Office of the Chief Investigator
Transport Safety

Rail Safety Investigation
Report No 2017/02

Collision between truck and tram

At Elliott Avenue, Parkville on

22 May 2017

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.

SAFETY SUMMARY

What happened

At about 0805 on Monday 22 May 2017, a loaded truck and trailer travelling west on Elliott Avenue, Parkville collided with a city-bound, route 58 tram. The tram was derailed but remained upright. The truck rolled onto its side trapping the driver. The truck's fuel tank was ruptured resulting in a minor fuel spill.

As a consequence of the collision, 26 tram passengers were medically assessed at the site and 14 transported to various medical locations for treatment. The tram driver and truck driver sustained minor injuries.

What was found

It was found that that the truck entered the road intersection with the tramway as the tram was crossing Elliott Avenue. A late attempt to stop the truck was unsuccessful and it impacted the side of the tram. The driver of the truck subsequently tested positive for amphetamine and the presence of the drug in his system probably affected his driving performance.

There was no identified functional defect in phasing between road traffic and tram right-of-way signalling. On balance considering the traffic system functionality and witness information, it is probable that the tram entered the intersection with traffic signals in the tram proceed phase.

There were other factors identified that were not considered contributory to the collision, but increased safety risks at this tramway crossing. These factors included the intersection treed environment, and the absence of a safety interface agreement between Yarra Trams and VicRoads for this intersection. In addition, the design of the tram proceed phase of the traffic lights was inconsistent with tram operating parameters.

What has been done as a result

In response to this occurrence, electronic flashing warning signs will be added east of the intersection. In addition, the traffic lights have been modified to increase the time available for trams to clear the intersection.

The Chief Investigator has recommended the establishment of a safety interface agreement for the tramway crossing at Elliott Avenue.

Safety message

Drivers of road vehicles have an obligation to ensure that they comply with relevant laws that prohibit the presence of an illicit drug in their system when driving.

Effective interaction between rail infrastructure managers and road authorities is critical at locations such as at tramway crossings of roads.

TABLE OF CONTENTS

1. THE OCCURRENCE

1.1 The sequence of events

On the morning of 22 May 2017, the truck driver travelled from his home to collect the truck and trailer from its over-night location. He then drove to a construction site in Balwyn, about 12 km east of the central business district of Melbourne. The truck and trailer were loaded with soil from the site, and departed at about 0720 to deliver the soil to a location in the western suburbs of Melbourne.

The truck entered MacArthur Road at its eastern end and travelled west towards Flemington Road (Figure 1). The road then merges with and becomes Elliott Avenue. The truck was travelling in the left-hand lane of Elliott Avenue as it approached the tramway crossing. Road traffic around the truck was reportedly not heavy.

Figure 1: The location of the collision and the direction of the truck (blue) and tram (black)

Source: eWays (Melways) 2017, annotations by Chief Investigator, Transport Safety (Vic)

The tram driver had commenced his shift at 0500. He departed the route 58 tram from the West Coburg terminus at 0743.

The tram was travelling south as it approached Elliott Avenue (Figure 1). At the Stop on the north side of Elliott Avenue, the driver did not get a passenger call to stop nor were there passengers waiting for pick-up. Evidence was inconclusive as to whether the tram rolled through the Stop or stopped for a moment before proceeding towards the road. The tram began crossing the road between 0804 and 0805. There were also pedestrians crossing the road from both the north and south.

The truck driver did not recall or recount his final approach to the intersection. However, truck tracking data and road marks provided an indication of some aspects of the final moments before the collision. The truck was travelling at an estimated speed of 26 km/h before the brakes were applied hard (resulting in skid marks) and the truck turned to the left within the intersection. However, the truck did not stop in the available distance and collided with the side of the tram.

1.2 Consequences

The impact derailed the tram such that it fouled the outbound tram track. It remained upright but the truck rolled onto its side, trapping the driver and rupturing its fuel tank. The truck's trailer stayed upright and came to rest along the side of the tram (Figure 2).

Figure 2: The final location of the truck, its trailer and the tram, viewed from the road approach

Source: Chief Investigator, Transport Safety (Vic)

A total of 26 tram passengers were medically assessed at the scene and 14 transported to various hospitals for further observation and treatment. The tram and truck drivers suffered minor injuries and were also transported to hospital.

