Office of the Chief Investigator
Transport Safety

Rail Safety Investigation
Report No 2017/03

Collision

Tram 6008 and Tram 6005

Bourke Street, Melbourne

02 August 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

On 2 August 2017, Tram 6008 operated by Yarra Trams was on a scheduled commuter service from Bundoora to Docklands. At about 1436 that day, the tram approached the Spencer Street tram stop on Bourke Street in Melbourne's CBD. The tram did not stop and collided with Tram 6005 at a speed of about 15 km/h. At the time of the collision, Tram 6005 was stopped at the tram stop and passengers were disembarking. Several passengers in both trams fell, sustaining minor injuries. The tram drivers also sustained minor injuries.

What the Chief Investigator found

It was found that the driver of Tram 6008 probably experienced a micro-sleep episode as the tram approached the Spencer Street tram stop. Factors that probably contributed to this fatigue-related event were a shortened sleep the night before the shift, sleepiness after a meal, and the mid-afternoon circadian low.

It was found that the tram vigilance system was unable to detect and respond to this short period of inattention. At the speed the tram was travelling, the task-linked vigilance system would not intervene for at least 30 seconds.

What has been done as a result

Following this and other similar incidents, Yarra Trams is reviewing the vigilance system activation on the E Class tram and the availability of new technology to assist with driver alertness/drowsiness detection. The operator is also investigating systems that automatically identify possible hazards in front of the vehicle and warn drivers.

Safety message

Vigilance detection systems may not respond with sufficient speed to avoid accidents due to a loss of driver attention. Tram operators should consider additional measures such as driver fatigue monitoring.

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1. THE OCCURRENCE

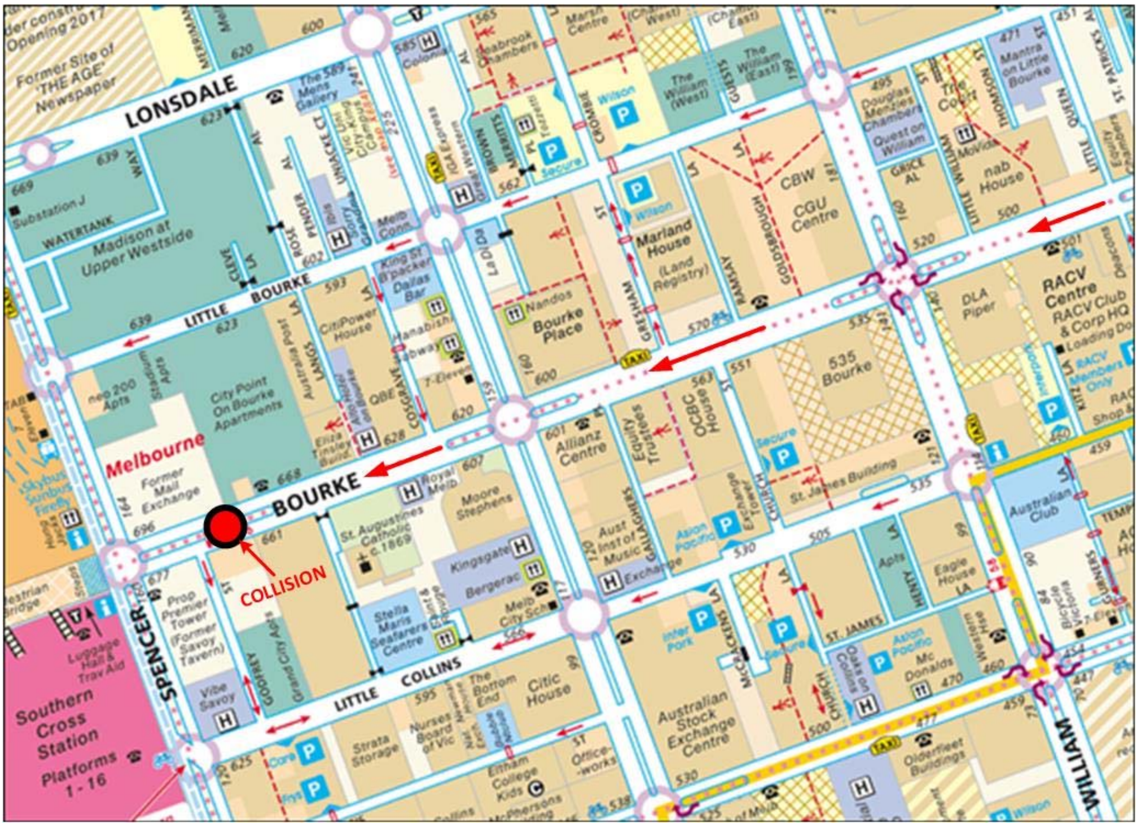
On the afternoon of 2 August 2017, Tram 6008 was operating on tram route 86 from Bundoora to Docklands. The driver for the service had worked a morning roster and after a lunch break at the New Preston Depot, joined the outbound Tram 6008 at Preston (Stop 42) and drove the remainder of that service to Bundoora. The driver then changed driving ends and prepared for the inbound service to the Docklands precinct.

