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Bus Safety Investigation Report

Bus fire m/o9340 — Lane Cove Tunnel, 14 April 2022

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Lane Cove Tunnel, New South Wales

14 April 2022

Cover photo: OTSI

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Executive summary

On the evening of 14 April 2022, bus m/o9340 caught fire while operating a passenger route between Sydney and Dural, New South Wales. The bus was travelling along the Gore Hill Freeway with a driver and 14 passengers on board when a fire started in the engine bay at the rear of the bus. The driver was not aware of the fire as the bus entered the Lane Cove Tunnel (LCT), travelling westbound.

Once in the tunnel, a passenger at the rear of the bus noticed the fire and alerted the driver and other passengers. The driver quickly pulled over and stopped in the left-hand lane (Lane 1) just past a breakdown bay. The driver opened the single door at the front of the bus, and the passengers evacuated the bus and travelled west (in the direction of travel) in the tunnel. Cars began to pass the stationary bus and smoke from the fire was blown west along the tunnel. The driver activated the battery isolation switch on the bus and observed all passengers exit the bus before attempting unsuccessfully to extinguish the fire.

The LCT Traffic Control Room Officers (TCROs) were alerted to pedestrians in Lane 1 further along the tunnel about 45 seconds after the bus stopped. The TCROs started to implement a traffic management plan to protect the pedestrians, then using closed-circuit television (CCTV) in the tunnel, they discovered the bus on fire. The TCROs updated their response and implemented a fire response plan, deployed the tunnel deluge system to suppress the fire and closed the westbound tunnel.

Emergency services attended and Fire and Rescue NSW extinguished the fire.

The investigation found that the fire in the engine bay was likely due to a fluid leak of either hydraulic oil or coolant which was likely ignited by a hot surface. The fire spread from the engine bay destroying the bus. The deluge system prevented the spread to the surrounding structure and limited the damage to the tunnel from the fire. The bus was fitted with an engine bay fire suppression system (EBFSS) which activated although the time of discharge and effectiveness of the system could not be assessed with the evidence available.

All the passengers were evacuated from the tunnel by passing motorists and another bus. Although there were no injuries, the passengers and driver were at risk of smoke inhalation and being struck by passing motorists due to smoke from the fire reducing visibility. The drivers of passing vehicles were also at risk from smoke inhalation.

The training and procedures that the bus operator, Hillsbus, provided their drivers for EBFSS and emergency evacuations in tunnels did not effectively address the differences in EBFSS alerting processes between different systems, or provide adequate information and procedures for a tunnel environment, specifically the Lane Cove Tunnel. While it could not be determined if the EBFSS alerted the driver when it discharged, the driver had not been trained in the system fitted to the bus, reducing the likelihood they would have been able to detect and respond.

The initial response by Transurban to the bus fire and pedestrians in the tunnel was delayed as their automatic visual incident detection system (AVIDS) provided reduced coverage for the automatic detection of incidents. In this instance, the bus stopped between the AVIDS detection zones and the first camera the pedestrians walked past did not detect their presence. Once the TCROs became aware of the fire, they responded effectively to the incident.

There were several recommendations from this investigation, with a key recommendation that Transport for NSW (TfNSW) facilitate coordination between tunnel operators and TfNSW accredited bus operators to develop and implement updated emergency procedures and preparedness arrangements for bus services operating in tunnels.

Safety message

While emergencies and fires within tunnels are rare, they present a potentially high consequence risk particularly for buses due to the number of passengers on the vehicle.

Bus operators should review their driver emergency evacuation training and procedures to ensure that information relevant to fire and life safety systems in tunnels is provided to drivers to enhance response to emergencies in tunnels. The review should consider the risks and required response by drivers for emergencies on their bus and include how they should evacuate passengers to a safe place if needed, as well as responding to emergencies involving other vehicles in tunnels.

Tunnel operators should review the effectiveness of their incident detection systems to ensure that the system operates as expected and any limitations of the system are understood and managed.

Part 1 — Factual information

Events leading up to the occurrence

1.1 On 14 April 2022, a Hillsbus driver commenced their shift at the Dural depot, New South Wales at 1230.[1] The driver was allocated bus m/o9340 and completed a pre-departure check before departing at 1240. The driver operated several routes before having a meal break between 1529 and 1626.

1.2 The driver then performed routes 620X and 652X which were both express services between Sydney and Dural. The routes stopped at Kent Street and Wynyard Station before travelling via the Lane Cove Tunnel (LCT) towards Dural. The bus travelled special[2] from Dural to Sydney between those routes.

The occurrence

1.3 At 2000 the driver commenced route 642X which was also an express route to Dural via the LCT. The bus departed Kent Street, Sydney with the driver and 14 adult passengers with no passenger requiring assistance.

1.4 While the bus was travelling along the Gore Hill Freeway, a fire started in the engine bay at the rear of the bus. The closed-circuit television (CCTV) systems fitted to the bus and along the motorway showed a visible glow on the road surface at the rear of the bus from around 2011 (Figure 1). The glow continued before flames were visible externally on the nearside[3] rear lower corner. No vehicles were observed to pass the bus once the glow was visible at the rear.

1.5 At 2012 bus m/o9340 entered the LCT portal while on fire (Figure 1). A passenger on the rear seat was recorded on the bus CCTV waving their hand in front of their face before partially covering their face with a piece of clothing. Shortly after, that passenger appeared to have observed flames through the window of the bus and alerted the driver and other passengers.

1.6 At that time, the bus was travelling in the LCT, in the middle lane. The driver quickly pulled over to the left to stop in Lane 1 and activated the bus hazard lights. As the bus was stopping, all passengers began to rise from their seats.

1.7 The bus stopped in Lane 1 at 2013:45, just past an emergency breakdown bay in the tunnel and between cross-passages[4] 17 and 18 (Figure 2). The driver kneeled[5] the bus, opened the door, and then isolated the battery isolation (master) switch on the dashboard. The first passenger alighted the bus at 2013:52, with the last exiting at 2014:04. The passengers began to walk/run in a westerly direction (in the direction of traffic) along the LCT.

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[1] Times in this report are in 24-hour clock form in Australian Eastern Standard Time.

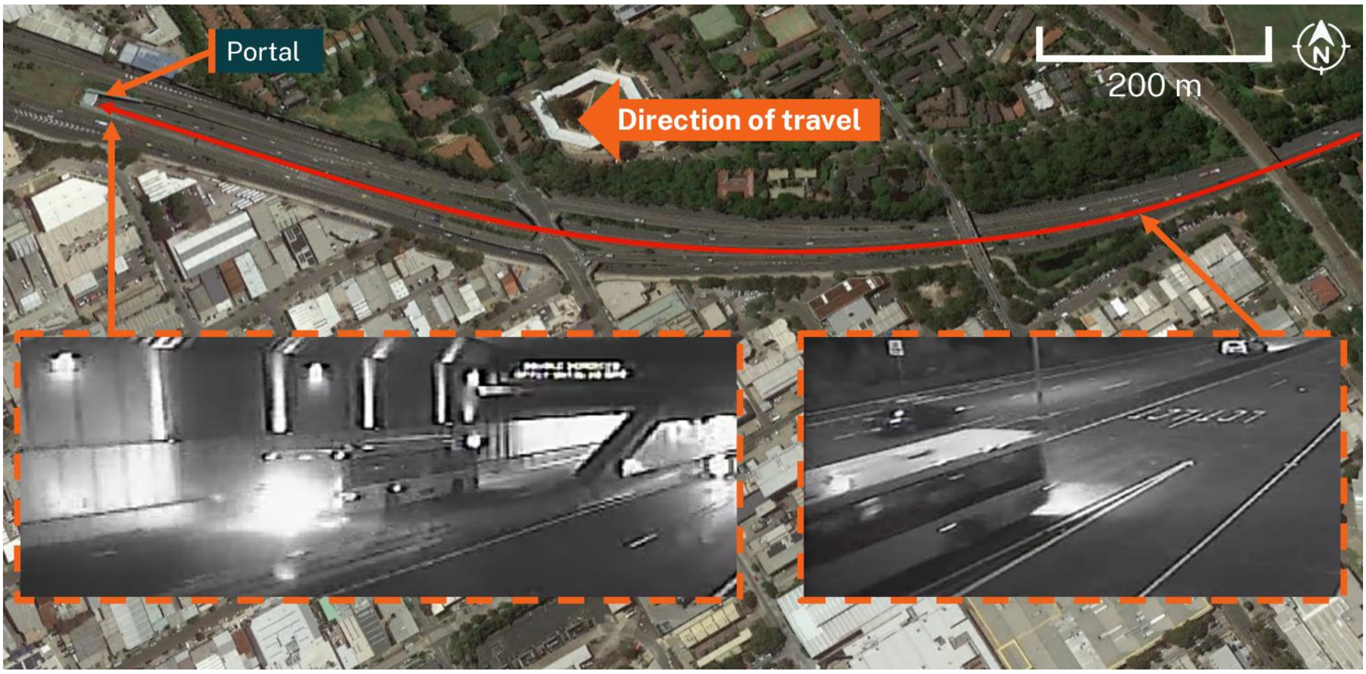
[2] Special refers to a bus operating between two locations while not in passenger service.

[3] Nearside: The left side when looking forward in the bus is the nearside as this is nearer to the footpath. The right side is the offside.

[4] Cross-passage: A passage providing pedestrian and emergency services personnel connection between adjacent tunnels. The cross-passages were numbered to identify the location. In the direction of travel, the cross-passage numbering was decreasing.

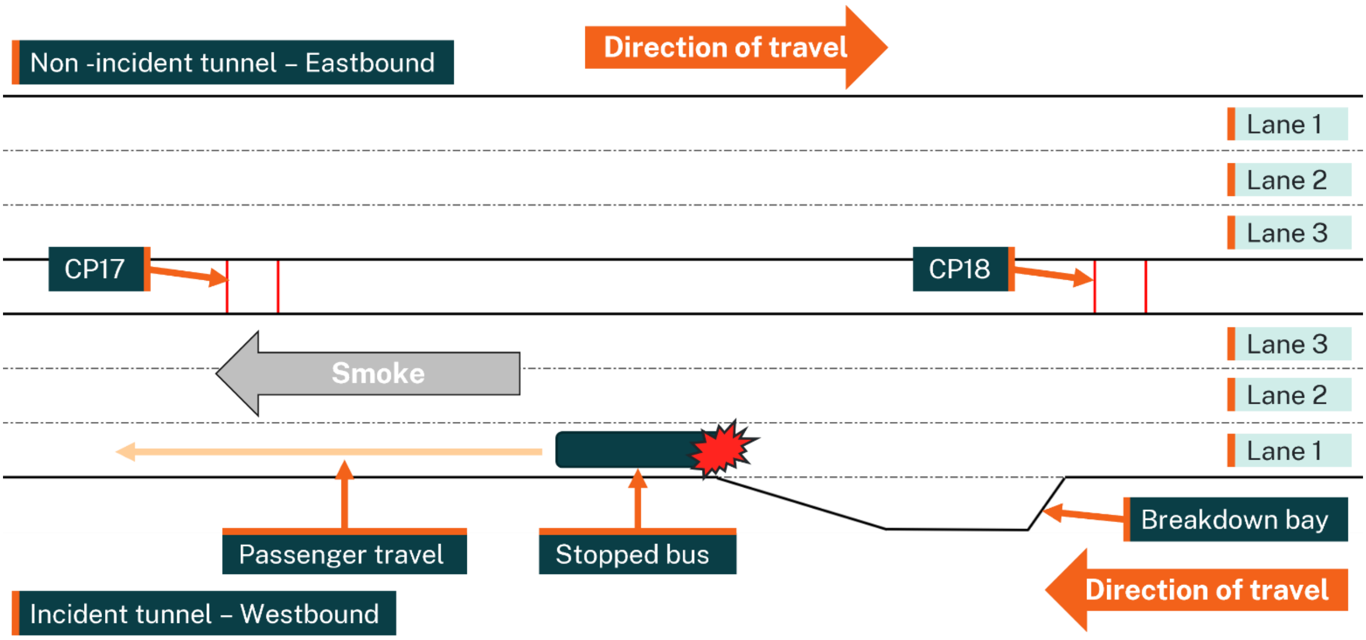
[5] Kneeled: Lowering the air suspension to make it easier for persons to enter and exit the bus.

