate number of crossing operations for analysis. Sites were chosen to ensure there were no features which may have affected the results (e.g. curves close to the crossing or side roads entering the main road close to the crossing).

Images of the sites included on the investigation are shown in Appendix A.

Table 2.1: Sites surveyed in the study

Crossing	Location	Direction of travel	Control type FL = Flashing Lights BB = Boom Barriers TS = Traffic lights	Speed Limit (km/h)
Queen Street at rail	Colac	S	FL only	60
Dawson Street @ rail	Stratford	E	FL only	60
Bungaree-Wallace Road @ rail	Wallace	Eastbound	FL only	80
Bungaree-Wallace Road @ rail	Wallace	Westbound	FL only	80
Bungaree-Wallace Road @ rail	Bungaree	Eastbound	FL only	80
Bungaree-Wallace Road @ rail	Bungaree	Westbound	FL only	80
Geelong-Ballan Road @ rail	Moorabool	Southbound	FL only	80
Geelong-Ballan Road @ rail	Moorabool	Northbound	FL only	80
Rooks Road @ rail	Nunawading	S	FL + BB	60
Webster Street @ rail	Dandenong	E	FL + BB	60

Crossing	Location	Direction of travel	Control type FL = Flashing Lights BB = Boom Barriers TS = Traffic lights	Speed Limit (km/h)
Tylden-Woodend Road @ rail	Woodend	Westbound	FL + BB	80
Tylden-Woodend Road @ rail	Woodend	Eastbound	FL + BB	80
Koroit Creek Road @ rail	Altona	Westbound	FL + BB	80
Koroit Creek Road @ rail	Altona	Eastbound	FL + BB	80
Mitcham Rd @ rail	Mitcham	Sothbound	FL + BB + TS	60
Moreland Rd @ rail	Coburg	Eastbound	FL + BB + TS	60
Mitcham Rd @ Premier Av	Mitcham	Southbound	TS only	60
Station Street @ Separation St	Fairfield	Northbound	TS only	60
Koroit Creek Road @ Maidstone St	Altona	Eastbound	TS only	80
Princess Hwy @ Old Geelong Road	Hoppers Crossing	Southbound	TS only	80

The length of survey at each site was adjusted to ensure sufficient rail and road traffic for analysis. The surveys generally lasted one week at metropolitan locations and two weeks at rural locations.

2.2 Level crossing sites linked to traffic lights

The Mitcham Road and Moreland Road rail level crossings are linked to traffic lights due to the presence of other features at the level crossing. In the case of the Mitcham Road rail level crossing a pedestrian crossing is present. In the case of the Moreland Road rail level crossing side streets and pedestrians (also bicycles on the bicycle path) are present.

The traffic lights at these railway level crossing may be triggered by either trains (coinciding with the activation of the level crossing) or pedestrians (in the case of the Mitcham Road crossing) or pedestrians, bicyclists, or vehicles exiting the side street (in the case of the Moreland Road crossing). The traffic lights at Mitcham Road can also be activated as part of a queue management strategy.

When the train activated the level crossing the traffic light turned yellow when the flashing lights of the level crossing commenced and then turned red four seconds later. The traffic lights turned green once the boom barriers had risen completely and the flashing lights had stopped, unless activation of one of the other triggers prolonged the red signal.

The signals could also be activated when a train was not present in which case the flashing lights and boom barriers were not activated. In this case the traffic lights operated as a standard signalised intersection or signalised pedestrian crossing.

2.3 Survey method

2.3.1 Arrangements for traffic recording

Traffic counters were used to monitor traffic at the sites. The traffic counters used accepted input both from:

1. pneumatic tubes laid across the road to detect the passage of vehicles, and
2. a non-voltage connections from the traffic light or level crossing controller.

This enables the logger to record traffic movements relative to the level crossing or intersection phase.

The pneumatic tubes were placed across the through lanes only. The investigation was not extended to see if red light running is more prominent for turning movements compared to through movements.

For the Mitcham Road rail crossing two data loggers were used (one interfaced with the pedestrian signal controller to log the pedestrian signal phases and all vehicles passing through the crossing, the other interfaced with the railway crossing controller to log the railway level crossing).

The two data loggers were synchronised with one another, allowing the research team to identify which activations of the pedestrian signals were due to activation by trains in conjunction with the railway crossing signals, and which activations of the pedestrian signals were due to other triggers. Violations were separated accordingly.

For the Webster Street and Rooks Road level crossings, traffic counters were setup to detect vehicles going around the boom barrier. A traffic counter was setup downstream from the level crossing and synchronised with the counter interfaced with the controller. It was assumed that vehicles detected crossing the downstream logger during the period when the boom barrier was down had gone around the boom barriers.

2.3.2 Analysis of compliance data

Compliance may be considered from two points of view:

- non-compliant behaviours per crossing operation
- non-compliant behaviours per vehicle entering.

The first is important as a direct indicator of the risk of a crash with a train, although not a perfect one as more than one vehicle may enter the crossing on a red signal on each crossing operation. The second is an indicator of the extent of compliant behaviour among drivers.

Both indicators are useful in understanding the pattern of non-compliance at different types of crossing.[1].

For convenience, non-compliant behaviours are referred to as *violations* in the rest of the report.

2.3.3 Further observations at Moreland Road crossing

Analysis of the results revealed a particularly high violation rate at the Morelend Road railway crossing. To gain a better understanding of these violations, video recordings of driver behaviour were made at this site, using the ARRB video trailer. This equipment has a video camera on a pneumatic mast, enable oblique views of the crossing to be obtained. In this case, the viewing height was approximately 4 metres.

The video tapes were subsequently analysed back in the office by an observer, who counted the number of different types of violation which occurred.

3 Results

3.1 Overall red flashing light and red traffic light violations

Red flashing light and red traffic light violations are shown in Table 3.1. The violation rates per 100 crossing operations and per 1000 vehicles are presented in the two right hand columns of the table. It can be seen that the violation rate varies considerably across the sites.

[1] The team considered the possibility of developing a single index that would incorporate both these indicators, but was unable to settle on a measure to which all members of the team agreed.

Table 3.1: Overall survey results

Crossing	Travel direction	Control type FL = Flashing lights BB = Boom barriers TS = Traffic lights	Speed limit (km/h)	No of operations	No of vehicles	Red signal violations	Vehicles entering on red signal/100 signal operations	Vehicles entering on red signal/1000 vehicles through the site
Queen Street, Colac	Southbound	FL only	60	74	37369	15	20.3	0.4
Dawson Street, Stratford	Eastbound	FL only	60	128	36102	66	51.6	1.8
Bungaree-Wallace Road in Wallace	Eastbound	FL only	80	151	4062	3	2.0	0.7
Bungaree-Wallace Road in Wallace	Westbound	FL only	80	151	4002	4	2.6	1.0
Bungaree-Wallace Road in Bungaree	Eastbound	FL only	80	153	5375	10	6.5	1.9
Bungaree-Wallace Road in Bungaree	Westbound	FL only	80	153	5282	15	9.8	2.8
Geelong-Ballan Road	Southbound	FL only	80	196	11773	21	10.7	1.8
Geelong-Ballan Road	Northbound	FL only	80	196	10181	10	5.1	1.0
Rooks Road, Nunawading	Sothbound	FL + BB	60	1951	75560	4410	226.0	58.4

Crossing	Travel direction	Control type FL = Flashing lights BB = Boom barriers TS = Traffic lights	Speed limit (km/h)	No of operations	No of vehicles	Red signal violations	Vehicles entering on red signal/100 signal operations	Vehicles entering on red signal/1000 vehicles through the site
Webster street, Dandenong	Eastbound	FL + BB	60	1796	74543	3351	186.6	45.0
Tylden-Woodend Road	Westbound	FL + BB	80	474	16696	59	12.4	3.5
Tylden-Woodend Road	Eastbound	FL + BB	80	474	13987	113	23.8	8.1
Koroit Creek Road	Westbound	FL + BB	80	501	21589	266	53.1	12.3
Koroit Creek Road	Eastbound	FL + BB	80	501	46161	442	88.2	9.6
Mitcham Rd (TS only i.e. pedestrian activated – violating red TS)	Southbound	FL + BB + TS	60	1082	55705	22	2.0	0.4
Mitcham Rd (FL + BB + TS i.e. rail activated violating red TS)	Southbound	FL + BB + TS	60	1090	55705	77	7.1	1.4
Mitcham Rd (combined – violating red TS)	Southbound	FL + BB + TS	60	2172	55705	126	5.8	2.3
Moreland Rd (combined – violating red TS)	Eastbound	FL + BB + TS	60	4108	48275	382	9.3	7.9
Mitcham Rd @ Premier Av	Southbound	TS only (intersection)	60	2917	47247	174	6.0	3.7