1.3 Weather and sun conditions

At the time of the collision, the weather was dry and clear. The intersection was in partial shade due to tree foliage.

The sun was behind the truck as it approached the intersection and was unlikely to have influenced observation of traffic signals.

2. CONTEXT

2.1 The intersection

2.1.1 Layout

The intersection is located within Royal Park about 4 km north of central Melbourne. Tram route 58 intersects the dual carriageway road that forms a thoroughfare between Royal Parade and Flemington Road. The road is named MacArthur Road on the eastern approach to the intersection, and then merges with and becomes Elliott Avenue a short distance east of the tramway intersection.

The tramway corridor traverses the parkland abutting Elliott Avenue. The surrounding park consists of treed and cleared areas, and the median strip between the carriageways had mixed vegetation including a large eucalypt immediately east of the tram crossing (Figure 3).

Figure 3: Aerial view of the tramway crossing of Elliott Avenue

Source: Google Earth, annotated by Chief Investigator, Transport Safety (Vic)

2.2 Traffic control

2.2.1 Advanced warning for road users

Approaching from the east (the truck's approach), a 60 km/h road speed sign was located about 160 m from the intersection. Two sets of *Traffic Lights Ahead* signs were installed on the approach, the first about 210 m ahead of the intersection and the second set 80 m ahead. The traffic lights were visible from this inner set of advanced warning signs (Figure 4).

Figure 4: View towards the crossing from the second set of Traffic Lights Ahead signs

Source: Chief Investigator, Transport Safety (Vic)

2.2.2 Road traffic control lights

The tramway crossing at Elliott Avenue was protected by conventional traffic lights (Figure 5). The lights had recently been upgraded to LED (light emitting diode).

Figure 5: Road traffic lights on the east-to-west carriageway (the carriageway used by the truck).

Source: Chief Investigator, Transport Safety (Vic)

The intersection also had two pedestrian crossings with conventional signals and push buttons, to allow pedestrians to cross Elliott Avenue on the eastern and western edges of the tram corridor. There were also lights for cyclists crossing on the eastern edge.

2.2.3 Tram control lights

Route 58 trams travelled on reserved track through Royal Park and across Elliott Avenue. The tram corridor comprised two tracks: one for Melbourne-bound services (east track) and one for outbound services (west track).

The passenger Stops at Elliott Avenue for both in- and out-bound Route 58 tram services were located a short distance to the north of the road. Crossing Elliott Avenue, trams in both directions had an operational speed limit of 15 km/h.

The intersection was controlled by a conventional road traffic light controller, interfaced to tram three-aspect signal lights on the northern and southern tram approaches, and by road traffic lights on Elliott Avenue.

The traffic lights for Melbourne-bound trams was located between the tram Stop platform and the road edge (Figure 6). The 'T' lights were in a vertical configuration with red (top), yellow (middle) and white (bottom).

Figure 6: Tram approach to Elliot Avenue from the North - the tram stop (left) and 'T' light (right)

Source: Chief Investigator, Transport Safety (Vic)

2.2.4 Traffic light operation and sequencing

The traffic light controller operated in two phases: one providing a signal for road vehicles to proceed (A phase) and the other for tram traffic and pedestrians to cross (B phase). The cycling through these phases was triggered by sub-surface detectors that identified the presence of road and tram vehicles, and by push-button activation by pedestrians and cyclists.

Each of the four lanes of the road carriage way was equipped with a vehicle detector ahead of the Stop line. If the traffic lights were in the B phase (tram proceed), a road vehicle stopped on a detector would trigger a call for the A phase (road traffic proceed).

Tram approaches from both directions were also fitted with vehicle detectors. The southern tram approach was equipped with an additional advance detector.

For trams approaching from the north (the tram in this incident), the vehicle detector was located at the City-end of the tram Stop, 16 m from the northern edge of the road. A tram approaching from the north would activate the detector and call for the B phase. If the lights were already in B phase (for example, from a pedestrian call), then the B phase would (if required) be extended for the tram to cross. If the lights were in the A phase when the tram was detected, they would sequence into B phase and provide the tram with a white 'T' to proceed.

The B phase clearance times[1] were based on a design tram speed of 35 km/h and clearance distance of 30 m. This compared with the tram operating speed limit of 15 km/h and the clearance distance from the detector to the southern edge of the road of about 46 m.