Figure 1: Approach of bus m/o9340 towards the Lane Cove Tunnel



The image shows the path travelled by bus m/o9340 before entering the tunnel in Lane 1. The two inset images show the fire as viewed from the roadside cameras, initially as glowing on the road surface and then visible flames at the rear of the bus as it was entering the tunnel.
Source: Transurban and SIX Maps NSW, modified and annotated by OTSI

Figure 2: Bus stopping location



The diagram shows the stopping location of the bus relative to the breakdown bay and cross-passages 17 and 18. The cross-passages are shown as CP17 and CP 18 which connected the incident and non-incident tunnels. The area upstream of the fire was free from smoke.
Source: OTSI

1.8 Once the bus stopped, vehicles began to pass the bus in Lanes 2 and 3.

1.9 While the passengers were evacuating the bus, the driver was standing and observed all passengers exit the bus. Once the last passenger had alighted, the driver accessed the fire extinguisher located inside the cab, next to the door, and attempted to extinguish the fire.

1.10 At 2014:29, the LCT Traffic Control Room Officers (TCRO) were alerted by an alarm to pedestrians in Lane 1, west of cross-passage 17 (Figure 3). The TCROs' initial response was to provide protection to the pedestrians by implementing a traffic management plan (TMP) to close Lane 1, which commenced at 2014:44.

Figure 3: Passenger movements

The upper image from camera TVR747 shows the passengers walking immediately ahead of the bus in Lane 1, with cross-passage 17 visible in the distance. These pedestrians were not detected by tunnel pedestrian detection systems. The lower image from camera TVR746 showing a single passenger after they had walked approximately 60 m further along the tunnel and west of cross-passage 17. This passenger triggered the alarm to TCRO's which initiated the emergency response.
Source: Transurban, modified and annotated by OTSI

1.11 After unsuccessfully attempting to extinguish the fire, the driver returned to the bus at 2015 to collect their bag before walking west in the tunnel.

1.12 The TCRO manually searched the tunnel using the CCTV to determine where the pedestrians had come from and found the burning bus. The TCRO then commenced an emergency response for the fire.

1.13 At 2016:52 the TCRO activated the tunnel deluge system[6] above the bus and initiated a TMP to close Lane 2 and 3, and the westbound tunnel.

1.14 The westbound tunnel was closed around 2017, although there were vehicles already in the tunnel. The TCRO then contacted Fire and Rescue NSW (FRNSW) to notify them of the incident, confirming the location and access to the site.

1.15 A total of 15 vehicles, including a bus, passed through the active deluge system with significantly reduced visibility. A total of 78 vehicles passed the burning bus before traffic stopped, with the last vehicle passing at 2018:22.

1.16 Passengers evacuated from the bus were picked up by either passing motorists or a second bus which had driven through the deluge system and past the fire. The bus driver was picked up by an ambulance that was travelling in the tunnel at the time of the fire.

1.17 The TCROs deployed a second deluge zone at 2023:55 as the fire flared up.

Events following the occurrence

1.18 Emergency services attended the incident, with FRNSW attending the eastbound and westbound tunnels, as well as the LCT control room.

1.19 FRNSW commenced fighting the fire at 2034:14 with a fire hose from the tunnel while setting up a hose from a hydrant. The eastbound tunnel was closed at 2035 after the arrival of FRNSW and police in the non-incident tunnel.[7]

1.20 The deluge system was turned off at 2045:40 and FRNSW continued to cool the bus with a hose from their vehicle until 2047:47.

1.21 Between 2116 and 2121, police checked cross-passages 11 to 17 for any persons.

1.22 The eastbound tunnel was re-opened at 2137 and the bus was recovered from site about midnight. Maintenance personnel inspected the tunnel for damage – there was minor damage to the pavement and fan above the fire. The tunnel re-opened just before 0300 on 15 April 2022.

Incident location

1.23 The incident occurred within the Lane Cove Tunnel (LCT). The LCT opened in 2007 and was 3.6 km long, with the tunnel portals located at Artarmon and Lane Cove North.

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6 Deluge system: Open, fixed fire-fighting system comprising relatively large water droplets activated on a zone-by-zone basis.

7 Non-incident tunnel refers to the tunnel without the incident and can be used by emergency services to access the incident tunnel. The non-incident tunnel can also be used for the evacuation of persons from the incident tunnel if required.

1.24 There were two tunnels (tubes) with two to three lanes per tunnel. There were cross-passages every 120 m along the tunnel that were located and accessible from the right-hand lane (Lane 2 or 3). There were four breakdown bays along the tunnel as there was no shoulder[8] in the tunnel.

1.25 The bus stopped in Lane 1, approximately 1500 m into the tunnel, just past the breakdown bay between cross-passages 17 and 18 (Figure 2). In the direction of travel, the distance to the next breakdown bay was 970 m and the tunnel exit was 2100 m.[9]

1.26 There were fixed speed cameras in both tunnels and a CCTV system.

Environmental conditions

1.27 On 14 April 2022, the Bureau of Meteorology recorded a temperature range of 14°C to 25°C at the Observatory Hill weather station, located about 6 km south-east of the incident. At the time of the fire it was dark with minimal artificial lighting along the roadway.

1.28 The environment within the tunnel consisted of artificial lighting with mechanical ventilation that generally operated in the direction of traffic flow. The piston effect[10] of traffic movement also assisted in the flow of air through the tunnel.

1.29 The investigation determined the environmental conditions were not contributing factors to this incident. The smoke from the fire was controlled using the mechanical ventilation, which prevented backlayering[11] and provided an area of fresh air upstream (opposite to the direction of travel) of the fire.

Bus operator information

1.30 The bus operator was Hillsbus Pty Ltd (Hillsbus), which operated and maintained a fleet of buses under contract for Transport for NSW (TfNSW). Hillsbus was owned and operated by ComfortDelGro Australia (CDC or CDC NSW).

1.31 The operator's fleet of buses were fitted with Engine Bay Fire Suppression Systems (EBFSS) from three different manufactures. The systems functioned in a similar manner, although provided the drivers with different alerts or alarms to advise of a system discharge. Two of the systems provided a standalone indicator panel and alarm, the third system (Dafo) used the master warning alarm and engine fire alarm light on the dashboard to alert the driver

1.32 Bus m/o9340 was fitted with Dafo EBFSS (see *Engine bay fire suppression*). The same system was fitted to 175 of the operator's buses across six depots, with 78 buses at their Dural depot.

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8 Shoulder: An area to the side of the road that can be used to stop in an emergency.

9 At the maximum permissible speed of 80 km/h it would have taken approximately 44 seconds to reach the next breakdown bay and 95 seconds to exit the tunnel had the driver elected and been able to continue.

10 Piston effect: Force applied on the air in a tunnel by moving vehicles.

11 Backlayering: The movement of smoke and hot gases opposite to the imposed direction of airflow.

Driver training program

1.33 The operator had a driver training program that included training for emergency evacuations and fires. The training was delivered as part of the onboarding process and annually thereafter as a refresher. The training was generic and did not require assessment for all bus types.

1.34 The purpose of the emergency evacuation driver refresher training was to:

> Certify CDC [Hillsbus] drivers understand the operational instruments used to display emergency warnings and the safety requirements of evacuating a bus.

1.35 The training was delivered by qualified heavy vehicle driving instructors. The drivers were provided with guidance material[12,13] and presented with a bus evacuation video (*STA evacuation video*).[14]

1.36 Hillsbus' bus evacuation procedure detailed the steps for the driver to evacuate the bus (Figure 4). The drivers were encouraged during training to evacuate the bus as the first priority rather than attempting to extinguish a fire.

Figure 4: Hillsbus bus evacuation procedure

Step	Description of Action
1	Move bus to a safe parking location that provides a safe path for your passengers to disembark; • Open doors and activate hazard lights • Secure bus (handbrake) and turn off engine and battery
2	Contact OCC/Operations Centre to report via; • Duress Alarm • Mobile phone
3	Advise passengers of the situation and exit points (front/rear doors) and emergency access
4	Locate and identify an evacuation point, must be; • 150m away from bus • Away from traffic • Advise muster point
5	Help the elderly and any injured passengers to the muster point.
6	Before leaving the bus; • Check all passengers are evacuated
7	Continue to wait in muster point. Ensure you are contactable
8	Identify passengers who requier medical assistance.
9	Continue communication with OCC/Operations Centre via mobile phone.

Source: Hillsbus, CDC NSW TM4995 Emergency Evacuation Information guide

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12 CDC NSW (2019), Emergency Evacuation Driver Training, Information Guide, 2019_4995, 30 September 2019

13 CDC NSW (2019), Emergency Evacuation Driver Training, Pocket Book, 2019_4995, 30 September 2019

14 This video was produced by the State Transit Authority and was available as part of the Bus Industry Confederation Inc (2019), Bus Fire Evacuation Protocol. Available at https://movingpeople.com.au/bus-fire-evac

1.37 The trainer was to assess how the drivers would evacuate a bus in the following scenarios:

- a quiet street / single lane road vs a multi lane road;
- Sydney Harbor Bridge or tunnel; and
- a freeway.

Hillsbus advised that the drivers would be deemed competent when their response aligned to the content delivered during the training session.

1.38 Drivers were also trained to perform pre-departure checks to ensure that the bus was safe to enter service, and that alarms and fault lights were operational.

Driver information

1.39 The driver had been employed as a driver with Hillsbus from March 2017 and was based at the Dural depot. They had undertaken the mandatory training and assessment and were competent at the time of the fire.

1.40 At interview, the driver reported that they had operated bus m/o9340 without incident during their shift, up to the time of the incident. The driver reported that while operating route 642X, they did not notice any loss of power (electrical or mechanical), or see or hear any alarms, prior to the passenger alerting them to the fire.

1.41 Review of bus CCTV footage showed the driver infrequently checking their mirrors prior to entering the tunnel, when the bus was in free-flowing traffic and not changing lanes. The driver advised that once they were driving in the tunnel, they were focused on maintaining their speed due to the tunnels' speed camera.

1.42 The driver reported that once the passenger alerted them to the fire, they checked their nearside mirror, saw the flames and stopped the bus.

Driver training history

1.43 On 1 November 2019, the driver received emergency evacuation driver training. During the training, the driver was assessed for their knowledge and responses for the following emergency scenarios:

- a passenger on a full bus alerting the driver of smoke within the bus, while travelling through the Lane Cove Tunnel in peak hour (Figure 5)
- smoke sighted coming from the engine bay while travelling along a multiple lane surface road
- fire suppression alarm while travelling along the Sydney Harbour Bridge in Lane 3 with a passenger in a wheelchair on the bus.