The tram departed the Bundoora tram terminus (Stop 71) at about 1321. The driver reported that the trip was uneventful until about 1420. Around this time, the tram turned from Spring Street into Bourke Street and stopped at Stop 9. The driver reported that he began yawning and was feeling warm. He removed his outer jacket, opened the cabin window and adjusted the air conditioning to reduce the cab temperature.

While at Stop 9, the driver of Tram 6008 observed that there was another tram (Tram 6005) about a tram stop ahead. Both trams then proceeded down Bourke Street towards Spencer Street, with a gap remaining between the trams.

Tram 6008 continued along Bourke Street and stopped at William Street (Stop 3) at about 1434. The tram departed this stop about 20 seconds later. At around this time, Tram 6005, ahead, was approaching the Spencer Street stop (Figure 1).

Figure 1: Bourke Street, between William and Spencer Streets and path of trams to collision point



Source: eWays Melway 2017 with annotations by Chief Investigator Transport Safety

After Tram 6008 departed the William Street stop, there were several traction and braking applications made by the driver. After crossing King Street, the last recorded driver action was a brief brake command about 30 m from the stationary tram ahead. The tram master controller then remained in the coast position until collision.

Tram 6008 was travelling at a speed of about 15 km/h when it collided with the rear of Tram 6005 at about 1436. The brakes on Tram 6008 were not being applied at the time of the collision and the slight downhill grade had resulted in a small increase in speed as it coasted into the stop. Tram 6005 was stationary at the Spencer Street stop and disembarking passengers.

As a result of the collision, several passengers in both trams were knocked from their feet and seven passengers sustained injuries requiring treatment. Four passengers were treated at the site by paramedics and three were transported to hospital. The driver of Tram 6005 was also transported to hospital for observation.

The impact pushed Tram 6005 forward by about 0.6 m and both trams remained on the track. There was moderate damage to both trams at their point of impact. The trams were driven under their own power to the New Preston Depot for inspection and repair.

2. CONTEXT

2.1 Yarra Trams

Yarra Trams operates the tram network in Melbourne across 24 different tram routes. At the time of the incident, it managed nine tram depots with a fleet of about 490 trams including 70 E Class trams and employs more than 1,200 tram drivers.

2.2 The trams

2.2.1 The E Class

Tram 6008 and Tram 6005 are E Class trams (Figure 2). The E Class tram is a three-section, four-bogie articulated tram that was first introduced to the Melbourne tram network in 2013. The trams are supplied by Bombardier Transportation.

Figure 2: E Class Melbourne tram

Source: Yarra Trams, Melbourne

E Class trams are bi-directional vehicles with a driving cabin at each end. Each tram is 33.45 m long and 2.65 m wide. It is driven by six 85 kW motors powering three bogies with one bogie unpowered. Power is supplied by a 600V DC catenary. The maximum design speed of this class of tram is 80 km/h.

The E Class trams are low-floor and can carry 64 seated and 146 standing passengers. They have a fully loaded mass of about 62 t.

2.2.2 Driving cabin

A driver's cabin is located at each end of the tram and is fully enclosed by laminated glass windscreen and cab-side windows. The driving seat is situated on the centre line of the tram. When seated, the driver has a near 180^0 field of vision, with minor obstruction in the line of the corner frames. Rear view mirrors are installed outside the cabin to provide the driver sight along the sides of the tram and to the rear.

The front windscreen of the cab is fitted with a retractable sun shade. There is no shading on the side windows. The side window to the right of the driver is fitted a 300 mm x 300 mm window that can be opened.

All driving controls are installed on the driver's seat armrests. The master controller is installed on the right armrest and the control buttons for horn, gong, sand, door select, track brake, hazard lights and headlight flasher are on the left armrest. On the side of the left armrest is the red vigilance button (Figure 3).

Figure 3: E Class tram driving controls. Inset: vigilance button on the side of the armrest.