Crossing	Travel direction	Control type FL = Flashing lights BB = Boom barriers TS = Traffic lights	Speed limit (km/h)	No of operations	No of vehicles	Red signal violations	Vehicles entering on red signal/100 signal operations	Vehicles entering on red signal/1000 vehicles through the site
Station Street @ Separation St	Northbound	TS only (intersection)	60	6680	55176	74	1.1	1.3
Koroit Creek Rd @ Maidstone	Eastbound	TS only (intersection)	80	6718	54934	10	0.1	0.2
Princess Hwy @ Old Geelong Road	Southbound	TS only (intersection)	80	7261	83821	29	0.4	0.3

3.2 Average violation by control type

Although there was some variation in the violation rates in similar operating environments, averaging across the crossings types in the different environments gave rise to a clear picture of the violation rates in different operating environments as shown in Table 3.2.

By far the highest violation rates per 100 signal operations and per 1000 vehicles entering occurred at the crossings controlled by flashing lights and boom barriers in 60 km/h zones. These sites catered for large numbers of both train and traffic.

Table 3.2: Average violation rate by control type

Control Type **FL = Flashing Lights** **BB = Boom Barriers** **TS = Traffic lights**	**Speed limit (km/h)**	**Average violation rate/100 signal operations**	**Average violation rate/1000 vehicles through the site**
FL only	60	35.9	1.1
FL only	80	6.1	1.5
FL + BB[1]	60	206.3	51.7
FL + BB	80	44.4	8.4
FL + BB + TS[2]	60	7.6	5.1
TS only (intersection)	60	3.5	2.5
TS only (intersection)	80	0.3	0.3

Notes:
1. based on Rooks Road and Webster Street level crossings only
2. based on violation rates for combined pedestrian and rail activations at both the Mitcham Road and Moreland Road level crossing.

Flashing lights and boom barriers in 80 km/h zones resulted in violation rates of both types which were considerably lower than those at similar crossing in 60 km/h zones, but still higher than those at other types of crossing.

Flashing lights only crossings in 60 km/h zones had violation rates per 100 signal operations which were only slightly lower than the flashing lights plus boom barrier crossings in the 80 km/h zones, but the violations per 1000 vehicles were considerably lower. Flashing lights only crossings in 80 km/h zones showed considerably lower violation rates per 100 crossing operations, but approximately similar violation rates per 1000 vehicles compared to similar crossing in 60 km/h zones.

The sites controlled by traffic lights in addition to flashing lights and boom barriers were present in 60 km/h zones only, and also catered for large train and traffic volumes. These sites had much lower violation rates per 100 signal operations than any of the other crossings in 60 km/h zones, and a much lower violation rate per 1000 vehicles than the crossings in 60 km/h controlled by flashing lights and boom barriers.

Road intersections controlled by traffic lights in 60 km/h had lower violation rates per 100 crossing operations than any of the railway crossings, although the rate per 1000 vehicles was higher than at the flashing lights only controlled crossings.

As Table 3.2 shows, the highest red signal and red flashing light violation rates occurred at sites equipped with flashing lights and boom barriers which had high exposure. The lowest violation rate occurred at intersection sites controlled by traffic lights.

The violation rates at both Webster Street and Rooks Road, controlled by flashing lights and boom barriers, were much higher than the rate at Mitcham Road, which was controlled traffic lights as well as flashing lights and boom barriers.

3.3 Timing of violations in relation to signal phases

At sites controlled by FL or FL + BB only, the first indication drivers have that the signal state is changing is the onset of the red flashing lights, which is also the signal to stop. At sites controlled by TS or FL + BB + TS the driver has a four second yellow period before the traffic light turns red. The first four seconds of flashing red are therefore equivalent to the yellow phase at traffic lights in terms of its message to drivers.

In addition to the yellow time, traffic lights have an all-red period (typically around 2 seconds) when drivers on all legs of the intersection are faced with a red signal.

AS 1742.7 (Standards Australia 2007) specifies that level crossings controlled by flashing lights should usually become active 20 seconds prior to the arrival of the train. For level crossings controlled by flashing lights and boom barriers this 20 seconds comprises an initial seven seconds of flashing lights alone, after which the boom gate begins to fall. The Australian Road Rules require that the driver must not enter the level crossing when the warning lights and bells are active, although no warning is given prior to the activation.

After the train has passed, if no other trains are detected approaching the level crossing, the boom barriers begin to rise. The lights do not stop flashing until all boom barriers have settled in their upright position. This generally takes 8 seconds, although it can be affected by factors such as the size of the boom barrier and the power of the motor. Only once the lights have stopped flashing are drivers permitted to pass through the level crossing.

Violations have been allocated to different categories according to the time during the operation of the crossing signals that they occurred. Table 3.3 shows the categories along with the precise nature of the violation for different types of signal control.

Table 3.4 shows the average rate of the each type of violations at each type of crossing control, with the exception of the Mitcham Road and Moreland Road sites, where the rates were so dissimilar that combining them would not be helpful. The results for the individual crossings on which these are based are presented in Appendix B.

Table 3.3: Risk grouping of timing of violations relative to control type

Control[1] / Risk group[2]	FL	FL + BB	FL + BB + TS	TS
Group 1	Flashing light only violation (i.e. within first 4 seconds after flashing lights commence).	Flashing light only violation (i.e. within first 4 seconds after flashing lights commence).	Flashing light only violation (i.e. within first 4 seconds after flashing lights commence).[3, 4]	Yellow phase. Therefore no violation.
Group 2	Red flashing light violation occurring 4 to 8 seconds after flashing lights commence.	Red flashing light violation occurring 4 seconds after flashing lights commence but prior to boom down.	Red traffic light violation occurring 4 seconds after flashing lights commence but prior to boom down when activated.	Red traffic light violation within 2 seconds of red signal.
Group 3	Red flashing light violation occurring 8 seconds after flashing lights commence but not within last 8 seconds.	Red flashing light violation occurring 8 seconds after flashing lights commence but not within last 8 seconds.[5]	Red traffic light violation occurring 4 seconds after red signal but not within last 8 seconds (i.e. prior to boom barrier being released to rise when activated).	Red traffic light violation occurring 2 seconds after red traffic light but not within last 8 seconds.
Group 4	Red flashing light violation occurring within the last 8 to 2 seconds of the level crossing activation.	Red flashing light violation occurring within the last 8 to 2 seconds of the level crossing activation (i.e. during boom up period).	Red traffic light violation occurring within the last 8 to 2 seconds prior to green (i.e. during boom up period when activated)	Red traffic light violation occurring within the last 8 to 2 seconds prior to green.
Group 5	Red flashing light violation occurring within the last 2 seconds of the level crossing activation.	Red flashing light violation occurring within the last 2 seconds of the level crossing activation (i.e. during boom up period).	Red traffic light violation occurring within the last 2 seconds prior to green (i.e. boom barriers have nearly fully risen when activated)	Red traffic light violation occurring within the last 2 seconds prior to green.

Notes:
1. FL = Flashing Lights, BB = Boom Barriers, TS = traffic lights.
2. Risk level does not entail a risk level based on a risk assessment rather a level where similar risk of a conflict could be considered for the purpose of comparing driver compliance relative to timing of violation and relative risk level of that timing of the violation.
3. Where data available. Data only available at the Mitcham Road level crossing.
4. Conflicting message conveyed during this period. Traffic light displays yellow, enabling a vehicle to pass through the crossing, but railway signal displays only red flashing lights.
5. This includes while the boom barrier is falling (i.e. vehicles sneaking under the boom barrier as it is lowered.