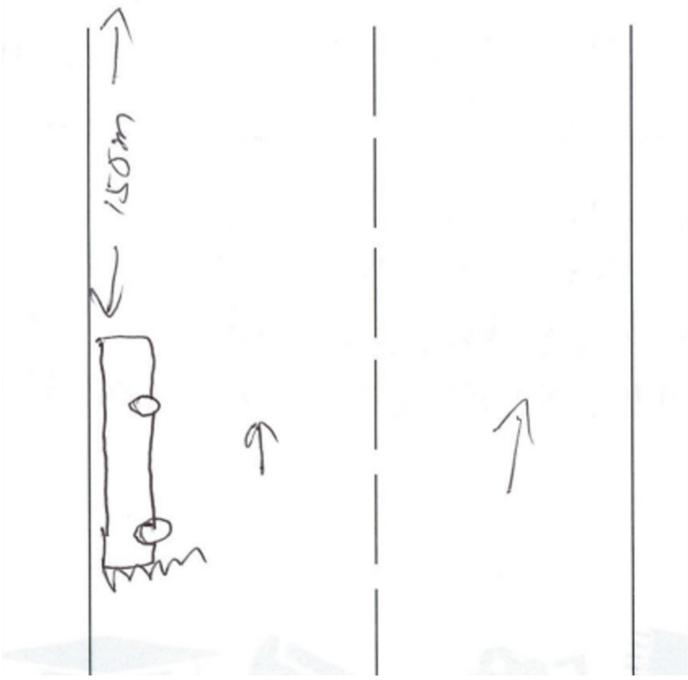
1.44 As part of the scenario for the Lane Cove Tunnel, the driver was required to detail where they would park the bus, who they would contact, and if they would evacuate into the tunnel. The driver was also required to draw the positioning of the bus in the lane. The driver's response was to stop in the left lane (Lane 1), contact the Operations Control Centre (OCC) by mobile and evacuate 150 m in front of the bus (Figure 5).

1.45 The driver was deemed competent for their responses to the three scenarios, and their knowledge of the fire suppression system (Firestorm system), tyre pressure monitoring and fire protocol (emergencies and fire extinguishers).

1.46 The driver had not received annual emergency evacuation refresher training since 2019.

Figure 5: Lane Cove Tunnel smoke scenario

Scenario	
You have entered the Lane Cove Tunnel in peak hour, your bus is full and your traveling in the left lane and a passenger yells out there is smoke at the back of your bus. Your priority is to ensure yourself and passengers are safe. Draw the bus and write points to answer the following questions.	
Where would you park your bus and how do you park?	Close to left lane
Who do you contact and how?	OCC by mobile phone
Do you evacuate your bus in the tunnel? If yes, how do you evacuate?	Yes, left lane



Excerpt from the drivers written assessment
Source: Hillsbus., modified by OTSI

Bus information

1.47 The bus was a 2007 Scania K94 and was fitted with a Volgren CR228L body. The bus was rigid with a single double leaf entry/exit door at the front of the bus. The bus had travelled 936,084 km.

1.48 The bus was authorised to carry 72 passengers (47 seated and 25 standing).

Engine bay

1.49 The bus was fitted with a vertically orientated five-cylinder turbocharged diesel engine. The turbocharger and exhaust manifold were located on the nearside of the engine bay (hot side). Most of the electrical systems (starter motor, alternator and engine control system) were located on the offside of the engine away from high temperatures. The air conditioner compressor was also located on the offside.

1.50 The engine used Shell Rimula R6 MS 10W-40 motor oil with the following properties:

- flash point 240°C[15]
- boiling point 280°C[16]
- auto-ignition > 320°C.[17]

1.51 The bus was fitted with a hydraulically driven cooling fan that was located on the nearside of the engine bay. The fan drew air from the outside through the radiator/intercooler assembly. There was a baffle plate positioned between the fan and the engine but air from the fan would likely flow across the engine bay. The fan was driven by a hydraulic pump mechanically coupled to the engine and used the same oil type as the engine. When the engine was cold the fan operated between 500-600 rpm.[18] Once the coolant temperature after the radiator was above 76°C, the fan operated between 1800-2000 rpm.

1.52 The Safety Data Sheet, for the coolant used, listed the product as not flammable. However, the coolant consisted of ethanediol (ethylene glycol) at a proportion of 45-55 per cent.

1.53 A flammable substance ignites immediately when exposed to flame. A combustible substance requires some effort (heat) before igniting. Both flammable and combustible substances are capable of burning. In terms of a flash point, a flammable substance has a flash point of less than 37.8°C, and a combustible substance has flash point greater than 37.8°C.

1.54 Ethanediol is combustible and had the following properties:

- flash point 111°C
- boiling point 198°C
- auto-ignition > 410°C.

1.55 The coolant was used for both the engine and the bus's heating ventilation and air conditioning (HVAC) system. The coolant header tank was mounted in the engine bay with multiple coolant pipes running across the engine bay and to the roof mounted HVAC system.

1.56 There were three Scania engine bay fire sensors (thermal cut off) in the engine bay. The three sensors were connected in series[19] and if triggered and serviceable, would provide an engine fire alarm (red) warning light on the dashboard to alert the driver (Figure 6). The sensors were normally closed[20] with an opening temperature of 130°C±10°C. The sensor would automatically

15 Flash point: The minimum temperature at which, under specified test conditions, a substance emits sufficient flammable gas to ignite momentarily on application of an ignition source.

16 Boiling point: The temperature at which the vapor pressure of a liquid equals the surrounding atmospheric pressure.

17 Auto-ignition: The lowest temperature at which a combustible material ignites in air without a spark or flame.

18 rpm: Revolutions per minute.

19 Series: An electrical circuit where each device is connected to the next and the same current flows through each device.

20 Normally closed: The state of a switch where the contact is closed and allows the flow of current in its normal state, a change of state disconnects the circuit.

reset once the temperature dropped at least 20°C below the activation temperature. There were no testing or inspection requirements for the sensors.

1.57 The engine bay was separated from the saloon of the bus by an aluminium sheet, with foam insulating material on the underside of the aluminium.

Engine bay fire suppression

1.58 The bus was fitted with a Dafo engine bay fire suppression system (EBFSS) that was installed by the original equipment manufacturer (OEM) prior to entry into service. The EBFSS consisted of the following:

- control unit
- Forrex agent tank – 12.5 L water and aqueous film forming foam (AFFF) solution, burst disc[21]
- nitrogen cartridge – cylinder pressurised to 124 bar, burst disc
- linear heat detector – temperature sensitive wire, melting point 180°C
- distribution pipe work, nozzles and actuating valve.

1.59 In the event of a fire, the insulation on the linear heat detector melted creating an electrical circuit indicating a fire to the control unit. The control unit would trigger the actuating valve, rupturing the burst disc and releasing the pressure from the nitrogen cylinder, to act on a piston within the agent tank, discharging the system. The water mist was designed to suppress a fire and cool hot surfaces.

The control unit would also activate an alarm (horn and light output) that was connected to an engine fire alarm light on the driver's dashboard and audible alarm (Figure 6). The audible alarm to alert the driver was not unique to the EBFSS and was the same alarm used for multiple other alerts or faults.

[21] The function of the burst discs on the agent tank and nitrogen cylinder was to retain the pressure or fluid prior to discharge. The discs would rupture when the actuating valve was activated or if they were exposed to a pressure above their design burst pressure.

Figure 6: Bus m/o9340 dashboard and fire alarm

Source: Hillsbus and OTSI, modified and annotated by OTSI

Communication equipment

1.60 The bus was fitted with two-way radio communication equipment systems that allowed the driver and Operations Control Centre (OCC) to communicate. Drivers also had a mobile phone that they could use to contact the OCC.

1.61 In the event of an emergency, drivers were required to report incidents to the OCC and follow their instructions. If required, drivers could discretely alert the OCC using a duress system which activated a microphone and allowed the OCC to hear what was occurring on the bus and take necessary action.

Maintenance

1.62 Bus m/o9340 was maintained in accordance with technical maintenance plan from Scania which included both time-based and kilometrage-based services.

1.63 Maintenance records were reviewed for the 12 months prior to the occurrence with the most recent inspections detailed in (Table 1).

Table 1: Bus m/o9340 maintenance

Date	Service	Frequency	Comment
15/03/2022	Safety check – General inspection	90 days	Inspection of 92 items including dashboard indicators, fire extinguishers and engine compartment (fluid leaks, conditions of hoses and wiring security). Inspection passed.
15/03/2022	Pre - Heavy Vehicle Inspection Scheme (HVIS) April	12 months	Inspection of 55 items including checks for dashboard indicators, fluid leaks and exhaust system. Inspection passed.
21/03/2022	Heavy Vehicle Inspection Scheme (HVIS) April	12 months	Inspection as per HVIS scheme criteria. Bus failed inspected due to defective airbag. Defective airbag resolved and no other issue.
22/03/2022	Fire Extinguisher service	6 months	Service of 2.5 kg fire extinguisher.

1.64 The EBFSS was maintained by a contractor and was serviced with reference to Australian Standard AS 5062:2016.[22] Maintenance records for five years prior to the occurrence were reviewed with the most recent inspections detailed in (Table 2).

Table 2: Bus m/o9340 EBFSS maintenance

Date	Service	Frequency	Comment
06/05/2020	Fire Suppression System Service - Out Sourced	12 months	Forrex agent tank overhaul and agent replacement listed as overdue since 2016. Fire system listed as approved pending fault rectification for faults in the system.
26/05/2021	Fire Suppression System Service - Out Sourced	12 months	Forrex agent tank listed as overdue. Fire system listed as not approved with defects to be fixed by the owner. Nitrogen cartridge weighed in tolerance.

[22] Australian Standard (2016), AS5062:2016, Fire protection for mobile and transportable equipment

08/09/2021	Other	10 years	Forrex agent tank overhaul completed. Nitrogen Cartridge listed as overdue pressure testing and fire system not approved. Nitrogen cartridge weighed in tolerance.

1.65 At the time of the occurrence, the nitrogen cylinder for the EBFSS was listed as overdue for pressure testing (Table 2). Although listed as overdue, the nitrogen cylinder was weighed on 8 September 2021, indicating the cylinder was still charged. When the services were completed, the system was listed as not approved although the work orders associated with the inspections were closed as completed.

1.66 Post incident, the maintenance provider advised that the systems should have been marked as approved, as the defects were considered non-critical defects[23] as per AS5062:2016.

Tunnel operation

1.67 The tunnel and motorway were operated by Transurban[24] and controlled by the Traffic Control Room Officers (TCROs) at the Motorway Control Centre (MCC). The MCC was configured with a large display that provided a graphical representation of the tunnel and equipment, and six selected CCTV displays (Figure 7). There were also 24 CCTV screens that scrolled every three seconds showing the cameras from the tunnel and motorway.

In event of an automatic visual incident detection (refer to *Automatic visual incident detection system*) a camera would be highlighted on the large display to assist the TCRO with responding.

1.68 There were two workstations for the TCROs where they could control the tunnel operations management control system (OMCS). The fire panel and deluge control panel were also located within the control room (Figure 8).

1.69 Two TCROs were on shift at the time of the fire and responded to the incident. Both operators were trained and competent to perform their roles.

1.70 Both TCROs had completed scenarios-based assessments for their responses to a vehicle fire within the tunnel using a training simulator. The assessments were completed in November 2019 for one TCRO and February 2022 for the other.

