Office of the Chief Investigator
Transport Safety

Rail Safety Investigation
Report No 2012/07

Collision

Truck and Passenger Train

Abbotts Road Level Crossing, South Dandenong

3 November 2012

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THE CHIEF INVESTIGATOR

The Chief Investigator, Transport Safety is a statutory position under Part 7 of the *Transport Integration Act 2010*. The objective of the position is to seek to improve transport safety by providing for the independent no-blame investigation of transport safety matters consistent with the vision statement and the transport system objectives.

The primary focus of an investigation is to determine what factors caused the incident, rather than apportion blame for the incident, and to identify issues that may require review, monitoring or further consideration.

The Chief Investigator is required to report the results of an investigation to the Minister for Public Transport or the Minister for Ports. However, before submitting the results of an investigation to the Minister, the Chief Investigator must consult in accordance with section 85A of the *Transport (Compliance and Miscellaneous) Act 1983*.

The Chief Investigator is not subject to the direction or control of the Minister in performing or exercising his or her functions or powers, but the Minister may direct the Chief Investigator to investigate a transport safety matter.

EXECUTIVE SUMMARY

In the late morning of 3 November 2012, a Melbourne suburban passenger train collided with a semi-trailer truck at the Abbotts Road level crossing in Dandenong. The collision resulted in one train passenger fatality, injury to five other passengers and the critical injury of the train driver. The driver of the truck was not injured.

The investigation found that the level crossing warnings were activated by the train as it approached the crossing and that the boom barriers were in a horizontal position when the truck was still about 100 metres from the crossing. All other warnings including flashing lights were also operating. The truck driver did not respond to the warnings until the truck was about 20 metres from the rail crossing and by then had insufficient distance in which to stop.

It was concluded that the truck driver's situational awareness was diminished as the truck approached the Abbotts Road level crossing. It is possible that the driver's cognitive functions were impaired by fatigue.

Current level crossing warnings are primarily visual and may be ineffective when a driver is fatigued or distracted. Non-visual warnings have the potential to provide other sensory information to alert drivers, and include passive devices such as road tactile features and active devices situated in the vehicle to provide an in-cab alert.

1. CIRCUMSTANCES

The MTM (Metro Trains Melbourne) passenger train collided with a semi-trailer truck at the Abbotts Road level crossing at about 1141 on 3 November 2012.

The truck had departed the Melbourne Wholesale Fruit Vegetable and Flower Market (Melbourne markets) in Footscray[1] at about 1100 bound for a supermarket in Dandenong South. It travelled via the Monash Freeway and South Gippsland Highway before turning onto Abbotts Road and travelling west (Figure 1).

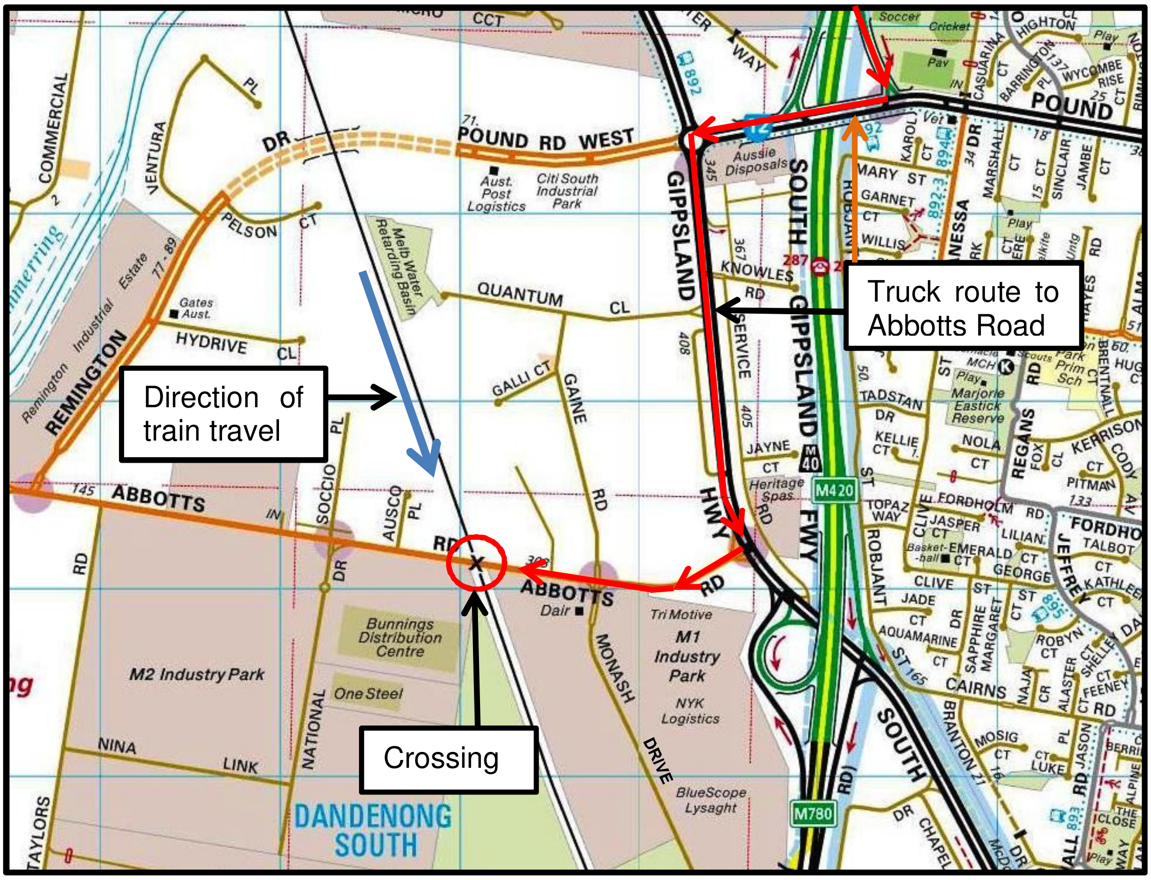

Figure 1: Vehicle route to the Abbotts Road level crossing. © Melway Publishing 2014. Reproduced from Eway Edition 2014 with permission.

MTM passenger train TD4223 had departed Flinders Street railway station at 1055, bound for Cranbourne. The train arrived at Dandenong railway station at about 1136 without incident and departed about half a minute later, travelling south, with 14 passengers on board. When the train was about 800 metres from the Abbotts Road level crossing, the crossing warning signals were activated. The train driver sounded the train horn when about 400 metres from the crossing and when a collision appeared imminent, the driver made an emergency brake application.

The truck entered the level crossing just before the train arrived. The prime-mover cleared the crossing; however, its semi-trailer did not and was struck by the train.