Source: Chief Investigator Transport Safety

2.2.3 Driving controls

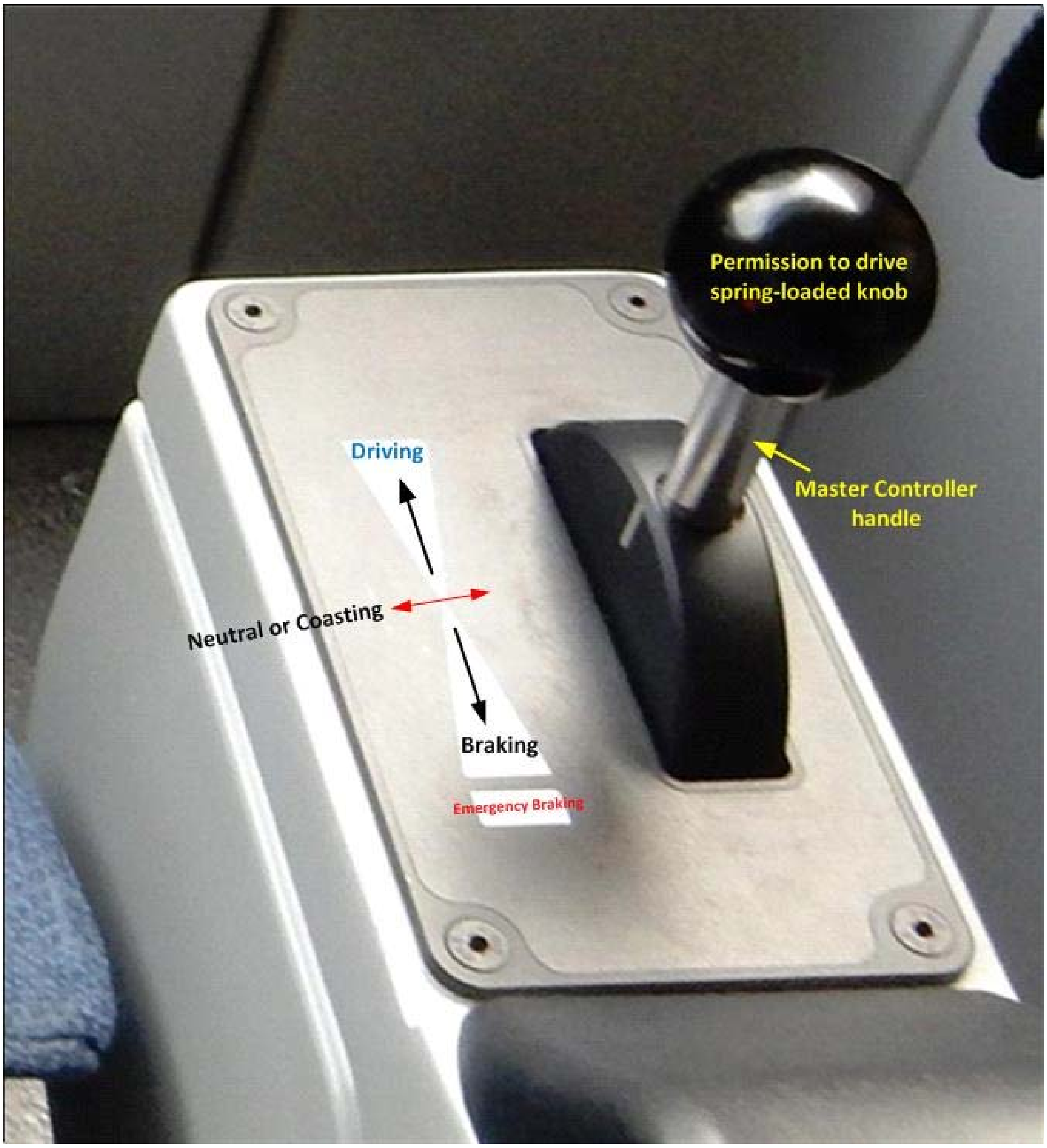
On the E Class trams, traction and braking are controlled by a master controller (Figure 4). The controller must be depressed to activate the driving/braking function. The handle can then be moved forward to drive the tram and backward to brake. Post-incident testing of the incident tram indicated that a downward force of about 15N was needed to activate the driving/braking function.

2.2.4 Deadman function

The deadman function is integrated within the master controller. Depressing the controller handle and maintaining the controller in its driving/braking mode will prevent a deadman system response. The force required to maintain the handle in the driving/braking mode was specified as 6N $\pm$3N. This force can typically be achieved with the resting weight of the hand and forearm. Post-incident testing of the incident tram driving end found that the force required to maintain the master controller in its active position was within the specified range.

If the master controller is released, there is a rapid system response. The response includes acoustic and visual warnings, followed 2 seconds later by a forced braking application.