2.2.5 Tram detector change of location

In 2006, the detector for Melbourne-bound trams approaching Elliott Avenue was moved about 13 m further away from the road edge. This change was made at the time of the installation of passenger platforms on the northern side of Elliott Avenue by VicRoads. The previous Stop had consisted of a tram safety zone that was located closer to the road.

2.2.6 Traffic control logs

The operation of the traffic control system at this location was recorded. The approximate time of the collision can be identified by the consistent nature of the traffic light phasing post-collision. From this time, the traffic lights cycled through 27 seconds proceed for trams, and 21 seconds proceed for road traffic. This phasing may have been the result of the southern tram detector being continuously triggered by the damaged vehicles on track.

The recorded data indicated that the road traffic lights had been green for about 56 seconds in the phase before the collision. The lights then transitioned over about 6 seconds to the proceed phase for trams and pedestrians (B phase). This phase change was probably the result of a call put on the system by pedestrians that were crossing from north to south on the eastern pedestrian crossing, just in advance of the tram. Evidence indicated that this was probably the phase in which the collision occurred. However, the precise time of the collision within the phase could not be identified.

There was no identified functional defect in phasing between road traffic and tram right-of-way signalling.

[1] The time when both phases are at a red aspect. The calculated clearance time (after a B phase) should be sufficient to allow the tram to clear the intersection.

2.3 Witness information

Independent witnesses to the event provided conflicting evidence on the status of the road traffic lights as the truck approached the intersection. Two occupants of a vehicle behind the truck indicated that the traffic lights were green for road traffic, whereas two (independent) pedestrians indicated that the traffic lights were green for pedestrians, and that road vehicles had stopped at the intersection.

At interview, the driver of the truck had difficulty recounting the sequence of events for the truck's journey along MacArthur Avenue towards the tramway intersection but stated that the road traffic lights were green.

2.4 The truck

2.4.1 Owner

The truck was owned and operated by Vic Wide Plant Hire Pty Ltd that operated a small fleet of trucks using contracted drivers.

2.4.2 Truck details

The truck was a 1996 Scania three-axle rigid tipper with a tare of 9,120 kg and GVM (Gross Vehicle Mass) of 25,500 kg. The trailer was a 2008 Hercules three-axle dog trailer that had a tare of 4,950 kg and a GVM of 25,500 kg. Both the tipper and trailer were fully loaded with soil.

2.4.3 Operation

Although not fitted with an event logger, the truck was equipped with a device that relayed its position and key operating parameters to a central recording system. The system recorded that the truck had travelled about 47 km on the morning of the incident before the collision.

The data sampling of the system was coarse, meaning detailed information about the approach speed of the truck along MacArthur Road was not recorded. The first relevant sample was taken when hard braking was applied before the collision. At the initiation of hard braking about a second before the collision, the truck's speed was recorded as 26 km/h.

2.4.4 Post incident inspection

Inspection of the truck identified front-end damage consistent with initial impact on the right-hand leading corner of the truck's driving cab (Figure 7).

The inspection did not identify any aspects of significance excepting that the depth of the tread on some tyres was low.

Figure 7: Collision damage to truck

Source: Chief Investigator, Transport Safety (Vic)

2.5 The truck driver

2.5.1 Qualifications and medical

The driver held a current Victorian licence with an endorsement for heavy vehicles. Victoria Police advised that the licence was valid for driving the incident truck. Previous employment included driving various types of heavy vehicles.

The driver did not reveal any pre-existing medical conditions.

2.5.2 Working hours

During his contractual employment with Vic Wide Plant Hire (from April 2016), the driver had been driving the same truck and trailer combination. He had received one traffic infringement (for speeding).

Hours of work were usually between 0700 and 1600 Monday to Friday and most Saturdays, albeit for shorter hours.

The driver stated that he was well rested before starting this shift having had Sunday off and going to bed at the usual time of about 2230. He awoke at about 0530, had breakfast and then drove to where the truck was parked. He conducted his usual pre-start inspection and there were no issues identified.

2.5.3 Post-incident testing

Post-incident blood testing of the truck driver detected the presence of amphetamine. The levels measured suggested that the driver was probably a habitual user of methylamphetamine.