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[1] The Melbourne Wholesale Fruit Vegetable and Flower Market in Footscray is about four km west of the Melbourne CBD.

The front of the train sustained significant damage at impact with the truck and the leading two carriages slewed to either side of the track, also damaging track-side infrastructure. A passenger in the first carriage sustained fatal injuries and five other passengers received injuries of varying severity. The train driver was critically injured and had no recollection of the incident.

The train had made contact with the rear portion of the truck's trailer resulting in the trailer breaking away from the prime-mover at the king-pin. The prime-mover was not impacted and the truck driver was not injured.

2. Factual Information

2.1 Abbotts Road level crossing

2.1.1 The crossing

The Abbotts Road level crossing is located between Dandenong and Lynbrook railway stations on the Cranbourne railway line. The level crossing is about 37 rail kilometres from central Melbourne. Abbotts Road intersects the railway line at an oblique angle (Figure 2). An estimated 7,500 road vehicles—of which about 10 per cent are heavy vehicles—and about 70 trains cross this road-rail intersection daily. There is no pedestrian pathway at this crossing.

Figure 2: Aerial view of the level crossing. © PASS Assets

The level crossing was a standard active type fitted with road and railway signage, flashing red lights, bells and half boom barriers. These warning devices are intended to alert road traffic to the presence of an approaching train and were operational at the time of the incident. The level crossing signalling equipment was fitted with an event recorder which provided information on the operational status of the Solid State Interlocking (SSI) circuits[2] and the level crossing equipment.

The flashing red lamps were incandescent types focussed at 15 and 120 metres in accordance with focussing diagram *PTC MS94/0240 Rev C* dated 22 May 1995. Following the incident, crossing signage and booms were restored in accordance with the current Australian Standard and the flashing red lamps replaced with LED lights.

[2] SSI is a computer-based system of interlocking developed in the 1980s by British Rail's Research Division, GEC-General Signal and Westinghouse Signals Ltd in the UK. The various level crossing functions are actuated by trains passing over track circuits.

The most recent ALCAM[3] (Australian Level Crossing Assessment Model) field survey of the Abbotts Road level crossing was conducted in August 2012 and did not identify safety issues.

2.1.2 Approaches to the level crossing

Approach by road from the east

Abbotts Road runs in an approximately east-west direction and connects the South Gippsland Highway to the Frankston-Dandenong Road with the level crossing about 650 metres west of the highway. From the highway, the road is four-lanes (two lanes in each direction) and curves to the right before straightening about 330 metres from the crossing. The controlled intersection with Gaine Road and Monash Drive (Figure 1) is about 250 metres from the crossing and the view of the crossing infrastructure from the intersection is unobstructed. Beyond this intersection, Abbotts Road reduces to a two lanes approaching the level crossing.

The speed limit for this section of Abbotts Road is 70 km/h. The speed advisory sign-post on the eastern approach to the level crossing was installed just west of the intersection with Monash Drive, but on the day of the incident its sign-board (70 km/h) was missing.

On the eastern side of the level crossing the leading edge of the Stop line was 5.6 metres from the boom barrier and 13.3 metres from the nearest (east) rail, measured along the centreline of the road.

Approach by rail from the north

The line between Dandenong and Cranbourne is a single bi-directional track and at the time of the incident this section had a line speed was 115 km/h. When approaching the Abbotts Road level crossing from the north (travelling south), the crossing becomes visible to the train driver when about 400 metres away. The road approaches are obstructed by buildings to the east and trees to the west (Figure 3).

Figure 3: Train approach

[3] ALCAM is a risk assessment model taking into account over 70 factors for each level crossing site. The model can generate multiple proposed mitigation measures which are scored to determine the optimum treatment for each level crossing and has been adopted in Victoria as a tool to assist with prioritising level crossing upgrades.

2.2 Site and associated evidence

2.2.1 Incident site observations

At the time of the incident the road was dry and the truck had left distinctive marks indicating its path and a section of heavy brake application. There was a pair of dual tyre skid marks commencing about 20.7 metres from the Stop line and curving to the right (Figure 4). The skid marks stopped at the crossing Stop line and rolling tyre prints continued on from that point, turning back to the left towards the lane. Later inspection of the truck trailer tyres (see section 2.7.3) indicated that the skid marks were most likely from the leading or mid trailer axles.

Figure 4: Truck skid marks (Note, the water on the road was not present at the time of the event)

Both boom barriers had been struck by the truck. The east-side boom barrier had been broken off about 1400 mm from its tip and a small portion of the west side barrier's tip was broken.

As a result of the impact with the train, the king-pin connecting the truck's trailer to the prime mover had been torn off, with distortion to both the mounting flange and the pin. The deck of the trailer (Figure 5) was propelled about 23 metres to the south, and had come to rest against a rail infrastructure building, destroying signalling equipment to the south west of the crossing. The top of the trailer was detached from the deck and had landed about 13 metres to the west of the point of impact.

Figure 5: **The deck of the trailer resting against the track infrastructure building. In the foreground are the exposed pits over which signal equipment boxes had been located.**

The collision caused the first five carriages of the train to derail and there was substantial damage to the first three (Figure 6). The leading car had swung to the west side of the tracks. It had rolled onto its side and detached from the second carriage, its trailing end stopping about 182 metres from the crossing.