Figure 4: Master Controller



Source: Chief Investigator Transport Safety

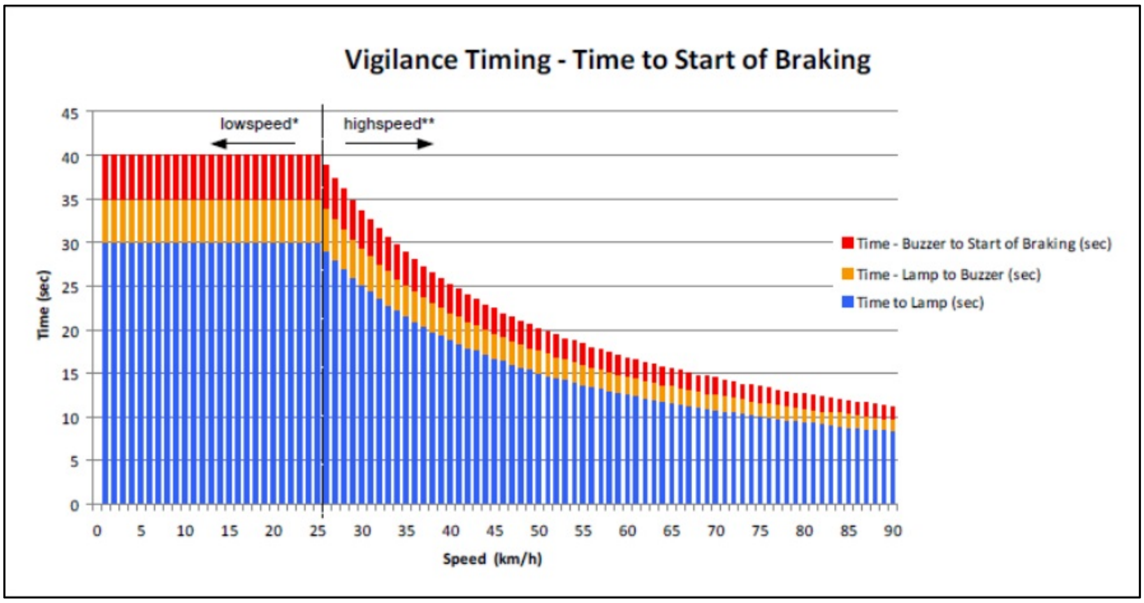
2.2.5 Vigilance function

The E Class tram is fitted with task-linked vigilance system. Whilst the tram is moving, the vigilance timer will be reset by normal driving tasks. Driver tasks that reset the vigilance timer include: a change in the position of the master controller; activation of the gong, horn, sanding, door select, track brake and hazard lights; pushing down on the master controller; and pressing the vigilance button on the side of the driver's left armrest (Figure 3) or on the driver's control panel.

If a driver action is not detected in a prescribed time, there is firstly a visual warning. If there is no driver response to that warning, there is an audible warning, followed by a forced brake application.

The response time of the vigilance system varies depending on the speed of the tram (Figure 5). If the speed of the tram is less than 25 km/h, the visual warning will commence after 30 seconds. If not acknowledged within 5 seconds, the audible warning will commence, and 5 seconds later forced braking is activated. If the speed of the tram is 25 km/h or greater, the system response is based on distance travelled rather than time. The visual warning commences after the tram has travelled about 210 m, the audible warning after a further 35 m, and forced braking after a further 35 m.

Figure 5: Vigilance timing graph



Source: Yarra Trams

2.2.6 Driver cab environment

The driving cab is fitted with a HVAC (Heating, Cooling and Air Conditioning) system. The system is designed to provide a continuous flow of fresh air into the cabin (80 m^3/h and four fan speed options are provided. For outside temperatures up to 22 ^{0}C, the default temperature setting in the cab is 22 ^{0}C. This setting can be manually adjusted by the driver within a range of 4^0 below the set point to 3^0 above the set point.

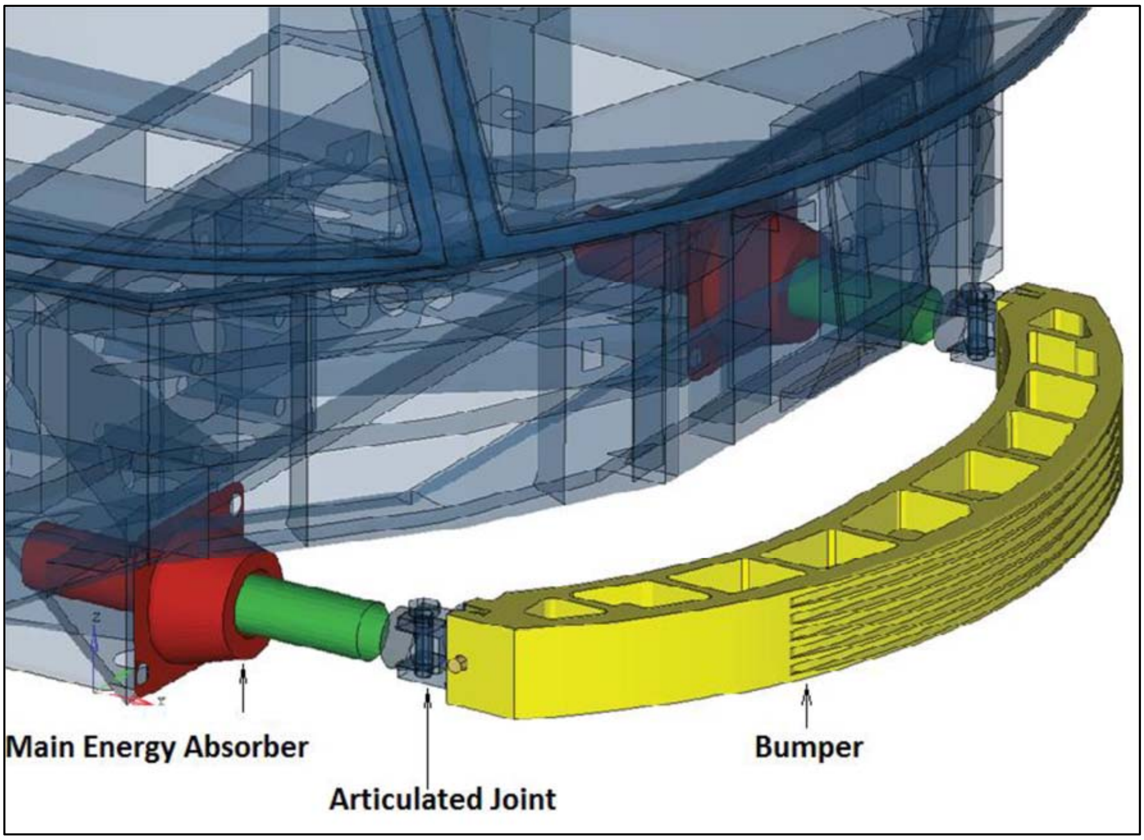
The outside temperature at the time of the incident was about 13 ^{0}C, and the default cab temperature was 22 ^{0}C. The actual temperature within the cab is not known as there was no temperature readout on the driving console that the driver may have noted, and the HVAC computer data storage had not been correctly loaded.