Vic Wide Plant Hire had a documented 'No Drug or Alcohol Policy'. The policy detailed a no-tolerance position on driving under the influence of drugs or alcohol. The policy stated that contractors were responsible for complying with the policy and the truck driver involved in this incident had agreed to the policy.

2.6 Methylamphetamine

2.6.1 Expert opinion

Expert medical opinion was sought on the effects of methylamphetamine (or more simply methamphetamine) on human performance, and in particular the effects on performance when operating a road vehicle.[2] Material presented in this report is drawn from that expert opinion.

2.6.2 General effects

Methamphetamine and similar drugs in the amphetamine class are the most commonly used illicit drugs after cannabis.[3] There is also the reported use of methamphetamine to mitigate against the effects of fatigue.[4]

Methamphetamine is a potent central nervous system (CNS) stimulant. It is a synthetic substance that is metabolized in the body to amphetamine. These drugs are related to the naturally occurring stimulant adrenaline. Methamphetamine is a commonly used illicit recreational drug. It has limited therapeutic uses, mainly for the treatment of attention deficit hyperactivity disorder (ADHD), and obesity (due to its appetite suppressing properties).

Methamphetamine has a wide range of dose-dependent effects. In low doses, it can lead to mood changes (euphoria or dysphoria), increases in alertness, concentration and energy in individuals who are fatigued, suppression of appetite and subsequent weight loss. Other psychological effects seen include feelings of apprehension and/or panic, excitation, exhilaration, rapid speech, rapid flow of ideas, restlessness, poor impulse control, grandiosity and repetitive and obsessive behaviours. The effects of methamphetamine will generally last between 4 to 8 hours, but residual effects can last up to 12 hours.

At higher doses, methamphetamine can induce psychosis, skeletal muscle breakdown, seizures and cerebral haemorrhage. Chronic high-dose use can result in unpredictable behaviour, rapid mood swings, delusions and violent behaviour. Toxic reactions (which can be fatal)[5] can occur independent of the amount used.

---

[2] Expert Opinion: Collision between tram and truck Elliott Avenue, Parkville, Flight Medicine Systems, Dr David G. Newman 22 May 2017

[3] Degenhardt L, Barker B, Topp L. Patterns of ecstasy use in Australia: findings from a national household survey. Addiction. 2004 Feb 1;99(2):187-95.

[4] Drummer OH, Gerostamoulos D, Chu M, Swann P, Boorman M, Cairns I. Drugs in oral fluid in randomly selected drivers. Forensic Science International. 2007 Aug 6;170(2):105-10.

[5] Molina NM, Jejurikar SG. Toxicological findings in a fatal ingestion of methamphetamine. Journal of Analytical Toxicology. 1999 Jan 1;23(1):67-8.

2.6.3 Effects on cognitive performance

The weight of scientific evidence suggests that methamphetamine use is associated with a number of significant cognitive performance impairments. These include impairments in executive function, information processing speed, psychomotor skills, language, learning, vision, memory (episodic and working) and perceptual narrowing.[6] A study by Bernheim et al showed that methamphetamine use is associated with persistent attentional and memory impairments (including object recognition memory).[7]

Safe driving depends, amongst other things, on good judgement. A review of the pertinent scientific literature on driving performance and methamphetamine use gives a useful insight into the impairing effect of methamphetamine on judgement. Methamphetamine use has been shown in several studies to be a causal or contributory factor in motor vehicle accidents. Logan showed that in a group of methamphetamine-using drivers, who were also determined to be responsible for the accident, their use of methamphetamine was found to have led to inappropriate risk-taking behaviour.[8] A number of studies have examined the effect of methamphetamine use on driving behaviours (using both simulated and real-world driving models).[9][10][11][12][13][14] The results of these studies show a generalised deterioration in cognitive and psychomotor performance leading to an impaired overall driving standard. The driving behaviours seen include:

- Erratic driving (failure to remain in the lane, rapid and erratic lane changes, weaving, drifting off the road, poorer signalling adherence)
- High risk driving (speeding, tailgating, failing to stop, impatience)
- Impaired attention (including inability to divide attention)
- Poor concentration
- Errors in judgment and perception

In a driving simulator study, chronic methamphetamine users were found to be more likely to exceed speed limits, weave from side to side and leave less distance between their vehicle and oncoming traffic when turning across oncoming lanes.[15] In another simulator study, drivers were given a single dose of methamphetamine and subsequently demonstrated impaired car-following performance, increased inappropriate braking, and increased signal cancelling. The use of methamphetamine adversely affects driving ability through the combination of increased risk-taking behaviour and impairment of neurocognitive functions necessary to safely and effectively operate a motor vehicle.