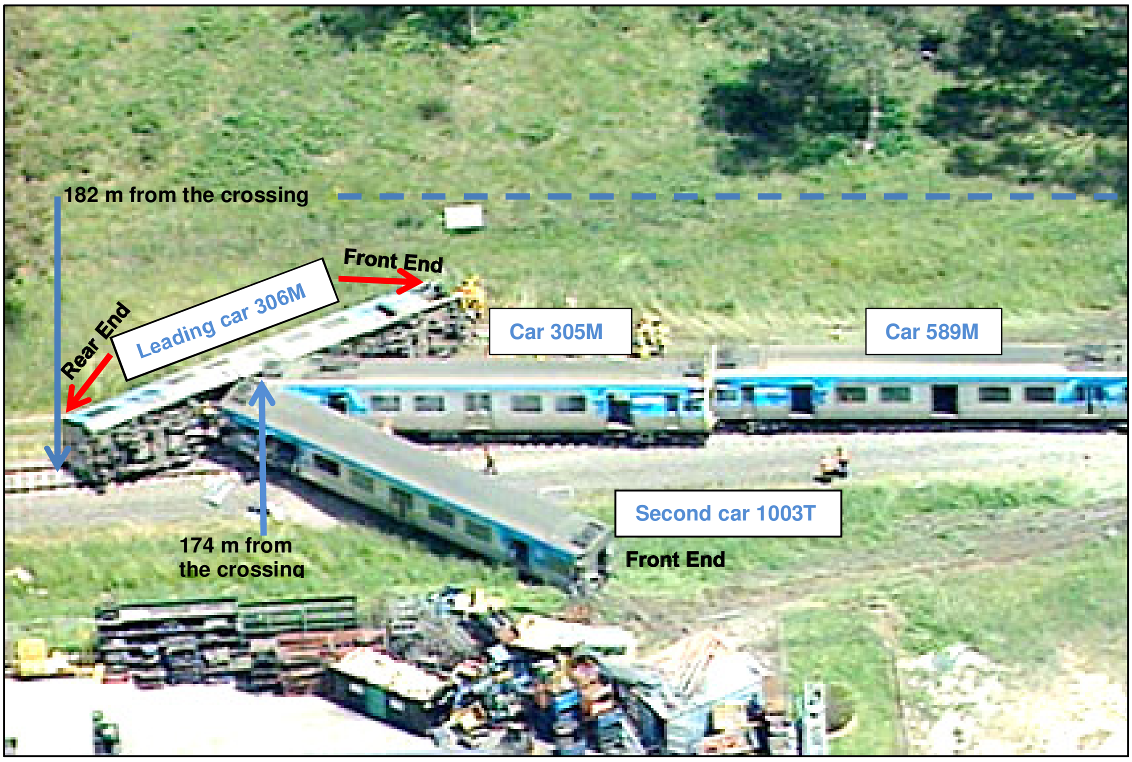

Figure 6: **Aerial view of the incident site. © Seven Network (Operations) Limited**

The second car had also derailed but remained upright and had swung to the east side of the tracks. The front end of the third carriage had stopped about 174 metres from the crossing. Both bogies of the third and fourth cars and the leading bogie of the fifth car had also derailed.

The derailment led to substantial damage to the track, sleepers, rail overhead systems and the signalling infrastructure.

2.2.2 Witnesses to the incident

The incident was witnessed by the occupants of two cars following the truck along Abbotts Road and the occupants of a number of vehicles stopped on the opposite side of the level crossing. They noticed that the bells and lights were operating and the boom barriers were horizontal when the truck travelled through them. They also said that the truck was not travelling very fast.

The witnesses in the car immediately behind the truck stated that the truck overtook them at the Monash Drive intersection. They stated that the truck was being driven steadily and within the speed limit. As they approached Abbotts Road level crossing, they noticed that the warnings lights were flashing and the boom barrier was down but the truck did not slow down. When the truck was almost at the crossing, they noticed the trailer brakes locking up and then being released and the truck attempting to manoeuvre around the boom gates.

The driver of a truck that was stopped on the opposite side of the crossing stated that he saw that the driver had his head facing down and when the truck was about 5 to 10 metres from the crossing the driver looked up and then appeared to apply the brakes. This witness saw the truck attempt to swerve around the boom barriers and hit the barriers either side of the crossing.

It was reported that the driver commented immediately after the incident that he may have fallen asleep.

2.2.3 Environmental conditions

The weather at that time was dry with clear visibility. The sun was at an altitude of about 60^0 above the horizon and about 125^0 to the right of the truck driver, when driving along Abbotts Road. There was no sun glare that would have affected the truck driver's visibility.

2.3 Reconstruction of event sequence

2.3.1 Point of impact

The forward-most impact by the train on the truck occurred on the right hand side of the truck's trailer, at its leading axle. At impact, the leading axle of the trailer tri-axle set was therefore approximately aligned with the west rail (Figure 7).

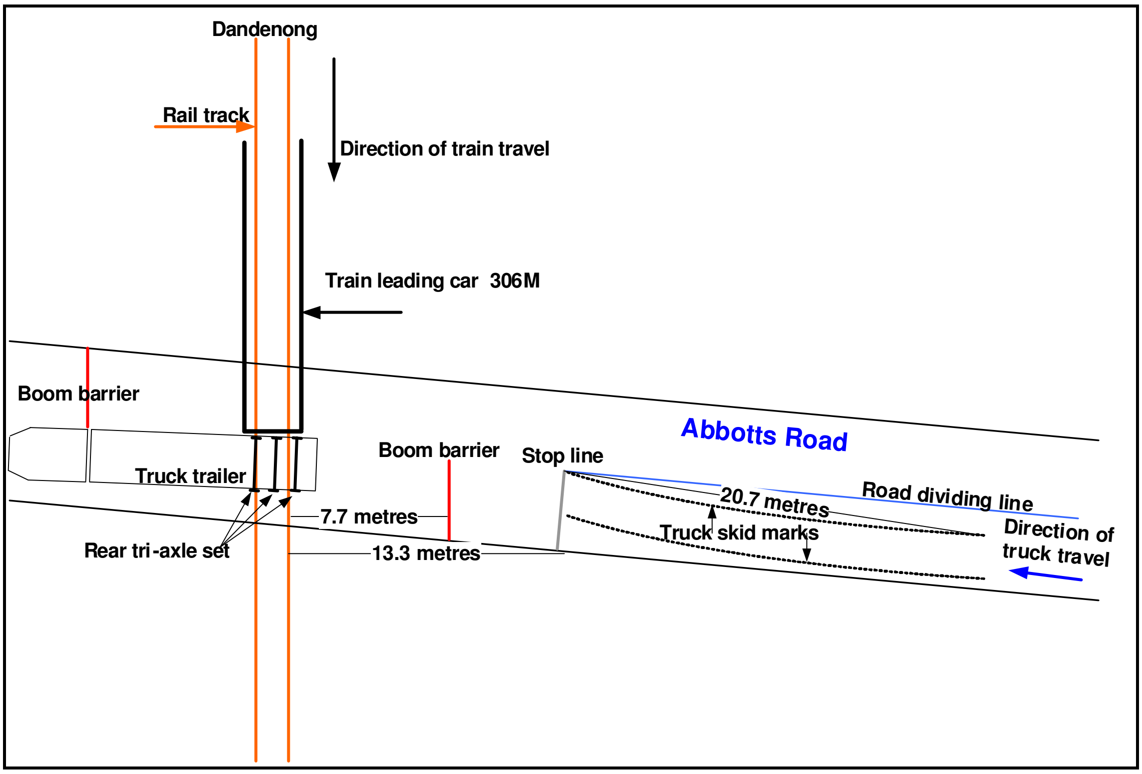

Figure 7: Incident site dimensions and approximate location of truck at time of collision

2.3.2 The truck approach

The truck was not fitted with a device that recorded its speed. The best estimate of truck approach speed was obtained from CCTV footage[4] of the progress of the truck along Abbotts Road. Based on this material, the average truck speed on the approach to the level crossing was estimated to be about 65 km/h. Using this estimate of truck speed prior to braking, a braking phase of 20.7 metres associated with the length of the skid, an assumed constant deceleration of 0.5g[5] during this skid and a constant truck speed after the release of the brakes, the speed of the truck at the time of impact was estimated as being about 40 km/h.