Table 3.4: Average violation rate by control type and timing group

Control Type[1]	Speed limit (km/h)	Average violation rate[6]									
		Group 1[2]		Group 2[2]		Group 3[2]		Group 4[2]		Group 5[2]	
		/ 100 operations	/ 1000 vehicles	/ 100 operations	/ 1000 vehicles	/ 100 operations	/ 1000 vehicles	/ 100 operations	/ 1000 vehicles	/ 100 operations	/ 1000 vehicles
FL only	60	16.0	0.4	1.6	0.1	16.0	0.6	1.6	0.1	0.8	0.0
FL only	80	2.5	0.7	0.4	0.1	1.3	0.3	1.0	0.2	1.0	0.2
FL + BB[4]	60	38.4	9.6	7.0	1.7	2.2	0.5	156.9	39.4	2.6	0.6
FL + BB	80	20.1	3.5	20.1	3.5	2.8	0.4	11.7	3.0	0.3	0.1
FL + BB + TS (Mitcham Rd rail activations only)	60	31.8	6.2	0.6	0.1	0.0	0.0	5.5	1.1	1.0	0.2
FL + BB + TS (Mitcham Rd pedestrian activations only)	60	Yellow phase		1.8	0.3	0.0	0.0	0.1	0.0	0.2	0.0
FL + BB + TS (Mitcham Rd combined)[4]	60	Yellow phase		2.2	0.8	1.3	0.5	2.0	0.8	0.4	0.1
FL + BB + TS (Moreland Rd combined)[5]	60	Yellow phase		0.6	0.5	4.0	3.4	3.4	2.9	1.3	1.1
TS only	60	Yellow phase		2.1	1.3	0.1	0.1	0.3	0.2	1.1	1.0
TS only	80	Yellow phase		0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Notes:
1. FL = Flashing Lights, BB = Boom Barriers, TS = traffic lights.
2. Refer to Table 3.3 for violation groups.
3. Based on Rooks Road and Webster Street level crossing only.
4. Based on violation rates for combined pedestrian and rail activations at the Mitcham Road level crossing. The combined rate does not equal the sum of the rail and pedestrian activations due factors such as activation by a pedestrian just before train activation or errors in synchronising both traffic counters.
5. Based on violation rates for combined pedestrian and rail activations at the Moreland Road level crossing.
6. Note also that violation rate is expressed both as violations / 100 signal operations and violations / 1000 vehicles passing through the site.

Traffic counters at the Webster Street and Rooks Road level crossings were set up to be able to detect vehicles going around the boom barrier (see Section 2.2).

Some of the vehicles detected within the violation group 3 at the Webster Street crossing may have gone around the boom barrier, however at Rooks Road the bulk of the group 3 violations occurred while the boom barrier was still falling. Although a small number of vehicles were detected after the boom barrier had been lowered, this may be due to vehicles encroaching over the stop line rather than driving through the crossing.

Further discussion on site specific examples where the investigation identified violations occurring mid phase are outlined in Section 3.5.

For sites controlled by other means (e.g. flashing lights only, traffic lights only or where only the traffic lights and not the boom barriers are active) mid phase violations were detected.

3.4 Average violation by control type and violation group

The average violation rate by control type and timing of violation group is outlined in Table 3.4. The main features of these results are:

- Violation rates were generally lower at sites controlled by traffic lights compared to sites controlled by level crossing controls.
- Level crossing controls (i.e. FL and FL + BB) have high violation rates during the first 4 seconds. At traffic lights, a yellow signal would be displayed during this period, giving motorists an opportunity to prepare to stop at red signal.
- At the Mitcham Road site controlled by FL + BB + TS, the violation rate after the first 4 seconds of the level crossing operation and for the remainder of the level crossing operation was significantly lower than at similar level crossings without the TS installed. Although compliance at the level crossings controlled by FL + BB + TS is better than at similar sites without TS, it is uncertain whether the presence of the pedestrian crossing influenced compliance.
- Although the analysis was able to identify those signal cycles activated by pedestrians and those activated only by trains, the investigation was unable to determine when pedestrians were present on the crossing during the level crossing operation, which may have affected driver compliance.
- Limited visual observations undertaken at the Micham Road level crossing suggests that driver compliance at the level crossing controlled by FL + BB + TS was improved by the presence of the TS as very numbers of vehicles violated the the red traffic light display even though no pedestrians were present on the crossing
- The combined rate at the Mitcham Road site does not equal the sum of the rail and pedestrian activations, due to factors such as activation by a pedestrian just before activation by a train, or errors in synchronising the pair of traffic counters. It was not possible to separate these in the analysis.
- It was not possible to distinguish between train activations and pedestrian activations at the Moreland Road site, as only one traffic counter was used, interfaced with the traffic lights. A relatively high number of Group 3 violations occurred at this site. Video recordings were taken at this site to provide a better understanding of these violations. Analysis of these recordings is presented and discussed in Section 3.5.3.
- Very few mid phase violations (i.e. violations which occurred more than 2 seconds after the red onset and at leat 8 seconds before the end of the red period) were observed at the traffic light sites. A detailed examination of the cycle length of the signals at Princes

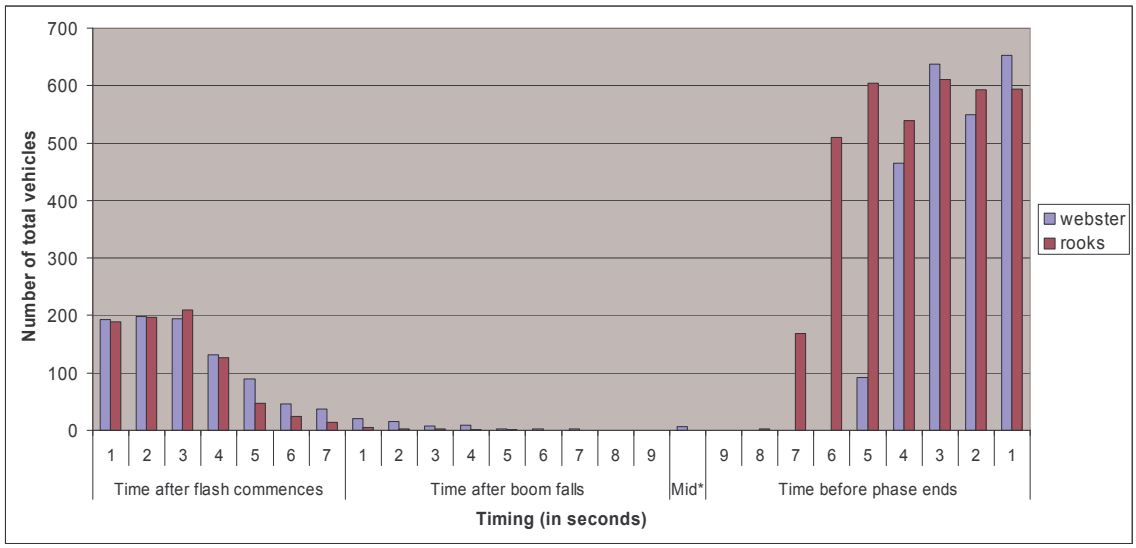
Highway at Old Geelong Road and Mitcham Road at Premier Avenue found that the mean cycle length of the traffic lights (i.e. the time between the start of the yellow signal and the end of the green signa)l was 28 seconds and 21 seconds respectively. This is significantly less than the time taken for the operation of the level crossing. Although this investigation was unable to determine if violation rate would be higher at signalised intersections that have long wait times for vehicles with little vehicle activity in the opposing direction, it is possible that wait times and level of activity in the opposing direction may influence compliance.

3.5 Time course of violations at selected sites

The time course of violations were examined in more detail at selected sites. Only sites with enough violations to establish a temporal pattern were examined in more detail in this section. The reader should refer to Appendix A for timing of violations at sites not referred to in this section.

3.5.1 Webster Street rail level crossing and Rooks Road rail level crossing – 60 km/h FL + BB

Vehicle violations at the Webster Street and Rooks Road rail level crossing, controlled by flashing lights and boom barriers, but no traffic lights, are shown in Figure 3.1.