2.2.7 Collision absorption systems

The E Class tram was designed and constructed to comply with European Standard EN 15227[1] for crashworthiness. The tram is fitted with a Crash Energy Management System (CEMS) with energy absorption capacity at tram ends and couplers. The main absorption systems are located at the tram ends and consist of two stages (Figure 6).

Figure 6: Drawing of tram collision absorption system

[1] Railway Applications – Crashworthiness Requirements for Railway Vehicle Bodies



Source: Yarra Trams, Melbourne

A reversible stage has an 80 mm stroke and uses a gas-hydraulic element intended to absorb energy from very low speed impact and then return the element to its original position. This system can therefore accommodate repeated small impacts. A second, irreversible stage for higher speed impacts uses deformation tubes that do not return to their original condition. The deformation tubes in this irreversible stage have a maximum stroke of 270 mm at a constant force of 250 kN. The energy absorption capability of the two tubes located at the tram ends is 67.5 kJ that equates to a design impact speed of around 17 km/h.

In this collision, the end-to-end impact resulted in energy absorption within both trams. The energy of impact exceeded the capacity of the reversible systems and the deformation tubes were deployed on both trams. Post-incident Inspection identified that most crash energy had been absorbed by the engagement of one deformation tube on each tram; the left tube on the moving Tram 6008 and the diagonally opposed tube on the stationary Tram 6005.

The length of tube deformation on Tram 6008 was about 250 mm and on Tram 6005 was about 200 mm. There was a small amount of deformation on the other two tubes. The combined energy absorbed by the deformation tubes on the two trams was consistent with the design energy associated with a impact speed of about 15 km/h. That two diagonally opposed tubes absorbed the majority of the energy was probably the result of imperfect alignment of forces at the point of impact.

2.3 Tram driver

2.3.1 Experience, qualifications and medical status

The driver of Tram 6008 qualified to drive B Class trams in June 2012 and E Class trams in August 2016. He attended the driver training refresher course in May 2017 and at the time of the incident, his qualifications were current.

In April 2017 and prior to the Bourke Street collision incident, the driver satisfied a Category 2[2] medical examination, the standard being applied by Yarra Trams at that time. Following this incident, the driver underwent a Category 1[3] medical examination and was found to be fit for driving E Class trams.

2.3.2 Roster and sleep

For the five days preceding the day of the incident shift, the driver reported adequate sleep of 8 hours per night. On 1 August the driver had a rostered day off. He reported going to bed around 2300 and awoke on 2 August at about 0530.

2.4 Fatigue management

Yarra Trams' 2013 Fatigue Management Policy outlined the organisation's approach to managing fatigue in the workplace. This was followed in 2015 with its Fatigue Management Program that had a stated purpose to assist managers and employees to understand and manage the risks associated with fatigue in the workplace.

Transport Safety Victoria (TSV) audited Yarra Trams' fatigue management in March 2016 and found deficiencies with some elements in its Fatigue Management Program. These included monitoring of driving hours, fatigue awareness training and implementing a risk register for fatigue management.

Pursuant to the audit, Yarra Trams implemented a system for monitoring driver actual working hours and introduced fatigue awareness training for driver initial induction and thereafter at least once a year during refresher training. The training consisted of a 1 hour module that covered the causes, symptoms and signs of fatigue, managing off-duty behaviour and on-duty rosters to prevent fatigue and common medical and health conditions affecting driver alertness. The training module did not provide drivers with information related to reporting fatigue or managing the risks associated with fatigue.