2.3.3 The train approach

The train was fitted with a data logger that recorded a number of operating parameters. Data from accelerometers mounted near the front of the train indicated a sharp increase in train lateral and longitudinal acceleration at the instant when the collision occurred, and so provided a clear point of reference in the records for examining other recorded parameters such as train speed, location and controls.

[4] CCTV footage from an adjoining factory's security cameras.

[5] Brown J F, Obenski K S, Osborn T R, *Forensic Engineering Reconstruction of Accidents*, Second Edition, Charles C Thomas, Illinois, 2002.

The records indicated that when the train was about 800 metres from the crossing, its speed was 110 km/h, increasing to 114 km/h when about 200 metres from the crossing. About 2.5 seconds before the collision the driver moved the Master Controller to the OFF position and then immediately made an Emergency Brake application. The train entered the level crossing about 0.25 seconds prior to collision and its speed was about 113 km/h. Wheel slip was not detected during the emergency braking application.

The recorded data also indicated that both high and low beam lights were switched on at the time of the incident and that the train whistle was sounded for about two seconds when the train was in the vicinity of the whistle board, about 400 metres from the crossing.

2.3.4 The crossing

Analysis of the level crossing SSI event recorder data indicated that all warning devices were active at the time of collision. The log also provided information on the operation and timing of flashing lights, bells and boom barriers. The SSI computer sequentially samples inputs once per second meaning that if an input changes state after it has been scanned, then the changed state will not be detected until the next cycle. Therefore there could be up to one second delay between an activity commencing and its status being recorded.

Active warning systems installed at level crossings in Victoria are designed to provide road users with the following staged warning, based on Section 4.5 of VRIOGS (Victorian Rail Industry Operations Group Standard) 012.0 Revision B[6]:

- the initial phase, flashing lights and bells are activated;
- seven seconds later the boom barriers commence to lower;
- the boom barriers are to be fully lowered within a further 12 seconds; and
- the boom barriers are to be in the fully lowered position for six seconds before the train enters the crossing.

The SSI event recorder indicated that the activation of lights, bells and barriers at this crossing was consistent with these stages. The flashing lights and bells were recorded as being activated about one second after the train was logged actuating the track circuit and the boom barriers began to lower seven seconds later. The barriers took about 11 seconds to lower to the horizontal position and then about five seconds later, the event recorder indicated horizontal detection was lost, probably when it was struck by the truck. A further two seconds later all communication was lost, probably due to the relay box adjacent to the crossing being destroyed shortly after the collision. Based on estimates of the progress of both vehicles in the final moments prior to collision, the barrier was fully lowered for at least six seconds prior to the train entering the crossing.

[6] The Victorian Rail Industry Operations Group is a collaborative committee comprised of a representative from each of its members. The group establishes standards for implementation throughout the Victorian rail network.

2.3.5 Synthesis of events

The approach information for the truck and train was aligned with the SSI crossing data and synthesised into a single timeline using the position of collision between the truck and train as the reference point. At this point the truck trailer's leading axle was approximately aligned with the west rail and the front of the truck about 14.3 metres past this rail and 15.9 metres past the east rail.

The estimated location of the truck and train at key points of the event are summarised in Table 1[7]. Negative distances are distances to the west of the track centreline.

Event	**Truck**	**Train**
	Position of the front of the truck from the track centreline (metres)	Position of the front of the train from collision (metres)
Flashing lights and bells are activated	422	780
Boom barriers commence descending	296	564
Boom barriers are detected horizontal	98	221
Truck brakes are applied	20.5	87
Train master controller to OFF	16.8	80
Train Emergency Brake application	14.3	76
Truck hits approach-side boom barrier	8.5	64
Truck brakes are released	-0.2	42
Collision between truck and train	-15.1	0

Table 1: Estimated position of truck and train prior to the collision

2.4 The truck driver

2.4.1 Qualifications and experience

The truck driver held a Heavy Combination vehicle driving licence issued by VicRoads, for over 40 years. The licence was appropriate for the vehicle he was driving at the time of the incident. The driver stated that he had been driving this truck for about 10 years, and on this particular schedule for the past three years. Prior to that he worked at one of the factories in the area and so was very familiar with the Abbotts Road level crossing.

The driver also stated that he had about 50 years' experience as an auto mechanic and was responsible for servicing the prime-mover and semi-trailer involved in the incident.

[7] The location of the truck was derived from a number of factors including estimates of the truck speed on the approach to the level crossing, during braking and at impact.

2.4.2 Post-incident testing

Following the incident the driver was tested for drugs and alcohol and neither was detected.

2.4.3 Driver recollection of events

The route the driver took that morning was one he used when he was running on-time. He remembered taking a right turn into Abbotts Road but after that had no recollection of events until he suddenly noticed the boom barriers in a horizontal position just ahead of his truck. The driver recalled applying the brakes and trying to steer around the barrier. He realised that he could not stop in time and released the brakes. He did not see the approaching train.

At the time of the incident the driver was the sole occupant in the truck. The truck radio/music system was switched off and he was not using his mobile phone.

2.5 Factors affecting truck driver's performance

2.5.1 Fatigue Assessment

Fatigue caused by sleep deprivation has been shown to adversely impact cognitive functioning. Fatigue involves a diminished capacity for work and possible decrements in attention, perception, decision making and skilled performance (Cercarelli LR, Ryan GA, 1996)[8]. The more fatigued an individual, the greater the impairment of cognitive skills and functioning.

The driver reported that he typically worked day shifts early in the week and early morning shifts, starting at about 0200, on the weekend. He would have the opportunity for a normal night's sleep when doing a day shift whereas he had a reduced period of sleep, typically about five hours, before the early morning shift.

In the week leading up to the incident, the driver's records indicate that he worked day shifts from the Monday through to Wednesday, then early morning shifts on the Thursday, Friday and the Saturday (the day of the incident). On the days he worked early morning shifts he finished driving between 1330 and 1400 and then returned to his workshop.

An estimate of the truck driver's potential state of fatigue at the time of the incident was made using the *Fatigue Avoidance Scheduling Tool* (FAST). It predicts task effectiveness using calculations developed from research into the effects of wakefulness and circadian rhythms on human cognitive performance. The bio-mathematical calculations used in FAST are designed to establish a score indicating an individual's overall state of fatigue and/or alertness, therefore denoting an individual's task effectiveness. The FAST model is, however, a predictive tool and should not be considered a definitive measure of a particular individual's state of fatigue.