Notes: *mid phase violations refer to logged vehicles detected at the logger installed at the stop line and not vehicles who have driven around the boom barrier. For further comment on vehicles that may have driven around the boom barrier refer below.

Figure 3.1: Vehicles entering the Webster Street railway crossing after the onset of the flashing red signal

Figure 3.1 shows that the violations at the level crossing for the two sites are very similar to one another in that they predominantly occur either:

- within the first four seconds of the flashing lights becoming active
- after the train has passed and the boom barriers begin to rise, the majority of the violations occurring within the last four second of the level crossing operation.

A traffic counter installed downstream from the rail level crossing was used to detect and record instances of vehicles passing over the crossing when the boom barriers were down. It was assumed that all these vehicles were driven around the boom barrier, using the opposite side of the road, rather than entering the road from entrances or side roads.

Since this analysis involves manual correlation of outputs from different counters, analysis was confined to randomly selected rail level crossing operations out of the full set of operations used in the analysis of infringement times.

***Webster Street** around boom barrier mid phase violations*

167 randomly selected rail level crossing operations out of a total of 1,796 operations were used in the analysis of infringement times at the Webster Street rail level crossing. Of these occasions, there were only eight occasions where vehicles were detected by the downstream logger while the flashing lights were operating.

On most of these occasions, more than one vehicle was detected, up to a maximum of four. In all, a total of 20 vehicles were detected. The average length of level crossing operation at times when vehicles were detected at the downstream logger was 1 minute 49 seconds and ranged from 53 seconds to 4 minutes and 40 seconds.

These times do not appear to be particularly long for railway crossing operations. On one occasion no vehicle was detected at the downstream logger even though the level crossing was in operation for 3 minute and 57 seconds.

A speed restriction is applied to that section of rail line at this site, which carries a number of long, heavily laden trains loaded with steel for Westernport.. Road users are therefore occasionally faced with very long delays, which maybe influencing drivers to undertake this manoeuvre at an increased level. The expectation of a long delay may therefore have influenced drivers to drive round the barrier, even though it had not been down for a particularly long time.

***Rooks Road** around boom barrier mid phase violations*

204 randomly selected rail level crossing operations out of a total of 1,951 operations were used in the analysis of infringement times at the Rooks Road rail level crossing. Of these occasions, there was only one occasions where vehicles were detected by the downstream logger while the flashing lights were in operation. On this occasion, the lights were in operation for a remarkably long period (7 minutes and 42 seconds), at a time (20:32) when traffic would be light.

It was also noted in the review that on three occasions the level crossing was in operation for extended periods of 5 minutes and 18 seconds, 2 minute and 58 seconds and 3 minute and 30 seconds and during these periods no vehicles were detected at the downstream logger even those these operations occurred at 7:01am, 3:38pm and 8:17pm respectively; traffic could be expected to be relatively light at the earliest and latest time, and building up to heavy at the middle time.

3.5.2 Tylden Woodend Road (westbound) and Kororoit Creek Road (eastbound) rail level crossing – 80 km/h FL + BB

Figure 3.2 (Tylden-Woodend Road rail crossing) and Figure 3.3 (Kororoit Creek Road rail crossing) show driver violations at level crossing controlled by flashing lights and boom barriers

situated in an 80 km/h zone. Both figures show separately the behaviour of traffic travelling in each direction.

The pattern of driver violations at both sites is different for each direction. Tylden-Woodend Road eastbound and Kororoit Creek Road westbound have the majority of their violations occurring at the end of the phase. However, Kororoit Creek Road eastbound has the majority of violations occurring at the start of the phase, while at the Tylden-Woodend Road there are a substantial number of violations for traffic in both directions at the start of the signal operation. Due to the large number of violations at the end of the phase, the proportion of violations at the start of the phase is less for eastbound traffic. The implication is that the pattern of violations at level crossing sites are not uniform from crossing to crossing, or and from one approach to the opposite approach at the same crossing.

The fact that motorists are prepared to enter the crossing until the boom barrier begins to fall to fall or before its rise is complete suggests that motorists may be judging the need to stop by the position of the boom barrier .

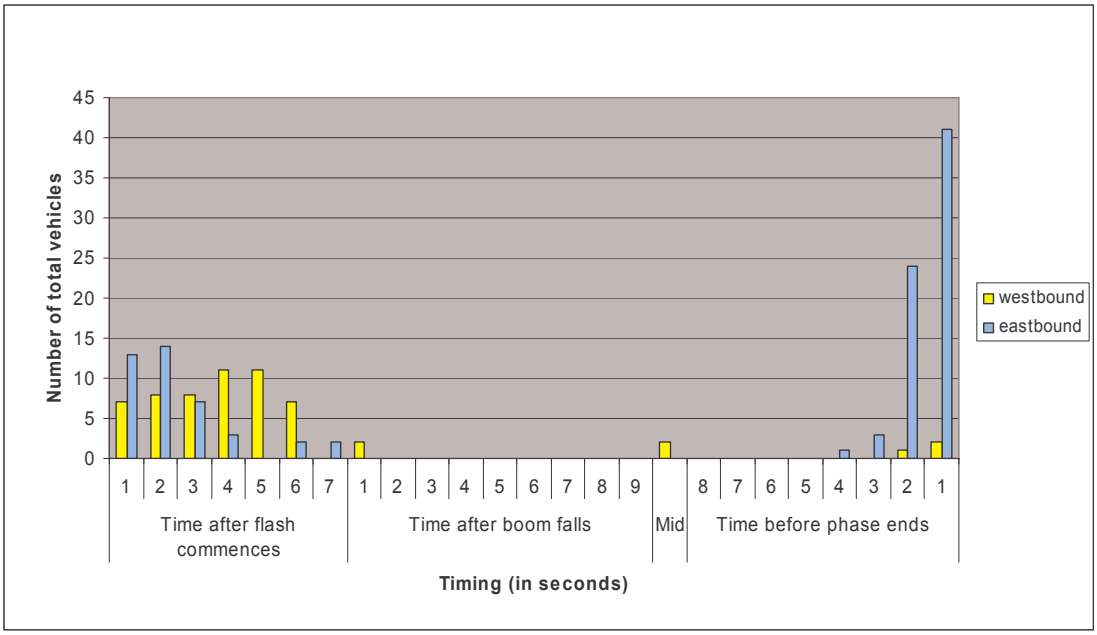


Figure 3.2: Vehicles entering the Tylden-Woodend Road rail crossing (both directions) after the onset of the flashing red lights

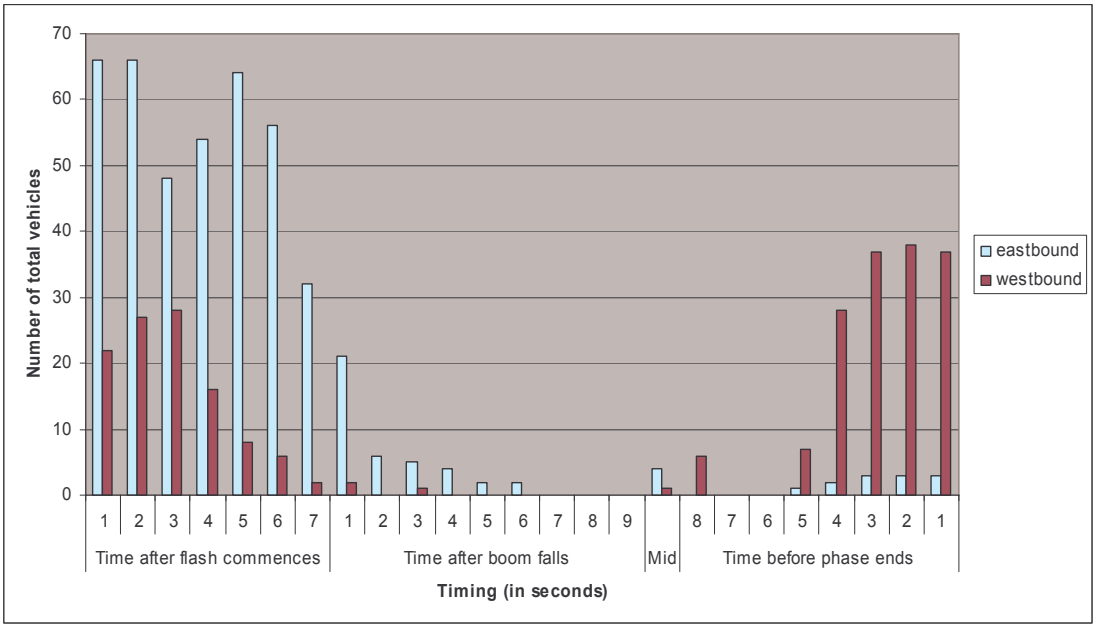


Figure 3.3: Vehicles entering the Kororoit Road rail crossing (both directions) after the onset of the flashing red lights

3.5.3 Mitcham Road and Moreland Road rail level crossing – 60 km/h FL + BB + TS

Figure 3.5 and Figure 3.7 shows the number of vehicles entering the Mitcham Road and Moreland Road rail level crossing respectively. The two graphs are for all operations (pedestrian and rail activated) and show vehicles proceeding through the level crossing during the yellow period, during the first nine seconds of the red period, during the middle part of the red period, and during the last nine seconds of the red traffic signals period.