In September 2016, Yarra Trams issued an additional fatigue management policy document. Among other things, the policy provided for 'developing appropriate fatigue management plans to identify, assess and manage the risks' and 'educating Workers to use their training to identify, report and manage any risks likely to be associated with fatigue'.

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[2] In accordance with the National Standard for Health Assessment of Rail Safety Workers, August 2017, a Category 2 health assessment requires the person to complete self-administered questionnaires on sleep disorders, alcohol dependency and psychological problems; and undergo medical examination to assess the key body systems to identify conditions that might affect rail safety task performance including cardiovascular, psychological, musculoskeletal and visual systems.

[3] National Standard for Health Assessment of Rail Safety Workers, August 2017: A Category 1 health assessment requires, in addition to a Category 2 health assessment, a cardiac risk level assessment; testing for diabetes and cholesterol; and a resting electrocardiograph.

At the time of the incident, Yarra Trams had not yet implemented a Risk Register or updated their Risk Management Procedures. These items that were outstanding from the audit, were completed in December 2017. An updated Fatigue Management Procedure was published, 'to provide a process for Yarra Trams to identify and manage, so far as reasonably practicable, all fatigue related risks for its operations'.

2.5 Infrastructure

2.5.1 Bourke Street

Bourke Street is straight with good visibility for tram drivers in either direction. From the Spring Street stop, it runs East to West on a generally downhill grade for 1.85 km to Spencer Street. The distance from the William Street tram stop to the commencement of the Spencer Street tram stop (safety zone) is about 300 m. This includes a distance of about 120 m after crossing King Street.

The tram tracks run in the centre of Bourke Street, without separation from road traffic except at tram stops. All streets intersect Bourke Street at right angles. There is a significant amount of road and pedestrian traffic on Bourke Street and intersecting roads.

Inspection of the track following the collision found that the section of track between King Street and Spencer Street was dry and clean.

2.5.2 Spencer Street tram stop

Spencer Street tram stop on Bourke Street (Figure 7) is a 'super stop'. It has a raised platform to allow access for wheelchairs into low floor trams, and is equipped with touch screen information, ticketing machines, passenger information displays and next tram announcements.

The length of the platform is about 58 m and the safety zone extends a further 11.5 m at the Spencer Street end and 8.5 m at the other end. Two E Class trams can be accommodated at the platform, with all doors opening onto the platform.

From the Spencer Street tram stop, trams may turn right or left to travel along Spencer Street.

Figure 7: Spencer Street tram stop on Bourke Street.

Source: Chief Investigator Transport Safety

3. Safety Analysis

3.1 The incident

Tram recordings indicate that there was no recorded driver action for about 8 seconds before the collision. This equates to a travelled distance of about 30 m. It is also unclear whether minor braking prior to this was a conscious driver action, as the driver had no recollection of events after crossing King Street.

Based on available evidence, it is probable that the driver had a microsleep episode after crossing King Street and before arriving at the Spencer Street stop. A microsleep is a brief, unintended episode of loss of attention that may occur when a person is fatigued but trying to stay awake. Studies have shown that such microsleep events can occur frequently in individuals engaged in prolonged monitoring and vigilance tasks such as driving.[4] The person is often not aware that a microsleep has occurred. While in a microsleep, a person fails to respond to outside information. Microsleeps are most likely to occur at certain times of the day when the body is programmed to sleep, such as pre-dawn hours and mid-afternoon hours.[5]

3.2 Factors associated with driver microsleep

3.2.1 Rest and working hours

Time spent continuously awake

At the time of the incident, the driver had been awake for approximately 9 hours. This is not an unusually long period and time spent continuously awake is unlikely to have been a factor.

Fatigue accumulated over the previous 7 days (cumulative fatigue)

The driver reported regular sleeping hours of about 8 hours per night and significant cumulative fatigue for this individual is unlikely.

Fatigue prior to duty (acute fatigue)

The driver reported having reduced sleep of between 6 and 6.5 hours on the night before this incident shift. Various studies have suggested a dose-response relationship between loss of sleep the night before and subsequent increased daytime sleepiness. In one study, people reporting more than 7 hours 30 minutes sleep had significantly less probability of falling asleep than those reporting sleep durations less than 6 hours 45 minutes per night.[6] Other studies have confirmed that chronic sleep restriction to fewer than 6 hours per night has been shown to impair performance and to increase the tendency to involuntarily fall asleep.[7]

The effects of sleep reduction on cognitive performance, vigilance and daytime alertness have been well documented by several authors. The driver's sleep restricted state probably contributed to the performance impairment at the time of the incident.