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8 Cercarelli LR, Ryan GA, *Long distance driving behaviour of Western Australian drivers* in LR Hartley (Ed) Proceedings of the Second International Conference on Fatigue and Transportation. Promaco, Caning Bridge, 1996.

The FAST model provides an estimate of a number of parameters related to fatigue and performance. It estimated that at the time of collision the driver had an accumulated sleep debt of about nine hours and a lapse in attention was predicted to be four times more likely than that for a well-rested person. Similarly reaction time was estimated to be 35 per cent slower than for a well-rested person.

2.5.2 Diet

On the day of the incident the driver reported that he drank some milk but had not eaten before the incident. Medical opinion advised that the truck driver's low food intake could have adversely affected his cognitive state.

2.6 Managing fatigue for heavy vehicle drivers

2.6.1 Regulated working hours for solo drivers

Current laws for the management of heavy vehicle driver fatigue were developed nationally and enacted in Victoria in 2008 under the *Road Safety Act 1986*, Part 10A—Fatigue Management Requirements. This Act specifies permitted hours of work that includes driving tasks and other defined work activities. Compliance with the requirements of the *Road Safety Act* is the subject of investigation by other State agencies and has been excluded from the scope of this investigation.

2.6.2 Fatigue guidance

Complementing the legal requirements of the *Road Safety Act*, guidelines are provided on the management of fatigue[9]. The guidelines advise that a solo driver needs the opportunity for at least seven hours of continuous sleep in a 24 hour period, be given the maximum opportunity to sleep in preparation for the trip and should start a journey without sleep debt. In this instance the driver did have opportunity to obtain seven hours sleep each night; however, in the three nights prior to the incident he did not achieve this.

[9] National Transport Commission (NTC) Guidelines for Managing Heavy Vehicle Driver Fatigue, August 2007.

2.7 The truck

2.7.1 Configuration

The truck comprised a prime-mover and semi-trailer. The overall length of the truck was about 18.7 metres. The dimension from the front of the truck to the first axle on the semi-trailer was 14.3 metres and to the trailing axle was 16.7 metres.

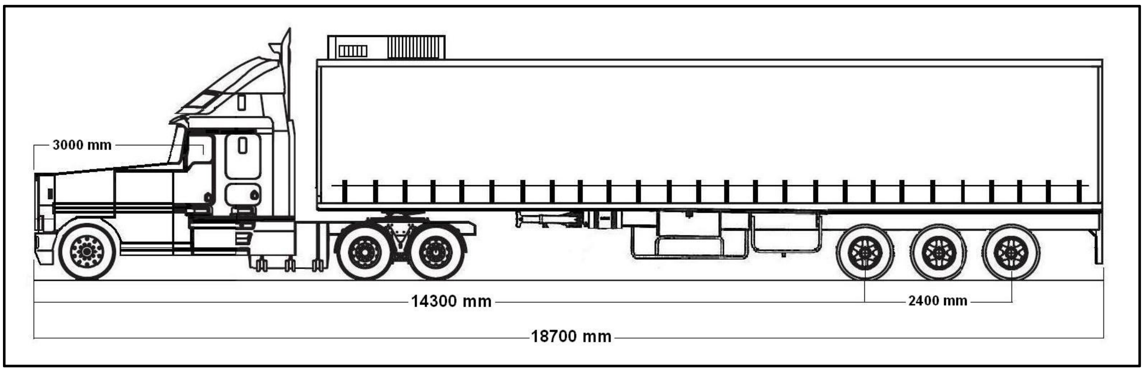

Figure 8: Diagrammatic representation of the prime mover and trailer (not to scale)

The prime-mover was a 1993 Western Star 4964 FX with a Detroit Diesel S60-425 engine, owned by a company based in Heyfield, Victoria. It had a registered tare weight of 15,880 kg and a registered gross combined mass (prime-mover and trailer) of 45,000 kg. The truck was not fitted with an engine data logger. Post-incident inspection did not reveal blind sectors in the forward direction from the driving position.

The semi-trailer was a 1996 Krueger ST-3-38 tri-axle refrigerated curtain-sider belonging to a freight shipping company based in Cowes, Victoria. At the time of the incident the trailer was loaded with 15 pallets of bagged potatoes weighing about 14 tonnes and eight pallets of flowers in boxes, weighing about one tonne.

2.7.2 Design stopping distance

Inspection guidelines[10] specify an average service brake deceleration of 2.8 m/s for this type of truck, equating to a stopping distance of about 58 metres from a speed of 65 km/h. If the truck was able to achieve an average deceleration of 0.5g (4.9 m/s) then the stopping distance would be about 33 metres.

2.7.3 Post-incident damage inspections

Semi-trailer

Damage to the trailer was consistent with impact to its right side. The forward most impact damage was at the leading axle of the rear tri-axle set, with progressively more severe damage to the rear. The rear-most axle had been dislodged and pushed back. There was significant penetration of the tray structures from the mid-axle, towards the rear. The tread surface of the trailer's tyres had recently been abraded. Most tyres showed signs of lateral scrubbing consistent with being pushed sideways across the road surface.

[10] National Heavy Vehicle Inspection Manual, National Transport Commission, 2004.

The front and mid axle tyres had light flat spots and loss of rubber consistent with wheel lock-up due to braking. The flat spots on the tyres and the tread grooves were consistent with the tyre marks recorded on the west-bound lane on approach to the rail crossing. The trailer brake system was unable to be tested due to the extent of damage. On inspection there did not appear to be any brake surface contamination.

Prime-mover

There was no incident damage of significance identified on the prime-mover, excepting for local distortion at the king pin connection point. A light flat spot was located only on the offside tyres on the rear drive axle but there was no evidence of tyre scrubbing or flat spots that might be associated with heavy braking.

A third-party inspection of the braking system on the prime-mover found that there was excessive push rod travel on both brake assemblies on the steer axle and the brake assemblies on the nearside front and rear drive axles. There was excessive wear on both brake drums on the front drive axle and the brake drum on the nearside of the rear drive axle, with inoperative spring brakes on those corresponding brake assemblies. The inspection also noted that there was no service brake retardation on the nearside brake assembly on the front drive axle and there was air leakage from the brake foot-pedal valve. The condition of these items indicated that the braking capacity of this vehicle was reduced to some degree.