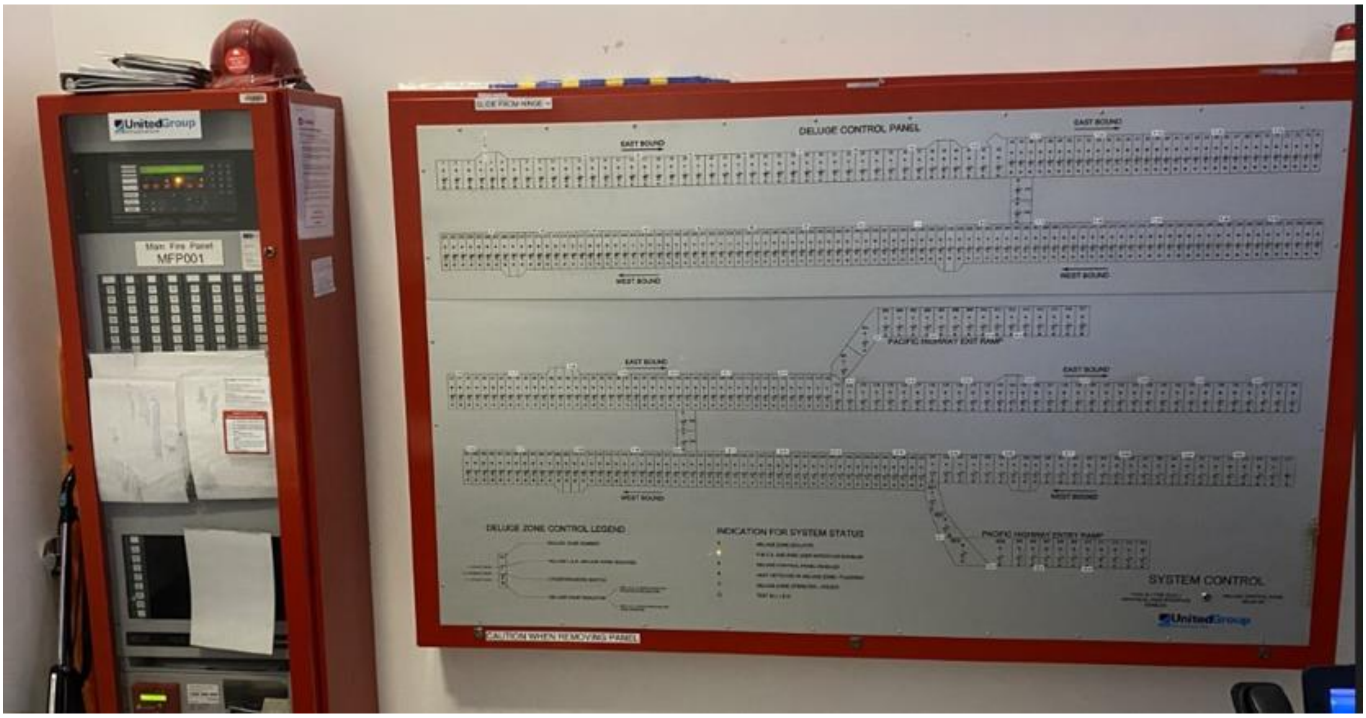
[23] Non-critical defect: A system impairment or faulty component not likely to critically affect the operation of the system.

[24] The legal entity for operating the Lane Cove Tunnel was LCT-MRE Pty Limited as part of Transurban's group structure and is more commonly known as Transurban.

Figure 7: Lane Cove Tunnel control room display

Source: OTSI

Figure 8: Fire and deluge control panel



Source: OTSI

Tunnel fire and life safety equipment

1.71 The tunnel was fitted with multiple fire and life safety systems that included:

- Fixed and variable message signage and lane usage signs for motorist. Fixed emergency exit signage for evacuees.
- Public address (PA) and radio re-broadcast (RRB).[25]
- Closed-circuit television (CCTV) cameras supplemented with automatic visual incident detection system (AVIDS).
- Mechanical ventilation to maintain airflow and control smoke.
- Emergency equipment cabinets (EEC) – each of which contained a motorist emergency telephone (MET) which allowed communication with the TCROs, fire hydrant and fire extinguisher. Cabinets were located every 60 m and accessible from Lane 2 or 3 only (right-hand lane).
- Breakdown bays (BB) – four bays per tunnel located left-hand side of the tunnel. Each bay had a breakdown bay cabinet (BBC) with a MET and fire extinguisher.
- Deluge system - manual or automatic. Manual activation through deluge panel. Automatic activation linked to linear heat detectors (range 75-95°C) along the roof of the tunnel.
- Cross-passages every 120 m to allow pedestrians to evacuate to the non-incident tunnel and emergency services access to the incident tunnel.

1.72 The emergency cabinets, breakdown bay and cross-passages were fitted with switches or sensors that would automatically alert the TCROs if they were opened or used. These would also display the CCTV camera showing the device.

1.73 Maintenance records indicated that the fire safety equipment had been tested and inspected as required by the operator on 7-8 March 2022 for the eastbound tunnel and 9-10 March 2022 for the westbound tunnel. The testing and inspection included the deluge system, fire door inspection and detector testing.

Incident and emergency response

1.74 Transurban had developed incident response plans, manuals and checklists to respond to unplanned incidents and emergencies. Additionally, Incident Response Crews (IRC) were available to respond to on-road incidents and assist emergency services as required. The IRCs, when not responding to incidents, would wait in staging areas along the motorway.

1.75 The TCROs could detect incidents on the motorway and in the tunnel, either manually or automatically:

- Manually through:
  - closed circuit television (CCTV)
  - motorist emergency telephones (MET)

[25] Radio re-broadcast: This system broadcasts local radio frequencies along the tunnel and allows for emergency messages to be broadcast directly to the vehicles if their radio is switched on.

- a telephone call from the IRC, Transport Management Centre (TMC) or other agencies.

- Automatically through:
  - automatic visual incident detection system (AVIDS)
  - alarms issued by the traffic management control system (TMCS) for abnormalities in normal traffic flow.

1.76 Once an incident was detected, the TCRO was required to verify the incident and respond accordingly. The required response time from an incident occurring, to detection and commencement of an appropriate action by the TCRO, was less than two minutes.[26]

1.77 There were 21 checklists for pre-defined incidents to assist the TCRO in responding to emergencies. Checklists included incidents such as fires, stopped vehicles, pedestrians on the roadway (prohibited users), and evacuations within the tunnel.

1.78 Traffic Management Plans (TMP) had been developed for each of the pre-defined events that the TCRO could initiate and modify as required by the incident.

1.79 The TCROs were authorised to order evacuations of the tunnel for pre-defined[27] events or as directed by emergency services.

1.80 In response to the fire, the TCRO initiated an uncongested fire TMP[28] and closed the westbound tunnel. Once the TMP was initiated, there were two audio broadcasts (PA and RRB) that were linked to the TMP that played on repeat. The first audio broadcast was to advise that the deluge system may be used:

> Attention motorists. This is the Lane Cove Tunnel Control Room. A major incident has occurred in the tunnel, which may be associated with the use of the overhead deluge system. Drivers are strongly advised to close windows and sunroofs or convertible roofs. Please remain inside your vehicle during operation of the deluge unless advised otherwise. Thank you for your cooperation [broadcast duration 26 seconds].

This broadcast was closely followed by directions to stop if drivers could see an incident ahead of them:

> Attention motorists. This is the Lane Cove Tunnel Control Room. A major incident has occurred in the tunnel. Drivers who can see the incident in front of them should stop, switch off their headlights and engines, and calmly wait for further advice. Any motorist who feels endangered by the incident should leave their vehicle and walk to the nearest safe emergency exit, located on the right-hand side of the tunnel. Please leave your car keys in the ignition and do not lock your doors. Thank you for your cooperation [broadcast duration 33 seconds].

1.81 In addition to the audio broadcasts, messages were displayed on the variable message signs both internally and externally of the tunnel to advise motorists. The following messages were communicated:

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[26] Transurban (2021), Incident Response Plan, LCT-OI-PL-1, 3 November 2021

[27] Pre-defined events requiring evacuations, a tunnel fire with downstream congestion, a tunnel fire with significant risk to upstream motorists in the absence of downstream congestion, and a toxic spill and directed by FRNSW to evacuate.

[28] An uncongested fire plan refers to a traffic management plan without downstream congestion, vehicles downstream of the fire were expected to continue and drive out of the tunnel.

- Internal – Switch on Radio Drive Safely; Switch on Radio; Switch Off Engine; Incident Ahead
- External – Lane Cove Tunnel On Ramp Closed Use Alternate route; Lane Cove Tunnel Closed Use Alternate Route; Lane Cove Tunnel Extended Delays Use A1; Lane Cove Tunnel Closed Use Pacific Highway; Extended delays.

1.82 The closure of lanes and the motorway required drivers to observe and obey the traffic signals and stop, which could delay the initial closure if vehicles do not respond. Boom gates at the tunnel portal could be closed to prevent vehicles entering the tunnel. The moveable median strips (MMS) on the tunnel approach roads could only be activated to divert traffic away from the tunnel once traffic had stopped.

Automatic visual incident detection system

1.83 The automatic visual incident detection system (AVIDS) used the CCTV from the tunnel to detect pre-defined traffic events and generate alerts to the Motorway Control Centre (MCC), using computer analysis of the recorded video.

1.84 The system was able to detect traffic events including stopped vehicles, pedestrians, smoke, fallen objects (debris) and vehicles travelling the wrong way. The system used algorithms that compared each frame of video with the previous one to identify differences that exceeded the designed alert thresholds. [29,30]

1.85 The detection of events relied on the system being configured correctly with the detection zone defined for the different event types. The detection of events also relied on sufficient video quality, as reduced quality could affect the detection rate. Video quality could be affected by camera type and lens, signal noise and cleanliness of the camera, requiring the system to be maintained.

1.86 The detection zones for stopped vehicles and pedestrians were generally configured with separate zones for each lane, so that alerts were lane specific. The maximum detection zone length for pedestrians was up to 75 m, while stopped vehicles was up to 300 m.[31] The camera position (height, position on the road and angle) could affect the detection capabilities.

1.87 Detection for stopped vehicles required a vehicle to be stationary for more than 15 seconds, within the detection zone, to generate an alert. Detection of pedestrians required their feet to be within the detection zone and for the pedestrian to be in zone for more than 3 seconds.

1.88 Detection for smoke was based on the deteriorating image quality for more than 5 seconds across the entire field of view for the camera. There were no AVIDS alerts generated for smoke during the incident.

1.89 The OEM of the AVIDS system recommended that there was overlapping coverage for the detection zones to prevent detection zone blind spots.[32] Similar details were contained in TfNSW *Smart motor design guides* (2017) which specified that there must be full coverage for

[29] Traficon (2010), VIP-T Specifications

[30] FLIR (2013), VIP-T Setup Guide

[31] The maximum detection zone length was dependant on the installation height of the camera. The stopped vehicles detection was up to 20 x the camera height while pedestrians was 10 x the camera height to a max of 75 m.

[32] FLIR (2020), ITS Camera Talk document

automatic incident detection.[33,34] The design guidelines from 2017 did not need to be retrospectively applied but demonstrated good practice.

Tunnel safety driver awareness

1.90 The Bus Industry Confederation (BIC) developed the *Bus Fire Evacuation Protocol Advisory*[35] to assist bus and coach operators to respond to fires. The advisory included a section on bus fires in tunnels and noted:

> Evacuating a bus within a tunnel is a high-risk event in that it is highly likely that the passengers and driver will be affected by smoke. Therefore, if a bus does experience a fire situation when travelling within a tunnel, the driver's focus should be to exit the tunnel before stopping and evacuating the bus. This may not always be possible and if not, then the driver needs to consider the locations of emergency exits within the tunnel and locate the bus so that passengers can reach the tunnel emergency exit.