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[4] Poudel GR, et al. Losing the struggle to stay awake: divergent thalamic and cortical activity during microsleeps. Human brain mapping. 2014 Jan 1; 35(1):257-69.
[5] https://www.tuck.com/microsleep/
[6] Banks S. Behavioral and physiological consequences of sleep restriction. Journal of clinical sleep medicine. 2007 Aug 15;3(05):519-28.
[7] Carskadon MA, Dement WC. Cumulative effects of sleep restriction on daytime sleepiness. Psychophysiology. 1981 Mar;18(2):107-13.

3.2.2 Postprandial somnolence

Postprandial somnolence or sleepiness experienced after eating is a response of the body to chemical changes during the digestion process. It is caused by many factors, such as the type of food consumed, sleeping habits, health condition and so forth.[8] Postprandial somnolence has been linked with subsequent performance impairments, particularly in tasks requiring vigilance and attention[9] and has also been implicated as a contributing factor to occupational injuries.[10] Additionally, not getting enough quality sleep and/or bad sleeping patterns can exacerbate sleepiness post-meal, and if postprandial somnolence occurs in combination with the mid-afternoon circadian low, the resultant effect on drowsiness is accentuated.

In the case of this incident, the event occurred about two hours after lunch. Studies have shown an increase in sleepiness for the period of 1.5 to 3 hours after eating a meal[11] and it is probable that postprandial somnolence contributed to the collision.

3.2.3 Circadian low

The circadian low is a specific phenomenon, based on the normal human circadian rhythm. It occurs to an extent in everyone to varying degrees. According to the National Sleep Foundation[12], circadian rhythm (also known as our sleep/wake cycle or body clock) is a natural, internal system that's designed to regulate feelings of sleepiness and wakefulness over a 24-hour period whether the body is working or not.

For most adults, the biggest dip in energy happens in the night between 0200 and 0500 and just after lunchtime, typically between 1300 and 1500, although sometimes later. These low points induce a strong physiological need for sleep at around these times.
When a person is sleep-deprived, they will notice bigger swings of sleepiness and alertness. Fatigue is the result of the combined interaction of the body's natural circadian rhythm in alertness/sleepiness and the effects of inadequate sleep. There is clear evidence that individuals working through either of these two low points in the circadian rhythm are at higher relative risk of an accident.[13]

At 1430, the driver was probably experiencing a circadian low that, combined with other effects, led to a fatigued condition.

3.2.4 Other factors

It is possible that the warmth from clothing and the cabin environment contributed to his sleepiness as he travelled down Bourke Street. A comfortable sitting position and the driver mainly performing a vigilance and attention task with little physical work, may also have been factors that contributed to a condition of reduced alertness.

[8] The Jakarta Post October 4, 2016 - Hidup Sehat Hidup Bahagia

[9] Colquhoun WP, Blake MJ, Edwards RS. Experimental studies of shift-work III: Stabilized 12-hour shift systems. Ergonomics. 1969 Nov 1;12(6):865-82.

[10] Justis EJ, Moore SV, LaVelle DG. Woodworking injuries: an epidemiologic survey of injuries sustained using woodworking machinery and hand tools. The Journal of hand surgery. 1987 Sep 1;12(5):890-5.

[11] Wells AS, Read NW, Idzikowski C, Jones J. Effects of meals on objective and subjective measures of daytime sleepiness. Journal of applied physiology. 1998 Feb 1;84(2):507-15.

[12] https://sleepfoundation.org/sleep-topics/what-circadian-rhythm ©2018 National Sleep Foundation, US.

[13] "Beyond the Midnight Oil", an inquiry into managing fatigue in transport by the House of Representatives Standing Committee on Communication, Transport and the Arts, The Parliament of the Commonwealth of Australia, October 2000

3.3 Tram vigilance systems

3.3.1 Deadman function

By its design, the Deadman function is unlikely to detect loss of alertness or driver microsleep. The tram's task-linked vigilance system is relied upon for this.

3.3.2 Task-linked vigilance system

The E Class tram vigilance system is designed to respond to driver inaction after the tram had travelled 210 m (or 30 seconds). Yarra Trams operate six other Class of trams on their network that have a range of Deadman and vigilance facilities (Table 1).

Table 1: Comparison of Deadman and vigilance systems

Tram Class	Description
Z, A, B	Deadman foot pedal. No task-linked vigilance system
W	Deadman foot pedal. A task-based system linked to power, sanding and brakes. If no activity for 8 seconds, audible alarm for 4 seconds. If still no driver response, the brakes are applied.
C	If thumb sensor or foot pedal are released for more than 3 seconds or maintained for more than 32 seconds, an alarm will sound for a further 2 seconds. If no action is initiated, brakes apply. No task-linked vigilance system
D	Deadman switch on the master control and left arm rest, either of which must be released every 30 seconds, for 4 seconds. If not, an alarm will sound for 4 seconds. If no action is initiated, brakes apply.
E	Deadman integrated with master controller. Task-linked vigilance with response after the lessor of 210 m or 30 seconds. (See sections 2.2.4 and 2.2.5).