---

[6] Scott JC, Woods SP, Matt GE, Meyer RA, Heaton RK, Atkinson JH, Grant I. Neurocognitive effects of methamphetamine: a critical review and meta-analysis. Neuropsychology Review. 2007 Sep 1;17(3):275-97.

[7] Bernheim A, See RE, Reichel CM. Chronic methamphetamine self-administration disrupts cortical control of cognition. Neuroscience & Biobehavioral Reviews. 2016 Oct 31;69:36-48.

[8] Logan BK. Methamphetamine and driving impairment. Journal of Forensic Science. 1996 May 1;41(3):457-64.

[9] Logan BK. Amphetamines: an update on forensic issues. Journal of Analytical Toxicology. 2001 Jul 1;25(5):400-4.

[10] Ogden EJ, Moskowitz H. Effects of alcohol and other drugs on driver performance. Traffic Injury Prevention. 2004 Sep 1;5(3):185-98.

[11] Walsh JM, Gier JJ, Christopherson AS, Verstraete AG. Drugs and driving. Traffic Injury Prevention.2004 Sep 1;5(3):241-53.

[12] Ramaekers JG, Kuypers KP, Samyn N. Stimulant effects of 3, 4-methylenedioxymethamphetamine (MDMA) 75 mg and methylphenidate 20 mg on actual driving during intoxication and withdrawal. Addiction. 2006 Nov 1;101(11):1614-21.

[13] Dastrup E, Lees MN, Bechara A, Dawson JD, Rizzo M. Risky car following in abstinent users of MDMA. Accident Analysis & Prevention. 2010 May 31;42(3):867-73.

[14] Silber BY, Papafotiou K, Croft RJ, Ogden E, Swann P, Stough C. The effects of dexamphetamine on simulated driving performance. Psychopharmacology. 2005 May 1;179(3):536-43.

[15] Bosanquet D, MacDougall HG, Rogers SJ, Starmer GA, McKetin R, Blaszczynski A, McGregor IS.Driving on ice: impaired driving skills in current methamphetamine users. Psychopharmacology. 2013 Jan 1;225(1):161-72.

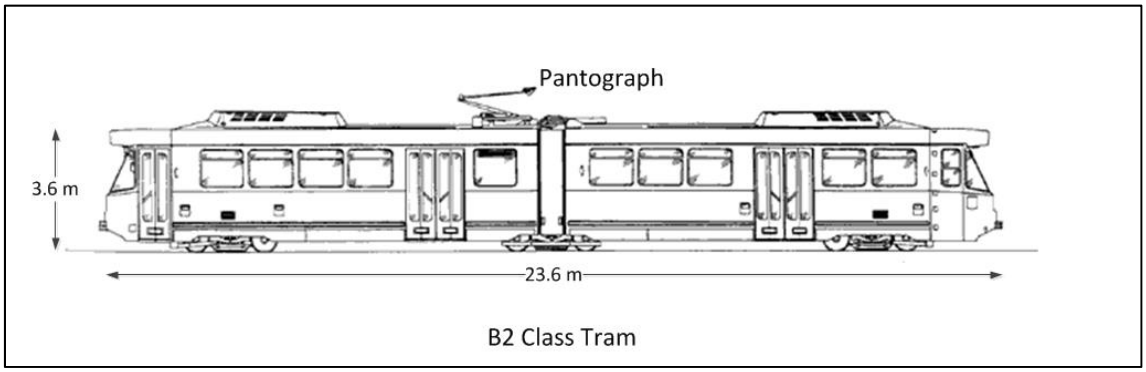
Visual function is crucial for safe driving. Methamphetamine use has been shown to adversely affect some key visual functions. Blurred vision and even nystagmus (involuntary rapid eye motion) have been described. A perceptual narrowing or "tunnelling" phenomenon has been documented.[16] Visual search tasks (an important driving-related skill) have also been shown to be impaired by low doses of amphetamine.[17] Visuoconstruction skills have also been shown to be impaired with methamphetamine use.[18] This skill represents the ability to organize and manually manipulate spatial information. Some authors have linked these visual performance deficits to a more general methamphetamine-induced restriction of perception.[19]

2.7 The tram

2.7.1 Details

Tram 2028 was a B2 Class with a capacity of 40 seated and 120 standing passengers and a tare mass of 34 t (Figure 8). There were 132 B2 Class trams built between 1987 and 1994. These trams are not fitted with event loggers.