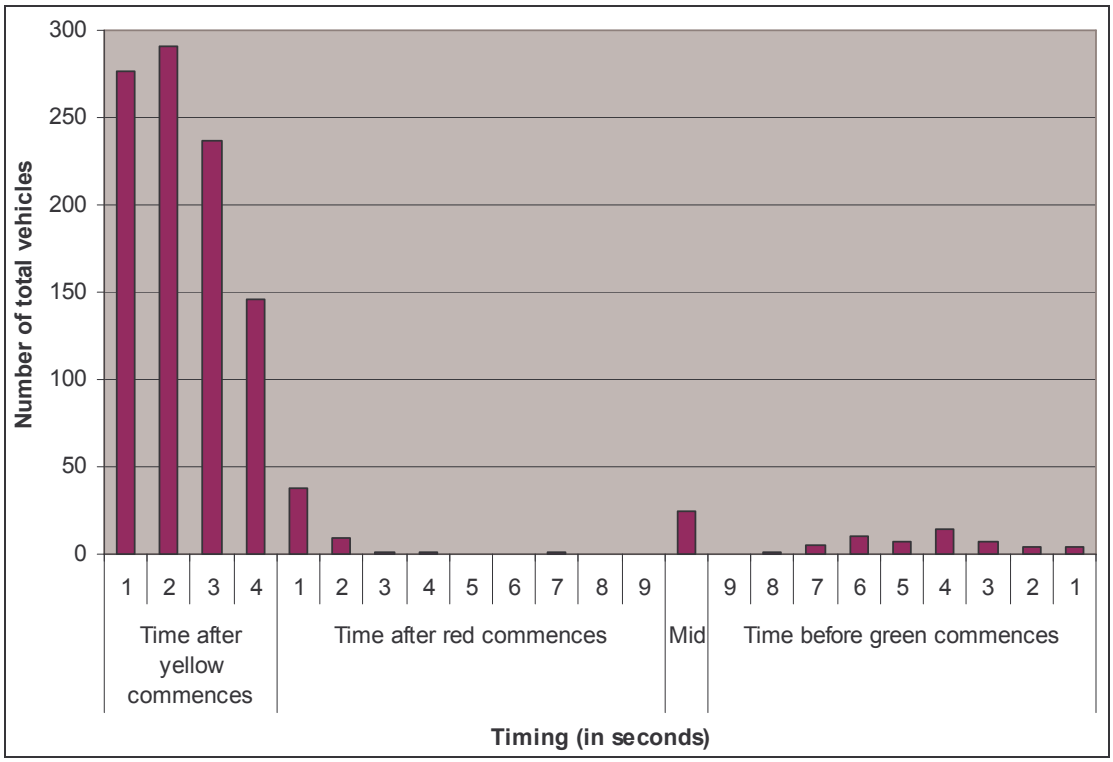


Figure 3.4: Vehicles entering Mitcham Road rail crossing after the onset of the yellow signal – for all signal operations

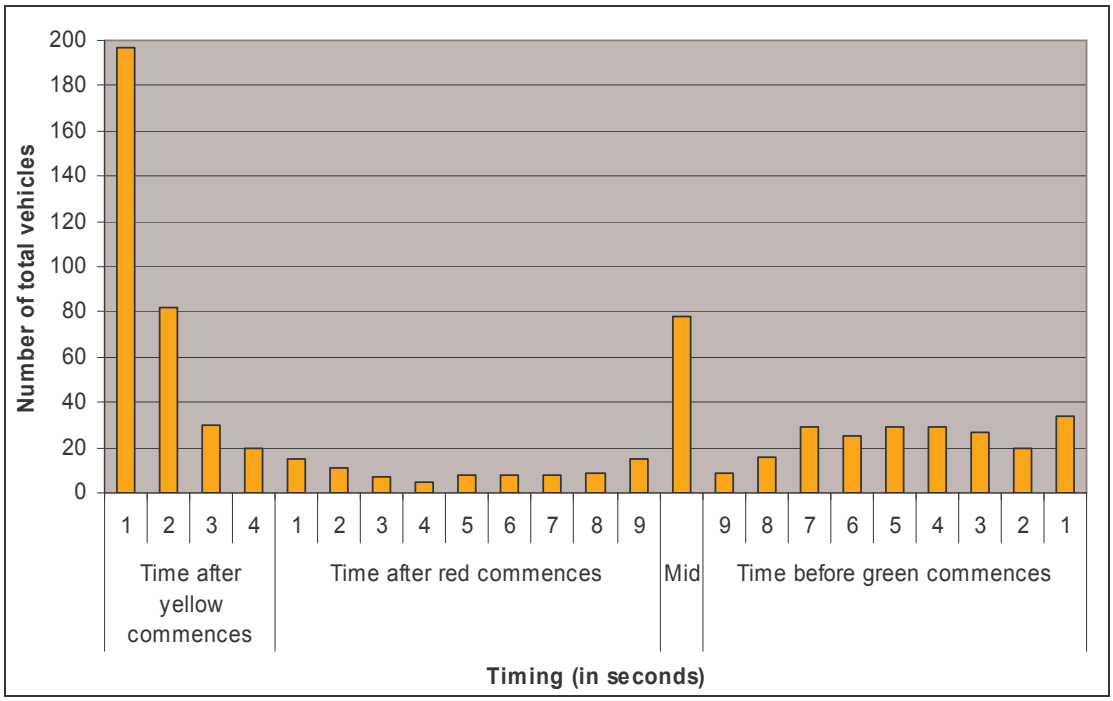


Figure 3.5: Vehicles entering the Moreland Road rail crossing after the onset of the yellow signal for all signal operations

Figure 3.4 shows that at the Mitcham Road rail crossing, very few vehicles entered the crossing after the yellow signal had been activated for four seconds. The vehicles that entered against the red signal did so within the first 2 seconds of the red traffic light display, during the middle of the phase or within 8 seconds of the activation of the green signal. This is due to the operation of the traffic lights which is combined with FL + BB control. It is assumed that possible reasons for this type of red traffic signal violations are due to:

- vehicles entering either just prior to pedestrians crossing or the boom barrier beginning to fall
- vehicles entering against the red as the boom barriers are not down and no pedestrians are using the crossing
- vehicle entering against the red prior to the change to green as the boom barrier has begun to rise and no pedestrians are using the crossing.

Although the general pattern of vehicle violations at the Moreland Road rail level crossing (as shown in Figure 3.5) is similar to the Mitcham Road rail level crossing there are some differences as outlined below:

- Fewer vehicles entered on the yellow signal, and most of these entered during the first two seconds of yellow.
- Of the vehicles entering during the first 9 seconds of the red signal, there was a less pronounced ‘spike’ in the first second than was the case at the Mitcham Road rail level crossing.
- There was a much greater number of vehicles, relatively and absolutely, crossing in the middle of the red period. It was not possible to distinguish between train activations and pedestrian activations at this site, as the traffic counter was interfaced only with the traffic lights. Video recordings were taken at this site to better understand thid high violation rate. It was apparent that the high rate was largely attributable to vehicles stopping in front of the line, in the area between the stop line and the rails. Approximately half of these were vehicles entering from a side street on the south of Moreland Road (Figure 3.6); stopping in front of the line meant that they avoided a long delay to join the westbound traffic stream (i.e. heading away from the camera in Figure 3.6) once the traffic lights changed to green for the through traffic. Details of the observations are documented in Appendix C.
- During the last seven seconds of the red period, vehicles began entering the crossing in larger numbers than was the case at the Mitcham Road crossing, and this continued fairly steadily until the end of the red signals.
- As can be seen from Figure 3.4 and Figure 3.5 vehicle compliance to the red traffic signal is relatively good, compared to a similar level crossing without traffic lights installed (e.g. Webster Street rail level crossing).