1.91 The Advisory included a 12-step evacuation protocol for drivers to learn and practice evacuating a bus (*Appendix 3: Evacuation protocol*). The protocol included the advice to avoid stopping in tunnels if possible, and if they have to stop in a tunnel, to try and stop before emergency exit door (cross-passage or longitudinal egress passage).[36] The Advisory was general in nature and required operators and drivers to adapt their response as appropriate for the route were operating.

1.92 The Transport for NSW (TfNSW) *Road User Handbook*[37] contained the following information for tunnels:

- If you break down in a tunnel:
    - pull over to the breakdown bay or the side of the lane
    - turn on your hazard lights
    - stay in your vehicle
    - wait for help to arrive (major tunnels are constantly monitored).

Other than breakdowns, there were no details within the *Road User Handbook*, *Heavy Vehicle Driver Handbook*[38] or *Hazard Perception Handbook*[39] for how road users were to respond to incidents or emergencies within tunnels. The information relating to breakdowns in tunnels assumed that drivers could remain in a vehicle. Furthermore, they did not provide information for how other motorists were to respond if they encountered an emergency or fire in a tunnel.

[33] Transport for NSW (2017), Smart motorway design guide, Traffic monitoring and surveillance

[34] Transport for NSW (2017), Smart motorway design guide, Tunnel traffic monitoring

[35] Bus Industry Confederation Inc (2019), Bus Fire Evacuation Protocol Advisory

[36] Bus Industry Confederation Inc (2019), Bus Fire Evacuation Protocol Advisory

[37] Transport for NSW (2022), Road User Handbook

[38] Transport for NSW (2021), Heavy Vehicle Driver Handbook

[39] Transport for NSW (2021), Hazard Perception Handbook

1.93 Austroads and the World Road Association both recommended that professional drivers receive training so that they understand how to respond to emergency situations in tunnels.[40,41]

1.94 The World Road Association, *Recommendations regarding Road Tunnel Drivers' Training and Information*[42] included details for checks drivers should perform prior to entering a tunnel and how to respond to fires:

- When approaching a tunnel, the driver must check for any dashboard warnings or fault indicators and ensure they have sufficient fuel.
- In case of fire or smoke coming from your own vehicle switch on hazard lights and try to drive out of the tunnel if possible. If you have to stop, try and stop near an emergency station as they contain an emergency telephone.
- In case of fire or smoke coming from another vehicle behind you, drive out of the tunnel. Raise the alarm when you have exited the tunnel by using an emergency telephone.
- In case of fire or smoke coming from another vehicle ahead, stop your vehicle, turn off your engine, switch on your hazard warning lights and leave your vehicle and exit the tunnel by the nearest emergency exit.

The material contained some information directing persons to self-evacuate where there was a fire on another vehicle, that information may not be appropriate and could increase the risk. The material did provide further information for drivers to follow the instructions of the tunnel operator during emergencies for their own safety.

Similar occurrences

1.95 A study of fires within Australian major road tunnels was undertaken by Austroads for the period between August 1992 and June 2016.[43] In this period, there were 78 fire incidents with no reported bus fires. The data set for this study relied on information provided by tunnel operators and may not have included all incidents.

1.96 While not contained in the Austroads data, there has been one instance of a bus fire in a tunnel reported to OTSI between 2005 and 2016. On 1 March 2016, Sydney Buses bus MO1668 was travelling east through the LCT when a passing motorist alerted the driver of a smoke at the rear of the bus. The bus stopped in a breakdown bay and the driver observed two small fires at the rear of the bus. The fire was extinguished by the tunnel Incident Response Crew prior to the arrival of Fire and Rescue NSW. Bus MO1668 was not fitted with an EBFSS at the time of the fire and there was relatively minor damage.

1.97 Transurban reported that there were no vehicle fires within the LCT in the five years leading up to the occurrence.

[40] Austroads (2018), Guide to Road Tunnels Part 3: Operations and Maintenance, AGRT03-18

[41] World Road Association PIARC (2011), Recommendations regarding Road Tunnel Drivers' Training and Information, Technical Committee C4 Road Tunnel Operation, 2011R04, Paris, France.

[42] World Road Association PIARC (2011), Recommendations regarding Road Tunnel Drivers' Training and Information, Technical Committee C4 Road Tunnel Operation, 2011R04, Paris, France.

[43] Austroads (2019), Fire Incident and Fire Safety Operational Data for Major Australian Road Tunnels, AP T341-19

Part 2 — Analysis

Introduction

2.1 The investigation focused on the factors that contributed to the fire, emergency training and response procedures for the bus and tunnel operator, and detection of traffic incidents in tunnels.

Examination of the bus

2.2 Based on observations and review of CCTV, the fire was first visible on the nearside of the bus, before the bus entered Lane Cove Tunnel (LCT). Glowing then became visible along the roadway on both sides of the bus as it continued.

2.3 Inspection of the bus showed that the fire started on the nearside of the engine bay before spreading from the engine bay, as the aluminium sheeting above the engine was unable to contain the fire. The deluge system likely prevented the spread of the fire to the front of the bus, which was heat affected but not damaged by fire.

2.4 The engine bay was significantly damaged due to the intensity and duration of the fire (Figure 9). The bus burnt from at least 2011:33 until around 2045 when the deluge system was turned off.

2.5 On the nearside of the engine, coolant pipework and the hydraulically driven cooling fan were positioned. While the engine was running, both systems and associated fluids of coolant and hydraulic oil were pressurised. Any leaks of either oil or coolant near a hot surface or other source of ignition can cause a fire. The cooling fan would possibly blow a fluid leak on the nearside across the engine bay exhaust and turbocharger (Figure 9).

2.6 Inspection of the hydraulic fan motor and pipework found that it was heat affected with damage to the flexible hydraulic hosing although there were with no obvious signs of a high-pressure leak. The investigation could not eliminate the possibility of a leak at a fitting or seal.

2.7 Post incident, there was no hydraulic oil in the reservoir for the hydraulic cooling fan or coolant remaining. Both systems were affected by the fire, and it was not possible to determine if they have leaked due to fire damage or been consumed by the fire.

2.8 There was no high amperage electrical wiring on the nearside of the engine bay. Inspection of the electrical wiring on the offside did not identify any arcing or short circuits. The starter motor and battery cables were damaged in the fire but there was no arcing or spalling on the cables.

2.9 It is extremely unlikely that the source of the fire was a fuel leak (diesel) or electrical fault in the engine bay as the bus operated, while on fire, for at least two minutes, with no reported or observable loss of power. Furthermore, an oil leak from the engine was unlikely to have initiated a fire as the oil was near full after the fire, with approximately 35-38 L remaining.

2.10 Due to the extent of the damage, it was not possible to determine the source of the fuel that initiated the fire beyond either hydraulic oil or coolant. The ignition source was likely a hot surface (turbocharger or exhaust) as there were no other significant heat sources near the fire initiation point.

Figure 9: Bus m/o9340 fire damage

Source: OTSI

Fire detection and suppression

2.11 The EBFSS was confirmed to have discharged as the burst disc on the bottom of the agent tank had ruptured.

2.12 The EBFSS was inspected on 26/05/2021 and the Forrex agent tank was overhauled on 08/09/2021. There were no records of faults that suggested the system discharged at a time other than during the occurrence.

2.13 The effectiveness of EBFSS depends on the capacity of the system and size of the fire but will not suppress all fires and may not prevent the re-ignition of a fire. The EBFSS was an important device to alarm the operator that there may be a fire. The system was designed to discharge a fire suppressant to inhibit a developing fire which allows evacuation time for passengers and operators. The time of discharge and effectiveness of the system fitted to bus m/o9340 could not be assessed with the evidence available.

2.14 The driver reported that they did not see or hear any alarms and were observing the speedometer once within the tunnel. The engine fire alarm light was near the speedometer if it was activated (Figure 6). The on-board CCTV did not record audio and there was no vision of the dashboard to confirm if a warning light or audible alarm was present.

2.15 Post incident testing confirmed that both the audible and visual indicator functioned when the dashboard from bus m/o9340 was installed in another bus. If the wiring was intact between the engine bay and the dashboard, the discharge of the system should have provided an alert to the driver.

2.16 The three Scania engine bay fire sensors, if activated, would have provided the driver with the same alert as the discharge of the EBFSS. As the sensors were in series, the activation of any one sensor should trigger the alarm circuit. The functionality of the system at the time of the fire could not be determined, although there was no maintenance regime to ensure the on-going functionality of the sensors.

Bus driver actions and response

2.17 The driver had operated the same bus for the duration of their shift and were on their third westbound trip through the LCT. They reported there were no alarms, or faults and the bus was driving normally.

2.18 The glow visible on the roadway and flames could be seen externally from the recorded CCTV (rearward facing camera) on the bus. From the driver's seat this may have been able to be seen earlier in the nearside mirror, however, in the absence of a fault or trigger to specifically observe this area, this could be missed. Once in the tunnel, the driver appeared to monitor their speed and did not look towards the nearside mirror.

2.19 When alerted by the passenger to the fire, the driver quickly looked to the bus's nearside mirror, before leaning back in their seat to look again. The driver then immediately pulled over to stop in Lane 1, just past the breakdown bay. In response to the fire, the driver generally responded as they had been trained and assessed and stopped in the left-hand lane.

2.20 Once stopped, the driver opened the door and activated the battery isolation (master) switch on the dashboard to isolate the power from the batteries. The driver did not alert the OCC or emergency services but reported they were focused on getting everyone off the bus and trying to put out the fire.

2.21 The driver did not identify or advise the passengers of an evacuation point, as required by Hillsbus' evacuation procedure (Figure 4). Although the location identified in the procedure would not have been safe in this instance if they had advised passengers of an evacuation point. The driver observed all passengers exit the bus before accessing the fire extinguisher from inside the bus and attempting to extinguish the fire.

2.22 After unsuccessfully extinguishing the fire, the driver returned to the bus and collected their bag before walking in the same direction as the passengers. The driver advised they later contacted the bus depot by mobile, while walking in the tunnel, to report the incident.

Passengers' response

2.23 The passengers evacuated from the bus without receiving information or being guided by the bus driver to a place of safety in the tunnel. The 14 adult passengers began walking or running in a westerly direction, with the flow of traffic.

2.24 Some passengers reported that they followed what others were doing, heard audio broadcasts, and saw signage in the tunnel. One passenger reported seeing the cross-passages but were prevented from accessing the evacuation points due to passing vehicles and reduced visibility in smoke.

2.25 There were no injuries but CCTV footage identified several occasions where vehicles drove past, very close to the passengers in Lane 1, with restricted visibility due to smoke from the fire.

2.26 It was initially reported by FRNSW that four passengers were found in a cross-passage but there was no available evidence to confirm this report. It was determined that all passengers were evacuated from the tunnel by passing motorists and another bus, with some passengers walking up to 400 m before they were picked up. During that time, they were exposed to smoke and passing traffic.

2.27 It is almost certain that the passengers were unaware of the fire and life safety systems within the tunnel including that ventilation operated in the direction of traffic.

Hillsbus training and procedures

Driver fire safety

2.28 Hillsbus had three different types of EBFSS fitted to their fleet. The associated training material Hillsbus provided their drivers focused on the indicator and fault panel for the Firestorm EBFSS. The two other systems fitted to their fleet provided the drivers with different alerts and warnings but were not included in the training material or assessment.

2.29 Hillsbus reported that the three systems functioned in a similar manner and the operator's focus was on the requirement for drivers to contact the Operations Control Centre (OCC) and follow their instructions.