Figure 8: Tram schematic, side view



Source: Chief Investigator, Transport Safety (Vic)

2.7.2 Post-collision inspection

Inspection of the tram identified side damage consistent with impact by the truck (Figure 9). The initial point of impact was probably at the left-side front entry and the more significant damage extended from this door though to the mid entry door near the tram articulation. Rearward of the articulation, damage was lighter and consistent with side-to-side impact with the truck's trailer.

There was limited structural encroachment into the passenger space. However, several windows had been shattered, including those of the central door, resulting in a significant amount of glass within the passenger compartment (Figure 10).

[16] Silber BY, Croft RJ, Papafotiou K, Stough C. The acute effects of d-amphetamine and methamphetamine on attention and psychomotor performance. Psychopharmacology. 2006 Aug 1;187(2):154-69.
[17] Kennedy RS, Odenheimer RC, Baltzley DR, Dunlap WP, Wood CD. Differential effects of scopolamine and amphetamine on microcomputer-based performance tests. Aviation, space, and environmental medicine. 1990 Jul.
[18] Scott JC, Woods SP, Matt GE, Meyer RA, Heaton RK, Atkinson JH, Grant I. Neurocognitive effects of methamphetamine: a critical review and meta-analysis. Neuropsychology Review. 2007 Sep 1;17(3):275-97.
[19] Stough C, Downey LA, King R, Papafotiou K, Swann P, Ogden E. The acute effects of 3, 4-methylenedioxymethamphetamine and methamphetamine on driving: a simulator study. Accident Analysis & Prevention. 2012 Mar 31;45:493-7.

Figure 9: Tram side impact damage, viewed from its leading end

Source: Chief Investigator, Transport Safety (Vic)

Figure 10: Passenger cabin and shattered glass

Source: Chief Investigator, Transport Safety (Vic)

2.8 The tram driver

The tram driver was based at the Essendon Depot and had been employed as a driver with Yarra Trams for about 28 years and held a current Category 'A' medical assessment. The tram driver was drug and alcohol tested following the incident and returned negative results.

2.9 Intersection management

2.9.1 VicRoads

VicRoads was the road authority responsible for MacArthur and Elliott Avenues. Its responsibilities were governed by the *Road Management Act 2004* (Vic).

VicRoads was also responsible for signalling infrastructure at the intersection, including road vehicle and tram detectors, and all traffic signals for road, tram and pedestrian traffic.

2.9.2 Yarra Trams

Yarra Trams was responsible for the operation of trams and the maintenance of tram infrastructure including track and overhead power distribution. Safety obligations applicable to Yarra Trams were detailed in the *Rail Safety (Local Operations) Act 2006* (Vic).

2.9.3 Interface between VicRoads and Yarra Trams

In Melbourne, there are about 700 intersections involving Yarra Trams operations, of which about 200 are pedestrian only. Of the approximate 500 involving roads, the road authority in most cases was VicRoads.

Rail Safety (Local Operations) Act 2006 (Vic) makes provision for Safety Interface Agreements (SIA) between rail infrastructure managers and road authorities. These provisions provide obligations to identify risks due to rail operations and rail - road crossings. There was no SIA in place for the intersection of Elliott Avenue and the Route 58 tramway.

2.9.4 City of Melbourne

The intersection is located within the City of Melbourne, the designated municipal council for the location. At this intersection, the council's responsibilities included the management of surrounding parkland area and the median strip between the road carriageways, including vegetation management.

2.10 Risk assessment of intersection following this collision

Following this incident, Yarra Trams conducted a risk assessment of the tramway crossing of Elliott Avenue. The risk assessment involved a site assessment that involved both Yarra Trams and VicRoads and a subsequent risk workshop not attended by VicRoads.

The risk assessment undertaken by Yarra Trams identified several further potential risk controls including:

- Grade separation
- Isolation through boom gates
- Engineering controls to modify road user speed and behaviour
- Additional passive and active early warning systems
- Local crossing changes to signalling configuration and/or vegetation

2.11 Previous occurrences

Yarra Trams advised that in the 3 years up to this incident, there had been four similar events at this location, three collisions and one near collision. The incidents were reported as involving road vehicles entering the intersection on a red light.