The W, C, D and E Class trams are fitted with some form of vigilance system. The permissible interval without driver acknowledgement of these systems is about 30 seconds, except the W Class which is 12 seconds. The E Class time settings are therefore consistent with several other trams within the Yarra Trams fleet. However, the 30 seconds setting was not able to detect and respond to a shorter period of inattention as occurred in this instance.

3.3.3 Other technologies for monitoring driver attention

There are a range of technologies in development and application for monitoring driver attention and providing warnings (Table 2). For example, Seeing Machine units have been installed on trams run by Croydon Tramlink[14] following an incident in which a tram derailed at high speed due to the driver having a micro-sleep[15].

[14] Tramlink is a light rail tram system serving Croydon and surrounding areas in South London, England,

[15] https://www.gov.uk/government/news/report-182017-overturning-of-a-tram-at-sandilands-junction-croydon: retrieved 7 August 2018

Table 2: Types of vigilance devices

Device	Key feature
Optalert	Uses infrared to detect eye movement and eye closure, emitting an alarm when fatigue is detected
Smart Cap	Monitors EEG and subjects these EEGs to an algorithm, emitting an alarm when fatigue is detected
B-Alert	Monitors EEG
Seeing Machine DSS	Camera tracks eye behaviour and alerts driver of potential fatigue or distraction
CoPilot DD850	Examines the pupil to detect fatigue and alert driver of potential fatigue

3.3.4 Collision warning and avoidance systems

Collision avoidance systems have been developed for public transport vehicles. For example, Bombardier Transportation and Mission Embedded[16] have developed a homologated obstacle detection and collision avoidance assistance system (ODAS) for trams and light rail vehicles, that detects and tracks obstacles including people, in real time and warns the driver about potential risks. In February 2019, after testing being carried out in Frankfurt, Marseille, Berlin and Cologne, ODAS was fitted on 74 Flexicity trams in Frankfurt that are in passenger service.

In automotive applications automatic emergency braking (AEB) systems have been found to reduce the incidence of collision. An analysis of international automotive crash data conducted by Fildes et al.[17] in 2015 showed cars fitted with AEB were 38 per cent less likely to collide with the car in front of them. Another study by Schittenhelm[18] in 2013 found AEB reduced rear end crash severity by 53 per cent and completely avoided rear end crashes by 35 per cent. *Source: Victorian Traffic Accident Commission*.[19]

[16] http://www.mission-embedded.com/mission_report/obstacle-detection/

[17] Fildes et al., (2015). Accident Analysis and Prevention - Effectiveness of low speed autonomous emergency braking in real-world rear-end crashes

[18] Schittenhelm, H. (2013). Advanced Brake Assist – Real world effectiveness of current implementations and next generation enlargements by Mercedes-Benz. Paper presented at the Enhanced Safety of Vehicles (ESV), Seoul, Korea.

[19] TAC: http://www.howsafeisyourcar.com.au/aeb/

4. Findings

4.1 Context

The following findings are made with respect to the collision between Trams 6008 and Tram 6005 at the intersection of Bourke and Spencer Streets on 2 August 2017. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Findings are expressed as safety factors. A *safety factor* is an event or condition that increases 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.

4.2 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 driver of Tram 6008 probably experienced a micro-sleep episode as the tram approached the Spencer Street tram stop. Factors that probably contributed to this fatigue-related event were a shortened sleep the night before the shift, sleepiness after a meal, and the mid-afternoon circadian low.

- **The E Class tram vigilance system was unable to detect and respond to the short period of inattention by the driver and no other system was fitted to detect and respond to driver inattention. [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 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 Driver vigilance monitoring

Number:	2018-03-001
Issue owner:	Yarra Trams

Safety issue description

The E Class tram vigilance system was unable to detect and respond to the short period of inattention by the driver and no other system was fitted to detect and respond to driver inattention.

Proactive action taken by Yarra Trams

Yarra Trams has established a Tram to Tram Collision Improvement steering group to review:

- the E-Class vigilance system, to determine the most suitable timing of vigilance control actions for the hazards and risks unique to the Melbourne tram network and its operating environment;
- availability of suitable new in-cab technology to assist with driver alertness/drowsiness detection and management;

The committee meets monthly to provide governance and guidance on key action items originating from the tram to tram collision review.

Yarra Trams have also engaged with the tram manufacturer regards developing a system to automatically identify possible hazards in front of the vehicle and warn drivers via acoustic and visual warning. The first trial of this system is expected to start in the 4th quarter of 2019.

Following a review of driver fatigue issues, Yarra Trams has revised their safety management system and updated several procedures and training modules to ensure greater awareness of the effects of health conditions and the hazard of fatigue on Rail Safety Workers.

The operator has also implemented a Lessons Learned Fact Sheet and initiated a 12:45 monthly conference call to share and discuss investigation outcomes with all depots and managers.