Figure 3.6: Moreland Road railway level crossing

Figure 3.7 shows the pattern of vehicle violations at the Mitcham Road rail level crossing for level crossing operations activated by rail only.

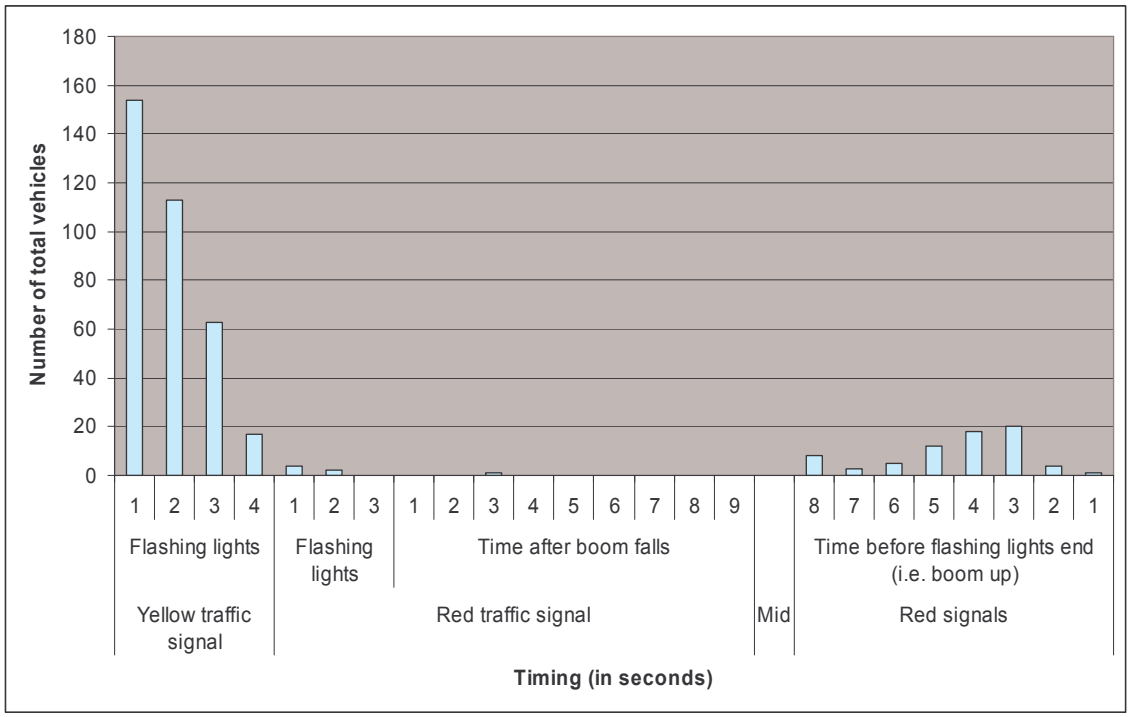


Figure 3.7: Vehicles entering Mitcham Road rail crossing after the onset of the yellow signal – for rail activated operations only

As can be seen from Figure 3.7, the number of violations beyond 4 seconds after the commencement of the flashing lights is very low when compared to level crossing without traffic

lights installed. In addition violations at the end of the operation (e.g. prior to the flashing lights stopping) is much lower than at level crossings controlled without traffic lights. This would suggest that vehicles are more likely to comply with the traffic signal at the end of the phase than the flashing lights of the level crossing.

Figure 3.7 also shows that vehicle compliance to the red traffic signal is relatively good, compared to a similar level crossing without traffic lights (e.g. the Webster Street or Rooks Road rail level crossing).

3.5.4 Mitcham Road at the Premier Avenue signalised intersection – 60 km/h TS only

The pattern of traffic violation was determined for the Mitcham Road at the Premier Avenue signalised intersection and shown in Figure 3.8. Other signalised intersections were not further analysed as violations levels were very low with the exception of the Station Street at the Separation Street signalised intersection which reported a high number of violations occurring within the last two seconds of the phase (see Appendix B).

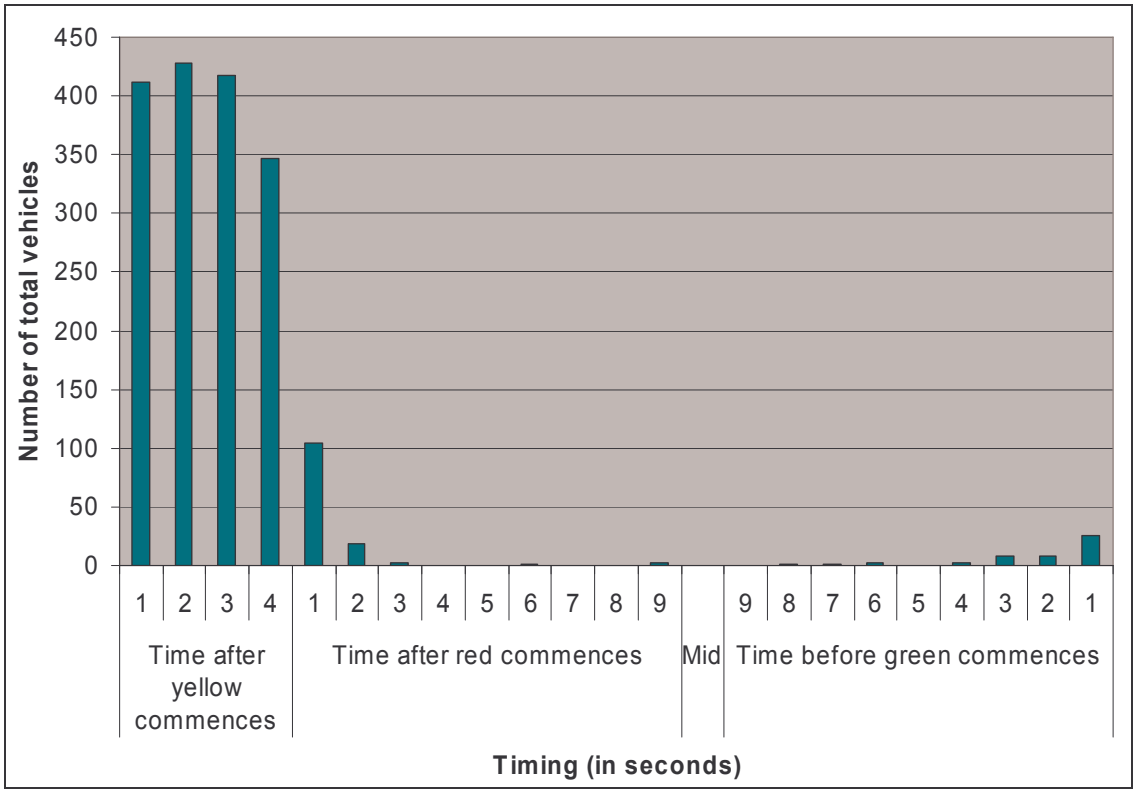


Figure 3.8: Vehicles entering the intersection of Micham Road and Premier Avenue after the onset of the yellow signal

As was the case at the Mitcham road rail crossing, the vast majority of vehicles which enter the Mitcham Road/Premier Avenue intersection do so during the yellow signal with few vehicles entering during the red signal. Of the vehicles entering during the yellow signal, most vehicles entered during the first second or the last second of the red signal. This suggests that most either misjudged the end of the yellow time, or anticipated the green signal.

3.6 Summary of the effects of traffic lights at railway level crossings

Vehicles entering within the first 4 seconds of the flashing light signals at crossings controlled by FL + BB + TS, on occasions when the signals are activated by a train, do so while a yellow traffic light is also displayed.