Before contacting the OCC, drivers would need to identify there was an alarm/issue that warranted them contacting the OCC. The two-way radio and duress system fitted to the bus would not operate once within the tunnel as the radio signal was blocked by the tunnel structure. The driver did not contact the OCC or activate the duress system in response to the incident – although activating the duress system would not have alerted the OCC of the incident.

2.30 EBFSS are a safety critical system designed to suppress a fire and alert drivers, giving them more time to evacuate the bus. It is essential that drivers identify and respond to fire alarms appropriately and as quickly as possible, to provide passengers with the best opportunity to evacuate safely.

2.31 The driver of bus m/o9340 had not been provided training, by Hillsbus, for the specific design of EBFSS fitted to the bus. This may have reduced the likelihood the involved driver would have detected and responded appropriately if the system discharged. Furthermore, Hillsbus had stopped refresher training due to COVID-19 and it had been 925 days since the driver completed fire safety training, when refresher training was normally provided annually.

Emergencies and evacuations in tunnels

2.32 The emergency evacuation procedures in the operator's driver training detailed the steps the driver needed to take to evacuate a bus (Figure 4). The driver was to locate a safe point to evacuate which must be 150 m away from the bus and away from traffic. The driver's assessed response (Figure 5) for an incident requiring an evacuation within the LCT was the same response for an incident occurring on a surface road.

2.33 Hillsbus advised that the emergency evacuation scenarios were assessed as per the State Transit Authority (STA) training video delivered as part of the training. The information contained within the STA video depicted that the emergency exits were on the left-hand side of the tunnel. The training material was generic and would not have ensured that drivers knew how to identify safety equipment in the tunnel, or how to get passengers to a place of safety when an exit was not on the left-hand side of a tunnel.

2.34 While a smoke event within the tunnel had been included in the training, the appropriateness of the scenario and required response had not been developed with input or review from the tunnel operator.

The specifics of the LCT, including the locations of the breakdown bays, motorist emergency telephones, cross-passages and ventilation, was not considered as part of the operator's driver training. Furthermore, Hillsbus did not have defined marking or competency criteria to assess the trainee's response to the emergency scenarios. While the driver trainers were qualified heavy vehicle driving instructors, there was limited information available to them to support their awareness for tunnels.

2.35 Tunnels pose a unique risk, and each tunnel can be different and require a different response in an emergency. Fires within tunnels are an emergency, and Hillsbus did not identify the specific risks associated with LCT evacuations and incorporate controls into their training and procedures including the fire and life safety equipment in tunnels.

2.36 Once in the tunnel bus drivers were not able to report incidents to the OCC as the buses two-way radio and duress system did not function, requiring drivers to either use their mobile or locate a motorist emergency telephone (MET). Both required the bus to stop and the safe stopping locations in the LCT to safely access a MET or how to identify the MET locations, were not included in the training.

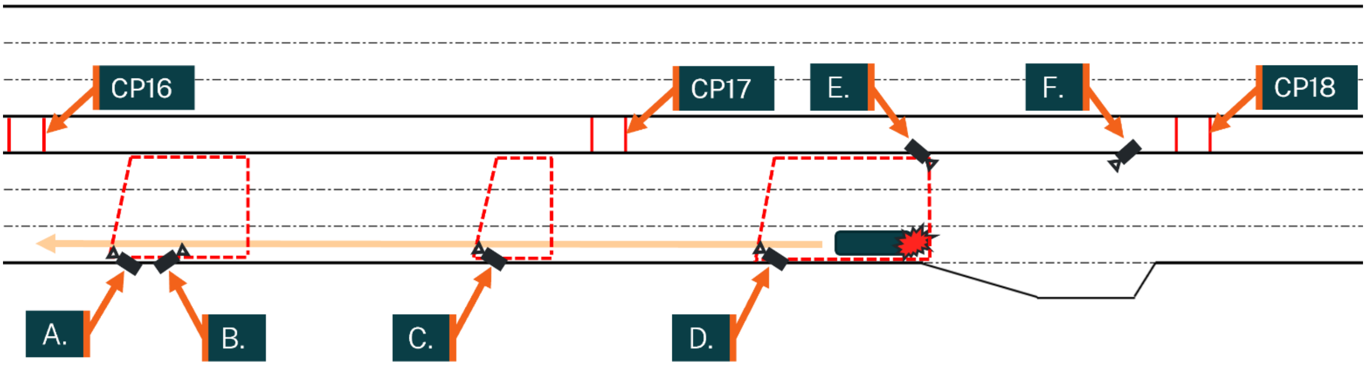
Tunnel response

Automatic incident detection

2.37 The configuration of the CCTV within the tunnel provided visual coverage for the entire tunnel, although, it was found there was not the same coverage for the automatic visual incident detection system (AVIDS). Traffic events could occur between the AVIDS detection zones along the tunnel without the TCROs being alerted to the incident. The detection blind spots for the Westbound tunnel between cross-passage 16 and 18 are shown in Figure 10. Based on the configuration and positioning of the cameras used for the AVIDS, it is likely that there were similar detection blind spots along both tunnels.

2.38 Where an incident occurred in a detection blind spot, it required manual detection by the TCROs to respond. The time to manually detect incidents could vary and relied on the TCRO either being alerted to a secondary incident or observing the incident on the CCTV displays (Figure 7) in the Motorway Control Centre (MCC).

Figure 10: Westbound tunnel with camera locations and detection blind spots



Legend:		Camera name:	
	Camera and direction	A. TVR745	D. TVR747
	Detection blind spot	B. TVF748	E. TVF551
	Pedestrian direction	C. TVR746	F. TVR549

The diagram (not to scale) shows the stopping location of the bus and movement of the pedestrians relative to the camera positioning and cross-passages (CP). The approximate detection zone blind spots are shown for the section of the westbound tunnel between CP16 and CP18 which was over a distance of about 240 m. The forward-facing cameras B and E did not have AVIDS capabilities.
Source: OTSI

2.39 Bus m/o9340 travelled about 1500 m into the tunnel while on fire before stopping at 2013:45. The passengers quickly evacuated the bus, and both the passengers and bus were visible on the CCTV in the tunnel. The stopped bus, while visible on camera TVR549 (Figure 10 – F), was outside the stopped vehicle detection zone for the AVIDS (Figure 11). As such, there was no stopped vehicle alert automatically generated by the system to alert the TCROs, delaying their initial response to the fire.

2.40 The stopped bus was also visible from camera TVF748 (Figure 10 – B), however there was no AVIDS set up for that camera. If AVIDS had been set up for that camera, the stopped bus would likely have been out of range of the design detection zone and in this event, smoke quickly obscured the view of the bus. Transurban reported that there was probably no AVIDS for camera TVF748 as there was an overlap with camera TVR746 (Figure 10 – C).

2.41 Had the bus stopped within a detection zone, it is probable that the TCRO's would have been alerted to the bus and fire after about 15 seconds. Instead, the stopped bus and fire was not detected for almost 3 minutes.

Figure 11: Bus stopping location and stopped vehicle detection zone

The upper image shows the bus stopped in the tunnel as seen from camera TVR549. The lower image shows the stopped vehicle detection zones with the stopped bus overlaid on the image.
Source: Transurban, modified and annotated by OTSI

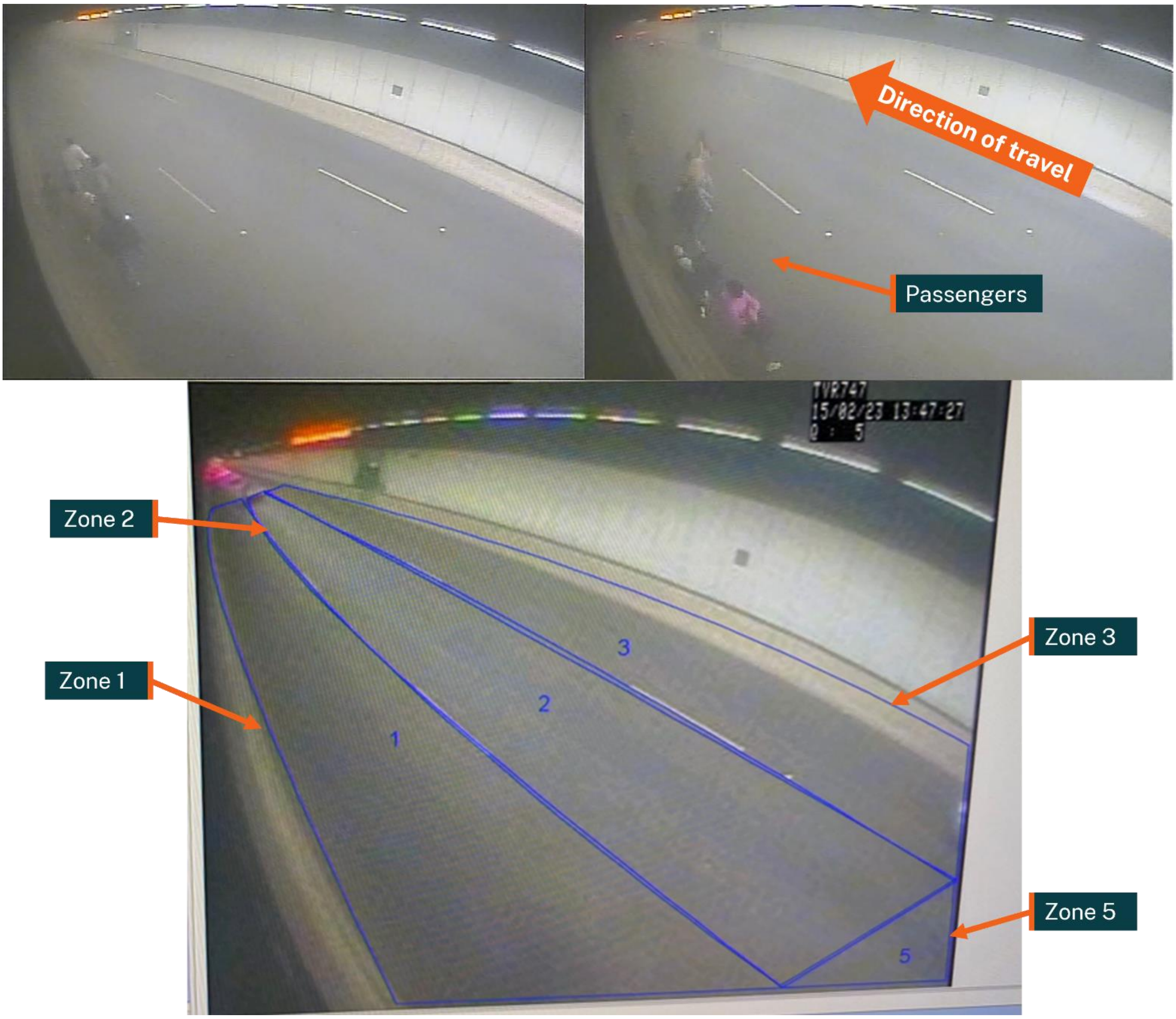
2.42 The passengers were visible walking in Lane 1 within the detection zone for camera TVR747 (Figure 10 – D and Figure 12) but there were no alerts generated for the pedestrians. Camera

TVR747 was the first camera the passengers travelled past after leaving the bus, and Transurban personnel reported they would have expected the system to have provided an alert.

2.43 It is likely that the pedestrians were not detected by the AVIDS for camera TVR747 due to combination of factors (Figure 12):

- The video quality for the camera TVR747 was less than camera TVR746 that detected some pedestrians about 30 seconds later (Figure 13). The system had the ability to provide camera quality ratings, although the quality rating at the time of the occurrence is not known. Post incident the camera was found to have reduced image quality of 5 out of 10.
- Smoke from the fire was visible and can affect the detection capabilities of the AVIDS which relies on differences and changes in pixels between video frames.
- The detection of pedestrians requires their feet to be visible in the frame and where multiple persons are moving closely it would be more difficult for the system to detect the individual pedestrians. Additionally, objects larger than 2 m are not considered as pedestrians and the multiple persons likely appeared larger than the threshold for pedestrians.