The most significant of these incidents occurred on 14 January 2015. A truck travelling east collided with a tram that was outbound from the city. The tram was carrying about 30 passengers and seven received minor injuries. As a result of reviews following this incident, warning signage was added to road approaches and the road traffic lights changed to LED to improve their conspicuity.

3. SAFETY ANALYSIS

3.1 The collision

The collision occurred as a result of the truck entering the road-tramway intersection when a tram was crossing. The driver of the truck saw the tram in the final moments but was not able to stop his truck in time to avoid the collision.

An analysis of traffic signalling system logs did not identify a fault with the traffic lights and they were probably working normally. However, there was conflicting witness evidence on the status of the road traffic lights at the time of the incident. On balance considering the traffic system functionality and logs, and witness information, it is probable that the tram entered the intersection with traffic signals in the B phase (tram proceed).

3.2 Driver drug use

3.2.1 Effects on driving performance

Testing of the truck driver identified amphetamine at a level that would indicate habitual use. The recorded level was also higher than might occur as a result of therapeutic dosing. The actual usage habits of this individual and the time since the last dose are not known.

Methylamphetamine has a generally adverse effect on human performance. Neurocognitive function is generally impaired, with poor judgement and decision-making being observed, as well as degraded visual function. Increased risk taking behaviour and generally poor driving behaviour have been demonstrated in many studies of methylamphetamine use in drivers.

Studies have found a positive relationship between blood amphetamine concentration and traffic related impairment.[20] Based on the recorded blood amphetamine level in this driver, adverse effects on performance are likely to have been present to some extent.

3.2.2 Policy and monitoring

The truck company had a no-tolerance drug and alcohol policy as a condition of employment. The driver was aware of the policy and had agreed to these employment conditions. Implementation of the policy relied on trust and random testing by Victoria Police to detect non-compliance. The driver's drug use was not detected prior to this collision.

[20] Gustavsen I, Mørland J, Bramness JG. Impairment related to blood amphetamine and/or methamphetamine concentrations in suspected drugged drivers. Accident Analysis & Prevention. 2006 May 31;38(3):490-5.

3.3 Intersection Environment

MacArthur Road (that merges into Elliott Avenue) passes through parkland comprising grassland, trees and other vegetation. On the near approach to the road's intersection with the tramway, the median strip was also planted with vegetation of various size. Travelling west, the lower vegetation within the median strip partially restricted the view to the northern side of the crossing and approaching city-bound trams (Figures 11 and 12).

Figure 11: View looking west towards the tramway crossing, from about 80 m

Source: Chief Investigator, Transport Safety (Vic)

Figure 12: The view when close to the tramway crossing, and limitations of the view to the north

Source: Chief Investigator, Transport Safety (Vic)

The environment at this intersection, while in keeping with the broader parkland, partially obscured approaching trams and could affect road user behaviours. Particularly for those unfamiliar with this tramway crossing, the parkland environment had the potential to lower road-user expectation of crossing tram traffic when compared to a typical inner city intersection. Vegetation in the median strip also restricted scanning opportunities.

Due to its unique configuration, assessment of this intersection by human factors specialists would be of value in assisting the development of risk control measures. VicRoads advised that they had not conducted such an assessment.

3.4 Safety Interface Agreement

The *Rail Safety (Local Operations) Act 2006* (Vic) makes provision for Safety Interface Agreements (SIA) between rail infrastructure managers and road authorities. The purpose of these interface coordination provisions was to ensure that rail transport operators and road managers identify risks to safety arising from the rail-road crossings and determine measures to manage those risks, 'so far as is reasonably practicable' (SFAIRP). This interface coordination is formalised in an SIA.

An SIA did not exist for the tramway crossing with Elliott Avenue. In the absence of a formal agreement covering the safety management at this interface, there was the potential for parties to act independently and risks not to be managed SFAIRP.

Given the City of Melbourne's role in managing adjacent land areas and the median strip, safety management may also be enhanced with a formalised mechanism that ensured vegetation management was consistent with safety management strategies.

3.5 Design parameters for design of tram proceed phase

Design calculations for the traffic signalling system were made by VicRoads.