The results of the survey may be summarised as follows:

- Violation rates vary among railway level crossings, even when the type of control is the same.
- Proportions of drivers committing violations is influenced by traffic and train volumes.
- Rates of entering against a red signal were higher in 60 km/h zones compared to 80 km/h zones. This is may be due to the level of traffic congestion and the length of wait if a crossing opportunity is missed, rather than the actual speed environment. The FL + BB sites located in 60 km/h zones used in this study were located in inner urban areas susceptible to greater traffic congestion compared to FL + BB sites located in the 80 km/h speed zones.
- Rates of entering against a red signal appear to be highest at sites provided with flashing lights and boom barriers. This may be due to drivers taking their cue as to the last possible opportunity to enter the crossing before the barrier descends, and the first possible opportunity after the barrier begins to rise from the position of the boom barriers rather than the signals.
- Rates of entering against a red signal are lower at the level crossing sites where traffic signals are installed. This includes vehicles entering 4 seconds or more after the onset of the railway crossing flashing lights.
- Rates of violating the red signal just prior to the end of the phase are lower at the sites where traffic lights are installed.

The traffic lights seem to have two main effects on driver behaviour:

- Drivers appear more likely to comply with the red traffic signal. By providing the yellow signal (at the commencement of the flashing red signal) followed by red four seconds latter a clear period when the drivers are not permitted to pass through the level crossing is provided. This appears to reduce the number of vehicles entering the rail crossing in the more critical zone, four seconds after the commencement of the flashing red signal.
- They reduce the number of vehicles entering the crossing after the boom has begun to rise, but before the red signal stops flashing. The number of vehicles which do this vary according to site conditions. At sites with high traffic flows, this can be the most frequent circumstance under which vehicles enter against a red signal. At sites with low traffic flows, few instances occur.

Although compliance with traffic lights at railway crossings is much better than compliance with flashing lights alone, it is lower than compliance at signalised intersections. This may be due to the period in which the hazard is present being more clearer at level crossing than at signalised intersections. At level crossings with boom barriers the presence of the hazard is defined by the boom barrier (i.e. the boom barriers are lowered when the hazard is approaching and the boom barrier is raised when the hazard has passed).

4 Discussion

Compliance with signals is better at railway crossings where traffic lights have been provided in addition to flashing lights and boom barriers than it is at crossings where only the flashing lights and boom barriers have been provided. The effect appears to come about mainly because:

- Drivers require some time to prepare to stop. The 4 second yellow signal provides sufficient preparation time and, with the onset of the red signal, a clear point at which entering the intersection or crossing is no longer allowed. In contrast, the flashing red light provides no preparation time, nor a clear point at which entry is no longer permitted. As a result of this ambiguity regarding the time at which stopping is really necessary, vehicles continue to enter the crossing well after the end of the 4 second period.
- Drivers appear to be more reluctant to proceed before the end of the red signal when traffic lights are present, even though the boom raising is substantially complete.

It should be borne in mind that these findings are based on comparing findings at different crossings where these different assemblies of control devices have been installed, rather comparing behaviour at the same sites before and after traffic lights have been added to the signal array.

Although compliance was greatly improved at the rail crossing sites with traffic lights, it was less than the compliance at signalised intersections. It is not clear why this should be so, but a possible reason is that drivers base their judgements regarding the last possible opportunity to enter a crossing before the train arrives and their first opportunity to enter the crossing once the train has passed on the position of the boom barriers rather than the state of the signals.

Perhaps road users feel confident enough in their own judgement not to have to rely totally on the signalling equipment, especially in view of the margins which apply with current railway crossing control equipment, which may appear to drivers to be very conservative in comparison to traffic lights. If this is the case, it is possible that the extent to which traffic lights achieve better compliance at railway level crossings may diminish over time as drivers become more aware that the same time relations between signal onset and train arrival and between train departure and signal offset apply.

The traffic lights at the railway crossings in the present study had been installed to support other functions, to cater for pedestrians in the case of the Mitcham Road crossing, and to cater for entering traffic as well as pedestrians and cyclists at the Moreland Road site. Compliance might well be different if the traffic lights were installed with the sole purpose of improving compliance at railway level crossings. The effects on compliance might be different again if the traffic lights were substituted for the railway level crossing signals, rather than supplementing them.

To fully understand the effect of providing traffic lights at railway level crossings, before and after studies should be carried out at a number of sites where traffic lights are added to the existing ensemble of rail level crossing control devices and are not used in conjunction with pedestrian facilities or signalised intersections, or where traffic lights are substituted for the conventional railway level crossing signals. Only by using a study design of this type can we be sure that the effects are due to traffic lights rather than other influences.

5 Conclusions

Compliance was better at railway level crossings provided with traffic lights in addition to the usual flashing lights and boom barriers. This may be because they provide a clear cue as to when entering the crossing is no longer permitted, reducing the number of vehicles entering

towards the beginning of the red period. It may also be because the red signal provides a clear indication of when entering the crossing is permitted after the passage of the train.

Compliance at railway level crossings with traffic lights in not as good as it is at intersections controlled by intersections. This may be because some drivers use the position of the boom barrier as an indication of when entering crossing is no longer permitted, and of when it is permissible once more.

Compliance varied markedly across the different level crossing controls, with best compliance for the crossings controlled by FL + BB + TS, and poorest compliance at sites controlled by FL + BB in 60 km/h zones. Low levels of compliance at these sites were probably due to long waiting times if a crossing opportunity was missed, due to a combination of long trains and low train speeds.

Sites controlled by flashing lights only had the highest levels of violations in the middle of the flashing red signal phase, the riskiest time for violations to occur.

To fully understand the effect of providing traffic lights, before and after studies should be carried out at a number of sites where traffic lights are added to the existing ensemble of rail level crossing control devices and are not used in conjunction with pedestrian facilities or signalised intersections. Only by using a study design of this type can we be sure that the effects are due to traffic lights rather than other influences.

References

Cairney, P, Knightly, I, Casey, K & Wishart S, 'Increasing compliance with railway level crossing procedures through education and enforcement – a pilot program', contract report VC73649 – 2, ARRB Group, Vermont South, Vic.

Standards Australia 2007, *Manual of uniform traffic control devices, part 7, railway crossings, AS 1742.7 – 2007,* Standards Australia, North Sydney, NSW.

Appendix A Images of surveyed sites and details

Photo's of surveyed sites are shown in Figure A 1 to Figure A 15.

Figure A 1: Rail level crossing – Queen Street in Colac

Figure A 2: Rail level crossing – Dawson Street in Stratford

Figure A 3: Rail level crossing – Bungaree-Wallace Road in Wallace

Figure A 4: Rail level crossing – Bungaree-Wallace Road in Bungaree

Figure A 5: Rail level crossing – Geelong-Ballan Road in Moorabool

Figure A 6: Rail level crossing – Rooks Road in Nunawading

Figure A 7: Rail level crossing – Webster Street in Dandenong

Figure A 8: Rail level crossing – Tylden-Woodend Road in Woodend

Figure A 9: Rail level crossing – Kororoit Creek Road in Altona

Figure A 10: Rail level crossing – Mitcham Road in Mitcham

Figure A 11: Rail level crossing – Moreland Road in Moreland

Figure A 12: Signalised intersection – Mitcham Road / Premier Avenue in Mitcham

Figure A 13: Signalised intersection – Station Street / Separation Street in Fairfield

Figure A 14: Signalised intersection – Kororoit Creek Road / Maidstone Street in Altona

Figure A 15: Signalised intersection – Princes Hwy / Old Geelong Road in Hoppers Crossing