2.8 The train

2.8.1 Technical

The train involved was a six-car Comeng type made up of two 3-car units. They were part of a fleet of 95 trains built between 1982 and 1989 by Commonwealth Engineering (Comeng) in Dandenong, Victoria. Each 3-car unit comprised two motor cars separated by a trailer car. The lead unit comprised cars 306M (leading car), 1003T and 305M and the trailing unit cars 589M, 1022T, and 583M. The length of the train was about 142 metres with a nominal tare mass of 262 tonnes. It had a seated passenger capacity of 546 and a maximum speed of 115 km/h.

The Comeng train is equipped with rheostatic, electro-pneumatic and air-actuated braking. In this instance, the leading 3-car unit was fitted with tread brakes and the trailing unit with disc brakes. For this configuration, effective deceleration should commence in less than three seconds following an emergency brake application and from a speed of 114 km/h the specified stopping distance is 643 metres.

Interrogation of the on-board train data logger indicates that an emergency brake application was made approximately 2.4 seconds before the collision. Brake cylinder pressures increased as expected in response to the driver's command however there was insufficient distance for the braking system to take effect and a significant reduction in speed to occur. No anomalies were identified in the response of the braking system to the emergency brake application.

All cars had completed the required scheduled maintenance exams. However, at the time of the incident, the rheostatic brake on motor car 583M was isolated. The train braking system compensates for such a condition through electro-pneumatic braking and the train was permitted to remain in service in this condition until the next scheduled workshop inspection. Train data logger information indicated that the braking system performed within specification at previous stops on the day of the incident.

2.8.2 Train driver details

The train driver joined MTM in 2009 and qualified to operate electric multiple unit trains in April 2011. His last medical examination was in September 2009 at which time he was assessed to be medically fit. The audit history for the driver indicated sound ability with conformance to rules and operating procedures. His last driver audit was in May 2012 when he was noted to be 'competent'.

The driver's roster for the previous seven days indicated that his hours of work were within the prescribed limits for MTM's management of fatigue.

2.8.3 Passenger distribution

CCTV cameras were installed inside each car and recordings indicated that there were 14 passengers on the train at the time of the incident. Two passengers were seated in the leading car. The passenger who was fatally injured was seated immediately behind the partition with the driver's cab, on the right-hand side and the other passenger in the leading car was seated on the left-hand side just forward of the rear door. There were five passengers in the second car, one seated at the front of the car and four in the mid-section. In the third car one passenger was seated towards the front and one at the rear. The remaining five passengers were located in the rear three cars.

2.8.4 Damage inspections and crashworthiness performance

Leading three-car set (306M-1003T-305M)

The leading car 306M was severely damaged. The car monocoque was compromised at a point about 15 metres from the leading end, with associated distortion of the floor, sides and roof. Internal fittings were mostly intact excepting in those areas where there had been structural deformation. Within the central section of the car, the floor was distorted and seating dislodged. Damage to the trailing end of car 306M was not severe.

There was considerable damage to the front of car 306M (Figure 9) and the coupler had been torn off. The car front had been penetrated on both the driver's side (left in the direction of travel) and the right side and debris from the truck's load was inside the carriage compartment. There was considerable loss of carriage side structures on the right side including into the passenger compartment.

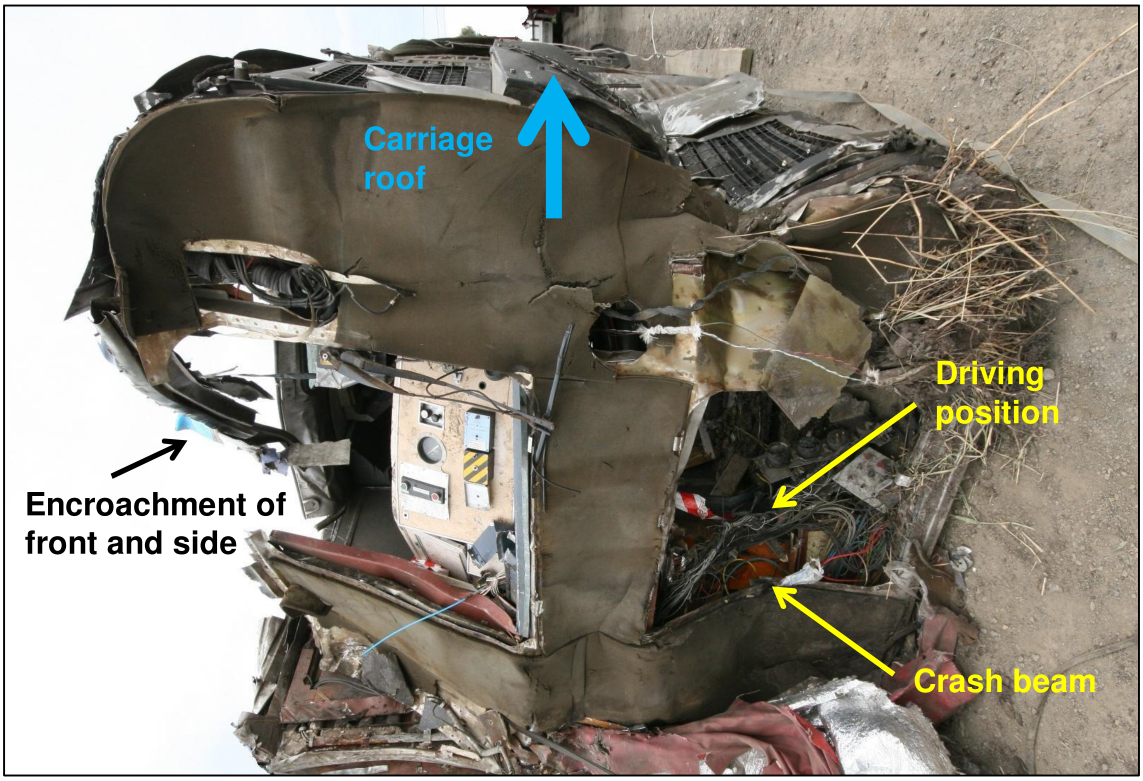

Figure 9: Front of car 306M, picture rotated to orientate roof at top

The two vertical collision posts on the cab front were intact. Both posts were connected at their ends and there was no notable distortion of these members. The horizontal 'crash beam' that was located at the front of the driving position, below the driver's window, was severely deformed but remained connected at its ends, indicating that it absorbed significant energy. Maximum deformation was measured as being about 175 mm at the beam's central point (Figure 10). It is probable that the beam acted to reduce the level of damage encroachment into the driver's space.