Figure 12: Pedestrian movements and pedestrian detection zone



The upper images shows the pedestrians that were not initially detected as seen from camera TVR747 with the lower image showing the pedestrian detection zone for the camera.
Source: Transurban, modified and annotated by OTSI

Figure 13: Camera image comparison between TVR746 and TVR747

The image on the left shows the recorded video from camera TVR746 prior to the fire compared to image on the right for camera TVR747 at the same time.
Source: Transurban, annotated by OTSI

2.44 The passengers initially visible in camera TVR746 initially did not trigger an alert, with several people running through the detection zone in close proximity to one another. The alert for the pedestrians was triggered at 2014:29, 44 seconds after the bus stopped when a single passenger walked through the detection zone (Figure 3) which alerted the TCRO.

Traffic Control Room Officers response

2.45 The pedestrians were detected once a single pedestrian walked past a second camera (TVR746) and travelled an additional 60 m west.

2.46 The TCROs response to the alert for pedestrians in the tunnel was to implement a traffic management plan (TMP) closing Lane 1. The procedures and checklists for responding to prohibited users (pedestrians) provided clear steps for the TCRO to manage the incident. These included closing lanes, using public address (PA) to provide instructions to the road users, and dispatching the Incident Response Crews (IRC) or police if necessary. The TCRO was to monitor and update the TMP as needed to protect the pedestrians.

2.47 The TCROs detected the burning bus, after searching the tunnel with the CCTV, and updated their response to manage the fire. They manually deployed the deluge system above the fire from the fire panel at 2016:52 and implemented an uncongested fire plan. A second deluge zone was activated at 2023:55, as the fire flared up. The deluge operated for almost 29 minutes and was effective at preventing the spread of the fire. There was no significant damage to the tunnel and westbound tunnel re-opened about 7 hours after the fire.

2.48 The procedures and checklists for responding to fires provided the TCRO with relevant information to manage the incident while recognising that each incident was different and required a tailored response.

2.49 The closure of incident and non-incident tunnels prevented further vehicles entering the tunnels but relied on drivers responding to the signs and traffic signals and stop.

2.50 Although authorised to order an evacuation of the tunnel, it was not required by Transurban's emergency response procedures, nor was it requested by FRNSW in response to the fire.

Audio broadcast and signage

2.51 The audio broadcasts (PA and RRB) associated with the incident related to the fire plan provided information to the motorists once the plan was initiated about 3 minutes after the bus stopped. The first broadcast advised the deluge may be used, while the second instructed drivers to stop if they could see the incident ahead of them.

2.52 Research by the World Road Association suggests that some drivers will attempt to driver past a fire or major incident in the tunnel underestimating the risks involved.[44] Given the potential for drivers continuing past a fire, the delay to advise drivers to stop increased the likelihood they would continue driving. Once the deluge was activated 15 vehicles (13 cars, one bus, and one taxi) drove through the deluge before traffic stopped.

[44] World Road Association PIARC (2011), Recommendations regarding Road Tunnel Drivers' Training and Information, Technical Committee C4 Road Tunnel Operation, 2011R04, Paris, France.

2.53 There were no audio broadcasts to alert the motorists of the pedestrians or to communicate information to the pedestrians to the assist with their evacuation.

2.54 The variable message signs (VMS) in the tunnel scrolled through four messages with one that advised motorists to switch off their engines. The VMS outside the tunnel advised motorists that the tunnel was closed but motorists needed to detect and respond before the TCROs could close the tunnel.

Safety actions taken

OTSI

2.55 On 25 November 2022, OTSI published a Bus Safety Advisory '*SA05/22 Bus fire safety and emergency incidents in tunnels safety advisory*' (*Appendix 2: OTSI Safety Advisory SA05/22*).

The key points for bus and tunnel operators were to assess the risks and controls (as per their Safety Management System) in place for tunnel transit, operations, and emergency evacuation operations for their specific bus fleet, specified passenger transit routes and tunnels being transited.

All bus and coach operators should:

- Ensure driver training covers all makes and models of EBFSS fitted across the fleet of buses in operation. Drivers and trainers should be aware of how all safety critical systems alert the driver and what pre-conditions have been met when the system is activated/discharged in an emergency.
- Review internal emergency tunnel procedures for any tunnel being transited as part of a passenger service. Different tunnels require different emergency evacuation procedures and have different evacuation routes and methods.
- For buses or coaches that do not have an EBFSS fitted, consider the items above and how they relate to the services provided when operated in tunnels.

Additionally, bus operators and tunnel operators should seek opportunities to engage one another to ensure specific tunnel evacuation and emergency procedures are incorporated into driver training programs. Careful consideration should be given to the factors in Appendix 1 - Tunnel Fire and Life Safety Systems and Equipment.

Transport for NSW

2.56 Transport for NSW (TfNSW) advised they had taken several safety actions in response to this incident and the investigation findings including:

- Reviewed the Bus Fire and Emergency Procedures for various operating environments including suburban areas, multi lane roads, bridges, tunnels, interchanges and in depots.
- Requested each bus operator who operates through Lane Cove Tunnel, M2 Tunnel and Eastern Distributor to provide their current bus fire and emergency procedures, for managing incidents occurring in the operating environments above.

- Required operators of scheduled bus services operating through tunnels to submit revised emergency management procedures that aligned with tunnel and infrastructure operators' procedures and with the Emergency Services agencies. Operators fire and emergency procedures were expected to include concise instructions to drivers addressing:
    - Communications to passengers and operations control
    - Safe parking of the bus
    - Energy and electrical shut down instructions; and
    - Evacuation and safety of passengers.
- Arranging for bus and tunnel operators to review each other's emergency management plans and consult on any revision and standardisation of the plans, including ensuring relevant contact details are provided.
- While noting there was some information within the NSW Road Users Handbook, TfNSW would expand their safety communications material for bus operators.

Part 3 — Findings

From the evidence available, the following findings are made with respect to bus m/09340 entering the Lane Cove Tunnel, NSW while on fire on 14 April 2022.

Contributory factors

3.1 Bus m/o9340 entered the westbound Lane Cove Tunnel with an active fire in the bus engine bay area, before the driver was aware of the fire. The driver subsequently stopped the bus in the tunnel after being alerted by a passenger of the fire.

3.2 A leak of either hydraulic oil or coolant was likely ignited by a hot surface on the nearside of the engine bay. The fire spread from the engine bay destroying the bus.

Other safety factors

3.3 The passengers evacuated the bus into the tunnel and travelled west while the driver tried unsuccessfully to extinguish the fire. Travelling west exposed the passengers to the smoke as the tunnel ventilation operated in the direction of traffic flow. Additionally, the passengers and driver were at risk of being stuck by passing motorists with reduced visibility as a result of smoke from the fire.

3.4 Hillsbus' training for engine bay fire suppression systems did not provide the drivers with information for all the systems fitted to their fleet likely reducing the ability for drivers to detect and respond to alerts and alarms. The driver of bus m/o9340 had not been trained in the system fitted to the bus.

3.5 Hillsbus' emergency evacuation training and procedures did not effectively manage the risks associated with evacuations in tunnels and had not considered the fire and life systems safety systems in tunnels.

3.6 The initial response to the fire and pedestrians in the tunnel was delayed as the design and configuration of the cameras for the Lane Cove Tunnel automatic visual Incident detection system (AVIDS) provided reduced coverage for the automatic detection of incidents. In this instance, the bus stopped between detection zones and the first camera the pedestrians walked past did not detect their presence. The pedestrians were likely not detected earlier due to the camera video quality, smoke, and the movements of multiple pedestrians walking closely together.

Other key findings

3.7 The Traffic Control Room Officers (TCROs) were automatically alerted to pedestrians in the tunnel by the automatic visual incident detection system (AVIDS), after the pedestrians walked past a second camera. The TCROs began to initiate a traffic management plan to protect the pedestrians before manually detecting the burning bus via closed circuit television. They updated their response and implemented a fire response plan and deployed the deluge system in accordance with the Lane Cove Tunnel procedures.

3.8 The engine bay fire suppression system fitted to the bus discharged at time unknown. While the dashboard alarms were functional on the bus post incident, it could not be determined if they provided an alarm to the driver at the time of discharge.

Part 4 — Recommendations

Noting that some remedial safety action has already been implemented, it is recommended that the following additional safety actions be undertaken as outlined below.

Hillsbus Co Pty Ltd

4.1 Review driver training to ensure drivers receive training on the indicators for an impending breakdown and emergency evacuation scenarios, aligned to appropriately assessed responses.

4.2 Review driver emergency evacuation training and procedures to ensure that information relevant to fire and life safety systems in tunnels is provided to drivers to enhance response to emergencies in tunnels. The review should consider the risks and required response by drivers for emergencies on their bus and include how they should evacuate passengers to a safe place if needed, as well as responding to emergencies involving other vehicles in tunnels.

Transurban

4.3 Review the configuration and effectiveness of the automatic visual incident detection system for the Lane Cove Tunnel to determine if enhancements can be made to ensure the automatic detection of incidents.

Transport for NSW

4.4 Facilitate coordination between tunnel operators and TfNSW accredited bus operators to develop and implement updated emergency procedures and preparedness arrangements.

Part 5 — Glossary

Auto-ignition	The lowest temperature at which a combustible material ignites in air without a spark or flame. NFPA Glossary
AVIDS	Automatic visual incident detection system
Boiling point	The temperature at which the vapor pressure of a liquid equals the surrounding atmospheric pressure. NFPA Glossary
CDC	ComfortDelGro Australia
Combustible liquid	Any liquid that has a closed-cup flash point at or above 37.8°C. (NFPA Glossary)
EBFSS	Engine bay fire suppression system
Flammable liquid	Any liquid having a closed-cup flash point below 37.8°C. (NFPA Glossary)
Flash point	The minimum temperature at which, under specified test conditions, a substance emits sufficient flammable gas to ignite momentarily on application of an ignition source. AS2484.1-1990
FRNSW	Fire and Rescue NSW
HVAC	Heating ventilation and air conditioning
IRC	Incident Response Crew
MET	Motorist emergency telephone
MCC	Motorway Control Centre
MMS	Moveable median strip
OCC	Operations Control Centre
OEM	Original equipment manufacturer
OMCS	Operations management control system
rpm	Revolutions per minute
TCROs	Traffic Control Room Officers
TMCS	Traffic management control system

Part 6 — Appendices

Appendix 1: Sources, submissions and acknowledgements

Sources of information

- the driver of bus m/o9340
- Armitage Group Pty Ltd
- Hillsbus Co Pty Ltd
- Transurban
- Transport for NSW
- Fire and Rescue NSW.