Appendix B Violations by type at individual crossings

Table B 1: Number and rate of violations

Crossing	Travel direction[1]	Type[2] of control	Speed limit (km/h)	No of operations	No of vehicles	Group 1 violations[3]	Group 2 violations[3]	Group 3 violations[3]	Group 4 violations[3]	Group 5 violations[3]
Queen Street, Colac	S	FL only	60	74	37369	15	0	0	0	0
					rate / 100 operations	20.3	0.0	0.0	0.0	0.0
					rate / 1000 vehicles through the site	0.4	0.0	0.0	0.0	0.0
Dawson Street, Stratford	E	FL only	60	128	36102	15	4	41	4	2
					rate / 100 operations	11.7	3.1	32.0	3.1	1.6
					rate / 1000 vehicles through the site	0.4	0.1	1.1	0.1	0.1
Bungaree-Wallace Road in Wallace	E	FL only	80	151	4062	2	0	0	0	1
					rate / 100 operations	1.3	0.0	0.0	0.0	0.7
					rate / 1000 vehicles through the site	0.5	0.0	0.0	0.0	0.2
Bungaree-Wallace Road in Wallace	W	FL only	80	151	4002	3	1	0	0	0
					rate / 100 operations	2.0	0.7	0.0	0.0	0.0

Crossing	Travel direction[1]	Type[2] of control	Speed limit (km/h)	No of operations	No of vehicles	Group 1 violations[3]	Group 2 violations[3]	Group 3 violations[3]	Group 4 violations[3]	Group 5 violations[3]
rate / 1000 vehicles through the site						0.7	0.2	0.0	0.0	0.0
Bungaree-Wallace Road in Bungaree	E	FL only	80	153	5375	5	1	3	0	1
rate / 100 operations						3.3	0.7	2.0	0.0	0.7
rate / 1000 vehicles through the site						0.9	0.2	0.6	0.0	0.2
Bungaree-Wallace Road in Bungaree	W	FL only	80	153	5282	5	0	7	3	0
rate / 100 operations						3.3	0.0	4.6	2.0	0.0
rate / 1000 vehicles through the site						0.9	0.0	1.3	0.6	0.0
Geelong-Ballan Road	S	FL only	80	196	11773	7	0	0	7	7
rate / 100 operations						3.6	0.0	0.0	3.6	3.6
rate / 1000 vehicles through the site						0.6	0.0	0.0	0.6	0.6
Geelong-Ballan Road	N	FL only	80	196	10181	3	2	2	1	2
rate / 100 operations						1.5	1.0	1.0	0.5	1.0
rate / 1000 vehicles through the site						0.3	0.2	0.2	0.1	0.2
Rooks Road, Nunawading	S	FL + BB	60	1951	75560	722	85	12	3618	3
rate / 100 operations						37.0	4.4	0.6	185.4	0.2

Crossing	Travel direction[1]	Type[2] of control	Speed limit (km/h)	No of operations	No of vehicles	Group 1 violations[3]	Group 2 violations[3]	Group 3 violations[3]	Group 4 violations[3]	Group 5 violations[3]
rate / 1000 vehicles through the site						9.6	1.1	0.2	47.9	0.0
Webster street, Dandenong	E	FL + BB	60	1796	74543	716	172	67	2304	92
rate / 100 operations						39.9	9.6	3.7	128.3	5.1
rate / 1000 vehicles through the site						9.6	2.3	0.9	30.9	1.2
Tylden-Woodend Road	W	FL + BB	80	474	16696	34	34	4	3	0
rate / 100 operations						7.2	7.2	0.8	0.6	0.0
rate / 1000 vehicles through the site						2.0	2.0	0.2	0.2	0.0
Tylden-Woodend Road	E	FL + BB	80	474	13987	37	37	3	69	0
rate / 100 operations						7.8	7.8	0.6	14.6	0.0
rate / 1000 vehicles through the site						2.6	2.6	0.2	4.9	0.0
Koroit Creek Road	W	FL + BB	80	501	21589	93	93	4	147	6
rate / 100 operations						18.6	18.6	0.8	29.3	1.2
rate / 1000 vehicles through the site						4.3	4.3	0.2	6.8	0.3
Koroit Creek Road	E	FL + BB	80	501	46161	234	234	44	12	0
rate / 100 operations						46.7	46.7	8.8	2.4	0.0
rate / 1000 vehicles through the site						5.1	5.1	1.0	0.3	0.0

Crossing	Travel direction[1]	Type[2] of control	Speed limit (km/h)	No of operations	No of vehicles	Group 1 violations[3]	Group 2 violations[3]	Group 3 violations[3]	Group 4 violations[3]	Group 5 violations[3]
Mitcham Rd (TS only i.e. pedestrian activated – violating red TS)	S	FL + BB + TS	60	1082	55705	-	19	0	1	2
rate / 100 operations						-	1.8	0.0	0.1	0.2
rate / 1000 vehicles through the site						-	0.3	0.0	0.0	0.0
Mitcham Rd (vehicles violating red FL for rail activations only)[4, 5]	S	FL + BB + TS	60	1090	55705	347	6	1	60	11
rate / 100 operations						31.8	0.6	0.1	5.5	1.0
rate / 1000 vehicles through the site						6.2	0.1	0.0	1.1	0.2
Mitcham Rd (combined – violating red TS)	S	FL + BB + TS	60	2172	55705	-	47	28	43	8
rate / 100 operations						-	2.2	1.3	2.0	0.4
rate / 1000 vehicles through the site						-	0.8	0.5	0.8	0.1
Moreland Rd (combined – violating red TS)	E	FL + BB + TS	60	4108	48275	-	26	163	139	54
rate / 100 operations						-	0.6	4.0	3.4	1.3
rate / 1000 vehicles through the site						-	0.5	3.4	2.9	1.1
Mitcham Rd @ Premier Av	S	TS only	60	2917	47247	-	123	4	14	33

Crossing	Travel direction[1]	Type[2] of control	Speed limit (km/h)	No of operations	No of vehicles	Group 1 violations[3]	Group 2 violations[3]	Group 3 violations[3]	Group 4 violations[3]	Group 5 violations[3]
rate / 100 operations						-	4.2	0.1	0.5	1.1
rate / 1000 vehicles through the site						-	2.6	0.1	0.3	0.7
Station Street @ Separation St	N	TS only	60	6680	55176	-	0	5	11	71
rate / 100 operations						-	0.0	0.1	0.2	1.1
rate / 1000 vehicles through the site						-	0.0	0.1	0.2	1.3
Koroit Creek Rd @ Maidstone	E	TS only	80	6718	54934	-	3	2	4	1
rate / 100 operations						-	0.0	0.0	0.1	0.0
rate / 1000 vehicles through the site						-	0.1	0.0	0.1	0.0
Princess Hwy @ Old Geelong Road	S	TS only	80	7261	83821	-	4	8	5	11
rate / 100 operations						-	0.1	0.1	0.1	0.2
rate / 1000 vehicles through the site						-	0.0	0.1	0.1	0.1

Notes:
1. E = Eastbound, S = Southbound, N = Northbound, W = Westbound
2. FL = Flashing Lights, BB = Boom Barriers, TS = Traffic lights.
3. Refer to Table 3.3 for violation groups.
4. Based on railway level crossing activation only. Note 4 second yellow signal is activated at the commencement of the flashing light. Green traffic signal is displayed once flashing lights stop unless pedestrian signals are activated in which case green traffic signal is only activated once pedestrian phase is finished.
5. The combined total of violations for pedestrian and rail activations does not equal as some operations will operate together and or overlap another activation (e.g. pedestrian signal may have be activated just prior to the rail level crossing activation).

Appendix C Analysis of Video Recordings from the Moreland Road Crossing

The ARRB Video trailer was set up on Moreland Road to the east of the crossing . The view of the crossing is shown in Figure 3.6. Digital video recordings were made during daylight hours on July 16th and 17th. Digital recordings made it easy to obtain accurate timings for events.

The recordings were analysed by identifying four different violation types under two signal operation conditions – traffic lights only operating, or both traffic lights and railway level crossing signals operating. The violation types to be identified were:

- running the red light, travelling straight ahead
- stopping in front of the stop line, travelling straight ahead
- running the red light, entering from the right
- stopping in front of the stop line, entering from the right.

The results of the analysis are shown in Table C 1.

Table C 1: Violations by type at the Moreland Road Level Crossing

	Traffic lights only	Traffic lights and RLC signals
Ran light, straight ahead	27	38
Stopped in front of line	38	6
Ran light, from right	13	12
Stopped in front of line, from right	31	10

Although the time after signal onset was not recorded, it was evident that a large proportion of the Group 3 violations arose from vehicles stopping in front of the stop line.