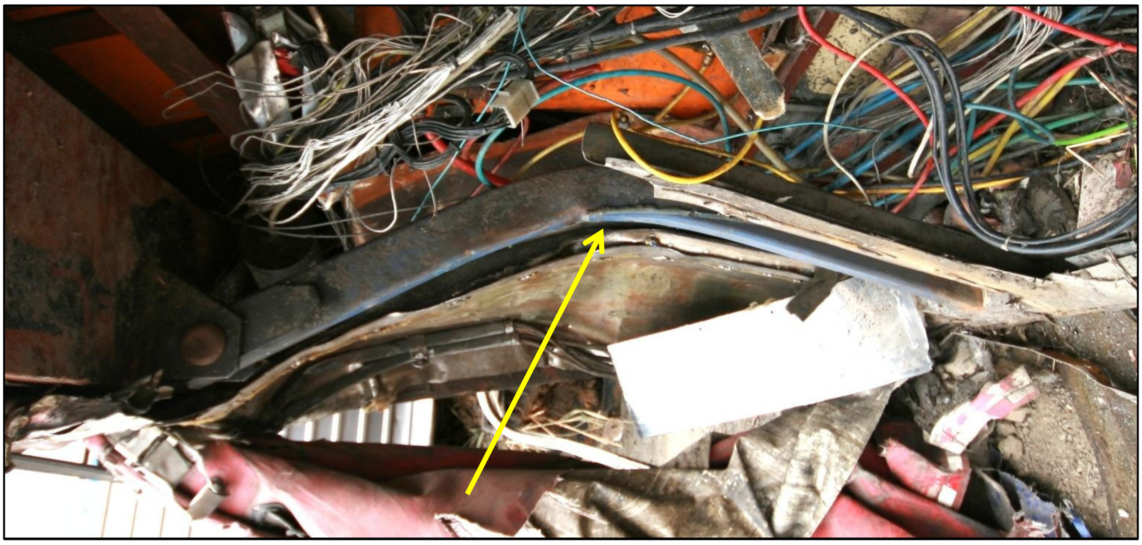

Figure 10: View from above of deformed crash beam at front of driver's cab

The trailer car 1003T suffered most damage at its trailing end, consistent with this end having impacted the following car, 305M. The internal passenger space, seating fixtures and equipment were intact excepting at this trailing end in way of the severe structural distortion. End collision posts at both ends remained intact.

The trailing car of the leading car-set, 305M, similarly exhibited localised structural damage where there had been interaction with an adjacent car and damage to the internal spaces and fixtures was again limited to these areas. The most severe damage was at the leading end of the car and an end collision post had been dislodged from its base connection (Figure 11).

Figure 11: Leading end of car 305M, note dislodged vertical collision end-post

The damage to the leading end of car 305M and dislocation of the collision post was consistent with override by the side sill of the trailing end of car 1003T. The connection detail of the damaged collision post was consistent with its design and there was no evidence of pre-existing material defect.

Trailing three-car set (589M-1022T-583M)

The leading car of this set (589M) had sustained minor damage to its leading end and the forward coupler was missing. The passenger space was largely undisturbed, with seats and fittings remaining attached. There was no noticeable internal damage in the trailing two cars (1022T and 583M) within this set.

2.9 Level crossing performance

2.9.1 Level crossing incident history

Since March 2005 and prior to this incident, there had been one fatal collision between a train and a road vehicle at this level crossing and reports of two near misses. In all three incidents the road vehicle was travelling east (the direction opposite to this incident) and failed to stop after the crossing was activated.

2.9.2 Warning times

VRIOGS specifies a minimum warning time of 25 seconds from the time the bells and lights are activated until the train arrives at the crossing. AS1742.7-2007 Manual of Uniform Traffic Control Devices, Part 7: Railway Crossings specifies a minimum warning time of 20 seconds prior to the arrival of a train at a single track crossing, while noting that some railway organisations may require longer times. Minimum warning times specified in other standards are typically within the range of 20 to 30 seconds.

MTM references the VRIOGS requirement of 25 seconds. To achieve this warning time, the track circuit at this location commenced 800 metres from the crossing. For a line speed of 115 km/h, this equates to a nominal warning time of 25 seconds. Actual warning times in each instance of crossing activation can be affected by any lag in the system after train detection. Following this incident, MTM measured the warning time at this location as being 22.4 seconds with a train approach speed of 113 km/h. This led to MTM reducing the track speed to 100 km/h.

Crossing performance on the day of the incident was examined by considering crossing SSI data and estimating the progress of the vehicles prior to collision. The boom barrier was struck by the truck about 23 seconds after the recorded activation of the lights and bells and just under two seconds later the train entered the crossing. Considering potential error associated with data logging and modelling estimates, the total warning time prior to the collision was likely to have been about 24 seconds and sufficient to alert a driver of the approaching train. The duration of the warning time is considered to have had no bearing on the incident and its outcome.

2.9.3 Signage

The road markings and signage installed at the Abbotts Road level crossing was consistent with the *1978 Australian Standard AS1742* Part 2 for level crossings. Although not mandatory for 70 km/h roadways, a 'RAIL' and 'X' was painted on the west-bound lane about 110 metres from the level crossing.

The 1978 level crossing signage standard was superseded in 2007 by *Australian Standard AS1742* Part 7. It is normal practice to adopt a later standard only at the time of major refurbishment or upgrade works. The difference between the two signage standards for this crossing application is minor and not significant to this incident.

2.9.4 Maintenance

MTM had six applicable maintenance service schedules covering track circuits, level crossing equipment and relays. Maintenance inspections scheduled for 2012 were completed in accordance with the required maintenance cycles with the exception of an overrun of 17 days for one track circuit inspection. This exception was not significant to this incident.

2.9.5 Risk management

Rail and road infrastructure managers are required under the *Rail Safety Act 2006* to identify risks to safety at each level crossing and develop a Safety Interface Agreement (SIA) that provides the mechanism to jointly manage these risks. At the time of this incident the SIA for the Abbotts Road level crossing between MTM and the City of Greater Dandenong was in draft form. The agreement was finalised in December 2012.

A risk assessment of the crossing was undertaken by representatives of MTM and the City of Greater Dandenong in March 2011. A further assessment was made by MTM in June 2012. Both reviews concluded that the crossing was in a serviceable condition with recommendations for improvement. The 2011 recommendation to resurface Abbotts Road was completed prior to the 2012 assessment.

Within the 2012 review, recommendations to be carried out within the next 3-5 years included the upgrade of flashing lights to LED lamps and duplication of Abbotts Road to assist with the increasing flow of industrial traffic. It was also noted that large capital works such as grade separation may need prioritisation beyond this five year timeframe.