For tram clearance movements, the traffic signalling system was based on a design tram speed of 35 km/h, compared to the tram crossing speed limit (at the time of the occurrence) of 15 km/h.

In addition, the tram detector on the northern side of the road was moved in 2006 to a location further from the road. This provided earlier activation of tram proceed lights, but also increased the transit time (from the detector) to clear the road. Traffic light B phase times were not altered at that time to accommodate the change in detector location.

These design anomalies meant that the design clearance times (for trams) were lower than they would be if the correct inputs were used, and therefore increased the likelihood of lights changing to the A phase (road traffic proceed) with a tram not yet clear of the road. However, in this occurrence, this design deficiency is unlikely to have been relevant or contributory, as the tram was crossing on proceed lights triggered by a pedestrian call that provided considerably more crossing time for the tram than a tram-only activation.

4. FINDINGS

The following findings are made with respect to the collision between a truck and tram at Parkville on 22 May 2017. These findings should not be read as apportioning blame or liability to any organisation or individual.

Findings are expressed as safety factors. A safety factor is an event or condition that increased safety risk and if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include occurrence events, individual actions such as errors and violations, local conditions, risk controls and organisational influences.

4.1 Contributing factors

A *contributing factor* is a safety factor that, had it not occurred or existed at the time of an event, then the event would probably not have occurred, and/or its adverse consequences would probably not have occurred or would have been less.

- The truck entered the road-tramway intersection as a tram was crossing.
- The truck failed to stop in sufficient time to prevent a collision with the tram.
- The truck driver's performance was probably affected by drug use.

4.2 Other factors that increased risk

Other factors that increased risk are safety factors that existed but did not meet the test for directly contributing to this event. These other factors are considered important to communicate in an investigation report in the interests of improved transport safety.

- **The intersection environment restricted opportunities for driver scanning and probably lowered road user expectation of crossing trams. [Safety Issue]**
- **There was no safety interface agreement between Yarra Trams and VicRoads for the tramway crossing at Elliott Avenue. This limited the opportunity for effective and shared risk management of the crossing. [Safety Issue]**
- **The design of the traffic light system for B phase (tram proceed) was inconsistent with operational tram speeds and the location of the northern tram detector. [Safety Issue]**

5. SAFETY ISSUES AND ACTIONS

The safety issues identified during this investigation are listed in the Findings and Safety issues and actions sections of this report. The Chief Investigator, Transport Safety expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the Chief Investigator prefers to encourage relevant organisation(s) to proactively initiate safety action.

All of the directly involved parties are provided with a draft report and invited to provide submissions. As part of that process, each organisation is asked to communicate what safety actions, if any, they have carried out or are planning to carry out in relation to each safety issue relevant to their organisation.

5.1 Intersection environment

Number:	2017-02-001
Issue owner:	VicRoads

Safety issue description

The intersection environment restricted opportunities for driver scanning and probably lowered road user expectation of crossing trams.

Proactive action taken by VicRoads

VicRoads advised that it and Yarra Trams had agreed to upgrade the warning signs east of the intersection to electronic flashing signs. This improvement is programmed to be completed in 2019.

5.2 Safety Interface Agreement

Number:	2017-02-002
Issue owner:	Yarra Trams

Safety issue description

There was no safety interface agreement between Yarra Trams and VicRoads for the tramway crossing at Elliott Avenue. This limited the opportunity for effective and shared risk management of the crossing.

Recommendation by the Chief Investigator

That Yarra Trams lead the establishment of a safety interface agreement for the tramway crossing at Elliott Avenue, and that VicRoads and the City of Melbourne collaborate with Yarra Trams as active parties to such an agreement.

5.3 Design of traffic lights for tram crossing

Number:	2017-02-003
Issue owner:	VicRoads

Safety issue description

The design of the traffic light system for B phase (tram proceed) was inconsistent with operational tram speeds and the location of the northern tram detector.

Proactive action taken by VicRoads

VicRoads advised that:

- The tram detector on the northern side of Elliott Avenue has been relocated closer to the road edge. This provides trams with a shorter distance to clear the intersection.
- The operation of traffic lights has been modified, increasing the 'red' time on all approaches from six seconds to eight seconds. This provides additional time for trams to clear the intersection before green lights are activated for road vehicles.