2.10 Technology and improving safety at level crossings

2.10.1 Conventional crossing protection

Active rail crossing protection combining automatic half barriers (AHB) and flashing lights and bells is the standard configuration used for high usage crossings in urban environments across Australia. The visual warnings provided by the barrier and the flashing lights are the most effective components of the protection for vehicle drivers, but rely on visual perception. In the case where a driver is drowsy or distracted, the visual stimuli can be ineffective.

2.10.2 Tactile stimuli

Road rumble strips provide aural and tactile stimuli and can be effective in alerting drivers in a reduced state of awareness to hazards ahead, including level crossings. Road rumble strips have been installed in advance of approximately 200 level crossings in rural Victoria.[11] These have been installed primarily on sealed high speed roads in rural locations to alert drivers to an upcoming hazard, where they otherwise might not encounter other traffic.

In urban environments, the potential benefits and suitability of using tactile stimuli ahead of level crossings is less clear. The benefit of rumble strips or other tactile road features in an urban area where road users have a much higher expectation of stopping and giving way would need to be established by further research or trials.

2.10.3 Technological advances

In-cab technologies to detect fatigue have been developed and are now appearing in production in some higher-end cars and also in heavy vehicles for mining.[12] The technology used in the cab of mining trucks is based on in-cab cameras monitoring the driver's facial activity to determine alertness and it can also detect distraction by detecting eye gaze moving away from the front of the vehicle.

[11] http://www.vicroads.vic.gov.au/NR/rdonlyres/7A3A6CD2-FD74-4911-A190-7A77B7EA072C/0/RumbleStripsReport_20081125.pdf.

[12] http://www.abc.net.au/news/2013-05-29/eye-tracking-technology-watches-out-for-sleepy-drivers/4720240.

Lane departure monitoring using windscreen mounted cameras to monitor the position of the vehicle relative to road markings is now available in production cars in Australia. This technology can provide an indication that a driver has a reduced state of awareness. Other in-cab technology involves the driver wearing specific items such as spectacles for eye blink rate monitoring or special caps for brain activity monitoring. Both systems detect fatigue and provide a warning. These in-cab systems can be effective in detecting decreased driver alertness and can, by providing in-cab stimuli (acoustic alert and/or seat vibration), alert a driver so that action can be taken.

Cooperative Intelligent Transport System (C-ITS) is a recent innovation that involves the integration of communication systems and multiple in-car technologies to allow vehicles and surrounding infrastructure to exchange information about the location, speed and direction of other road users also using C-ITS. This will enable drivers to monitor and be warned of potentially dangerous situations and so allow pre-emptive action to be taken to avoid accidents. In particular, Infrastructure-to-Vehicle technology has been trialled in Victoria at two urban actively controlled level crossings and a rural passive level crossing. This technology has the potential to provide an effective in-vehicle warning to increase the awareness of fatigued or distracted drivers approaching an activated level crossing. It is expected that within the next three to five years new cars will be installed with C-ITS technology, although it may take over a decade for this technology to become common in the Australian vehicle fleet.

3. ANALYSIS

3.1 The incident

There was an unobstructed view of the Abbotts Road level crossing at least from the preceding controlled road intersection, a distance of about 250 metres from the crossing. For a vehicle approaching at 65 km/h, the approach time from this road intersection is about 14 seconds. Both distance and time were sufficient in which to view the active warning devices and take appropriate action.

The crossing provided early visual warnings that—had they been detected—would have given the driver of the truck sufficient opportunity to bring his vehicle to a stop prior to the crossing. Flashing lights commenced when the truck was more than 400 metres distant, and the boom barrier began to lower with the truck 300 metres away. The boom barrier was horizontal when the truck was about 100 metres from the track. At this point, there was still sufficient distance in which to stop the truck.

The collision occurred as a result of the truck driver not detecting the crossing warning devices until very close to the crossing. The truck's brakes were applied when the truck was about 20 metres from the track and by this time there was insufficient distance in which to stop.

3.2 Truck driver's situational awareness

Situational awareness can be defined as 'The perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future'.[13] The late detection of the active warnings at the crossing was a result of the driver not maintaining adequate situational awareness.

On its more distant approach to the level crossing the truck was being driven steadily yet the driver did not detect the early active visual warnings. This suggests the driver had sufficient attentional resources to attend to local driving tasks such as following the curvature of the road but that the driver was not attending to indicators ahead. Then, as the truck neared the crossing, the driver was observed with his head down, an indicator of fatigue or distraction.

It is possible that the driver's ability to maintain appropriate situational awareness at a safety critical time, at a crossing that he had traversed many times before, was impaired by fatigue. On each of the three nights before the incident the truck driver had shortened sleep of about five hours. This led to a significant sleep debt on the day of the incident and the potential for reduced cognitive function.

3.3 Personal fatigue management

In the days leading up to the incident the driver had the opportunity to obtain a minimum seven hours continuous sleep in each 24 hour period, as recommended, but did not achieve this minimum in the three nights before the incident. To manage his fatigue, the driver needed to start his sleep significantly earlier on each night prior to his early morning shift.

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[13] Endsley MR, Design and evaluation for situation awareness enhancement, in Proceedings of the Human Factors Society 32nd Annual Meeting (pp 77-101). Santa Monica, CA: Human Factors and Ergonomics Society.

3.4 Enhancing driver detection of an activated level crossing

Current level crossing defences are primarily visual and may be ineffective when a driver is fatigued or distracted. The potential benefit of tactile warnings in the urban environment has not yet been established and further research in this area may be warranted. Other non-visual interventions that can provide an in-cab alert are also being developed.

While not reducing the obligation on drivers to be sufficiently rested and maintain adequate situational awareness of road and traffic conditions, new technologies are providing opportunities for detection of fatigue and distraction and providing other ways of alerting a driver of an activated level crossing.

4. CONCLUSIONS

4.1 Findings

1. The level crossing active warning signals operated as designed and were not contributory to the incident.

2. The mechanical condition of the truck brakes, although deficient, was not causal to the collision.

4.2 Contributing factors

1. The truck driver did not observe the active warning signals in sufficient time to stop the truck before the level crossing.

2. The truck driver lost situational awareness on the approach to the level crossing.

3. The truck driver's cognitive function was possibly impaired by fatigue.

5. SAFETY ACTIONS

5.1 Safety Actions taken since the event

After this incident the line speed for the rail approach to the Abbotts Road level crossing was reduced to 100 km/h to ensure that a 25 seconds warning time is achieved.

5.2 Recommended Safety Actions

No specific recommendations have been made as a result of this incident.

Safety at active level crossings may be improved by introducing non-visual stimuli for road vehicle drivers. New technologies that provide in-cab alert to drivers provide the potential for safety enhancement and the support of such technologies is encouraged, particularly in heavy vehicle applications.