References

Australian Standard (2016), AS5062:2016, Fire protection for mobile and transportable equipment

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CDC NSW (2019), Emergency Evacuation Driver Training, Information Guide, 2019_4995, 30 September 2019

CDC NSW (2019), Emergency Evacuation Driver Training, Pocket Book, 2019_4995, 30 September 2019

FLIR (2013), VIP-T Setup Guide

FLIR (2020), ITS Camera Talk document

Traficon (2010), VIP-T Specifications

Transport for NSW (2017), Smart motorway design guide, Traffic monitoring and surveillance

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Transport for NSW (2021), Hazard Perception Handbook

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Transurban (2021), Incident Response Plan, LCT-OI-PL-1, 3 November 2021

World Road Association PIARC (2011), Recommendations regarding Road Tunnel Drivers' Training and Information, Technical Committee C4 Road Tunnel Operation, 2011R04, Paris, France. Available at: https://www.piarc.org/en/order-library/11377-en-

Recommendations%20regarding%20road%20tunnel%20drivers-%20training%20and%20information

World Road Association PAIRC (2019), Road Tunnels Manual, Glossary. Available at https://tunnelsmanual.piarc.org/en/glossary

Submissions

The Chief Investigator forwarded a copy of the Draft Report to the Directly Involved Parties (DIPs) to provide them with the opportunity to contribute to the compilation of the Final Report by verifying the factual information, scrutinising the analysis, findings and recommendations, and to submit recommendations for amendments to the Draft Report that they believed would enhance the accuracy, logic, integrity and resilience of the Investigation Report. The following DIPs were invited to make submissions on the Draft Report:

- the driver of bus m/o9340
- Armitage Group Pty Ltd
- Hillsbus Co Pty Ltd
- National Heavy Vehicle Regulator
- Transport for NSW
- Transurban.

Submissions were received from the following DIPs:

- Hillsbus Co Pty Ltd
- National Heavy Vehicle Regulator
- Transport for NSW
- Transurban.

The Chief Investigator considered all representations made by DIPs and responded to the author of each of the submissions advising which of their recommended amendments would be incorporated in the final report, and those that would not. Where any recommended amendment was excluded, the reasons for doing so were explained.

Appendix 2: OTSI Safety Advisory SA05/22

Office of Transport
Safety Investigations

Safety Advisory SA05/22

Bus fire safety and emergency incidents in tunnels

The incident

The Office of Transport Safety Investigations (OTSI) is investigating a bus fire which occurred in the Lane Cove Tunnel on 14 April 2022. The bus was a Scania K94UB and was fitted with an Engine Bay Fire Suppression System (EBFSS). The EBFSS was installed by the Original Equipment Manufacturer (OEM) when the bus was delivered in 2007. The system provides an audible alarm and illuminates a light on the driver's dashboard if a fire is detected and the system discharged.

While the specific circumstances of this incident and contributing factors are still under investigation, OTSI has confirmed the fire started in the bus engine bay at approximately 2011[1] and continued to burn prior to the bus entering the tunnel at 2012. The driver was unaware of the fire until alerted by a passenger on the bus. The bus came to a stop in the tunnel just before 2014. All passengers evacuated the bus safely and walked within the tunnel to evacuate the area while the driver attempted to extinguish the fire.

The initial evacuation from the bus was completed safely and efficiently but once outside the bus, the passengers were left to manage their own evacuation of the area while remaining clear of smoke and attempting to evade other hazards such as passing motor vehicles. All passengers were picked up by passing vehicles including private cars, an ambulance and another bus.

A total of 78 vehicles (private motor vehicles and passenger buses) passed the burning bus prior to the tunnel being shut down and traffic flow stopped. Some vehicles drove through the activated tunnel deluge zone[2] which further restricted visibility due to deluge water and smoke in the vicinity of the incident.

Key points for operators

Bus and tunnel operators are reminded to assess the risks and controls (as per their Safety Management System) in place for tunnel transit, operations, and emergency evacuation operations for their specific bus fleet, specified passenger transit routes and tunnels being transited.

All **bus and coach operators** should:

- Ensure driver training covers all makes and models of EBFSS fitted across the fleet of buses in operation. Drivers and trainers should be aware of how all safety critical systems alert the driver and what pre-conditions have been met when the system is activated/discharged in an emergency.

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1 Times shown in 24-hour time as Australian Eastern Standard Time (AEST).
2 The deluge zone refers to the fixed fire suppression system fitted in the Lane Cove Tunnel.

- Review internal emergency tunnel procedures for any tunnel being transited as part of a passenger service. Different tunnels require different emergency evacuation procedures and have different evacuation routes and methods.

- For buses or coaches that do not have an EBFSS fitted, consider the items above and how they relate to the services provided when operated in tunnels.

Additionally, bus operators and tunnel operators should seek opportunities to engage one another to ensure specific tunnel evacuation and emergency procedures are incorporated into driver training programs. Careful consideration should be given to the factors in *Appendix 1 - Tunnel Fire and Life Safety Systems and Equipment.*

Transport for NSW (TfNSW) will coordinate with tunnel operators and bus contractors to facilitate the updating of emergency procedures and preparedness arrangements.

Safety message

The initial OTSI investigation findings highlight that bus operators and drivers must ensure they understand the evacuation procedures for any tunnel being transited as part of their passenger service as they are likely to be different for each tunnel. While evacuations within tunnels are rare, they present a potentially high consequence risk.

Bus and tunnel operators are encouraged to remain engaged with each other to understand changes in tunnel operations and to conduct appropriate education or training sessions to ensure passenger safety is maintained for the incidents in a tunnel.

For further information contact: Transport.Safety@otsi.nsw.gov.au

Appendix 1 - Tunnel Fire and Life Safety Systems and Equipment

- Longer tunnels are monitored and controlled 24 hours a day and have several different fire and life safety systems:
    - Closed circuit television (CCTV) and traffic monitoring equipment
    - Electronic signage for traffic control and speed changes
    - Radio re-broadcast system and public address system
    - Emergency cabinets including:
        - emergency telephone to contact the control room
        - fire extinguishers and hoses
    - Ventilation systems
    - Emergency exits or cross-passages
    - Fixed deluge fire suppression systems that can be operated automatically or manually.
- Shorter tunnels may not be continuously monitored and may have less equipment and capability to respond to emergency situations.

Considerations

- Depending on the location of the incident or fire, it may be safer to drive out of the tunnel before stopping.

- Ventilation within tunnels typically operates in the direction of traffic flow which can carry smoke and other hazardous gases forward of a stopped vehicle.

- The location of emergency exits and/or cross passaged can be in either the left-hand or right-hand lane depending on the tunnel and could be difficult to access.

- Cross-passages connect the two tunnels as an escape route but exiting into the other tunnel should only occur once it is safe. Follow the instructions, signage, and announcements of tunnel operators.

- Emergency telephones are located along the length of the tunnel and in emergency breakdown bays. The emergency telephones may be in the left-hand or right-hand lane depending on the tunnel and could be difficult to access.

- The duress and radio communications systems on the bus may not function within tunnels. Use of emergency telephones and mobiles may be required, however, mobiles may not reliably function.

- Drivers must observe and obey signage and instructions broadcast within the tunnel during emergencies. The deluge system may operate and if activated it is not recommended to drive through as visibility is affected and the condition of the road ahead cannot be confirmed.

- The information within the Bus Industry Confederation *Bus Fire Evacuation Protocol Advisory* and accompanying STA evacuation video may not be appropriate in all tunnels and suggests emergency exits and cross-passages are on the left-hand side when they could be on either side or in the middle between vehicle directional tunnels.[3]

[3] Bus Industry Confederation Inc (2019), Bus Fire Evacuation Protocol. Available at https://movingpeople.com.au/bus-fire-evac/

Appendix 3: Evacuation protocol

12-Step Evacuation Protocol for High Floor Bus or Coach

The following is a 12-step guide that provides a starting point for drivers to learn and practice bus evacuations. The time to practice evacuating a bus is long before a fire happens. The same holds true for a fire suppression system or fire extinguisher.

The time to learn to use this protocol is before the event when drivers have time to think about and integrate the learning process.

1. Pull over as quickly and safely as possible.
2. If possible avoid stopping in tunnels, interchanges, bus stations, outside service stations, schools, hospitals, congested areas or in the middle of an intersection.
3. If the fire is getting out of control, you will have to pull over immediately.
4. If you have to stop in a tunnel, try to stop before one of the emergency exit doors. This is so your passengers will not have to walk past the burning part of the bus to exit the tunnel.
5. Once stopped, apply the park brake, put the bus in neutral, and turn on your hazard lights, open the passenger doors and turn off the ignition and or battery isolated switch and activate any fuel isolation system if fitted.
6. Make an announcement over the intercom system and/ or by standing up and in a loud voice telling the group there is a problem and they need to:

> EXIT THE BUS VIA THE FRONT DOOR AS QUICKLY AS POSSIBLE....LEAVE ALL LUGGAGE....ASSIST ANYONE AROUND YOU.
>
> If the front door exit is blocked: THERE ARE EMERGENCY EXIT WINDOWS ON EITHER SIDE OF THE BUS...LIFT THE HAMMERS OUT AND SMASH THE GLASS, PUSH OUT THE BROKEN GLASS AND EXIT THE BUS, HELP OTHERS...LEAVE ALL LUGGAGE.

7. Drivers should assist with the evacuation by not being in the doorway but either assist passengers (from the driver's area) or at the base of the door step(s) assisting and directing passengers to the safest spot to gather (preferably 200 m away from the bus).
8. If passengers are attempting to exit via the emergency windows, anyone outside of the bus who is able should be asked to help those using the emergency window exits. (The driver should be trained in how the height of the bus and weight of the windows may be difficult to manage and practice using the windows). The driver should ask for passenger(s) assistance with the evacuation via emergency windows.
9. The driver should assist every passenger out of the bus to the best of their ability and not exit the bus until the evacuation is complete (within reason of the circumstances).
10. The driver should continue to make the announcement as noted in point 6 throughout the evacuation because people in the back, people sleeping, hard of hearing or disabled may not recognise the danger.
11. If there are disabled passengers, generally there is not time to use the lift so "lift and carry" may be an option if you engage other passengers. (Drivers should have some training on the best methods of "lift and carry" if there is a lift door on the bus and it is operable, the driver should open it as soon as possible because it provides another means of escape).
12. Move passengers away from the bus to the safest available location, contact the bus depot and or emergency services.

> ONLY ONCE THE PASSENGERS ARE SAFELY AWAY, AND IT IS SAFE TO DO SO, SHOULD YOU TRY TO EXTINGUISH THE FIRE, BUT NEVER OPEN ANY HATCHES TO ACCESS THE FIRE EFFECTED AREA.

About the Office of Transport Safety Investigations

The Office of Transport Safety Investigations (OTSI) is the independent transport safety investigator for NSW.

The role of OTSI is to improve safety and enhance public confidence in the safety of the NSW transport network through:

- independent investigation of transport incidents and accidents
- identifying system-wide safety issues and their contributing factors
- sharing safety lessons and making recommendations or highlighting actions that transport operators, regulators and other stakeholders can take to improve the safety of bus, ferry and rail passenger and rail freight services.

OTSI is empowered under the *Transport Administration Act 1988* to investigate rail, bus, and ferry accidents and incidents in accordance with the provisions of the *Passenger Transport Act 1990* and *Marine Safety Act 1998*. It also conducts rail investigations under the provisions of the *Transport Safety Investigation Act 2003* (Cth) and a Collaboration Agreement with the Australian Transport Safety Bureau (ATSB).

The aim of an OTSI investigation is to enhance transport safety by sharing safety lessons and insights with those organisations that can implement actions to improve safety. OTSI uses a 'no-blame' approach to identify and understand contributing safety factors and underlying issues. It does not assign fault or determine liability in relation to the matters it investigates.

An OTSI investigation is independent of any investigation or inquiry that a regulator, NSW Police or the Coroner may undertake. Evidence obtained through an OTSI investigation cannot be used in any criminal or civil proceedings. While information gathered by OTSI in the conduct of its work is protected, the Chief Investigator, under the *Transport Administration Act 1988*, may disclose information if they think it is necessary for the safe operation of a transport service.

OTSI is not able to investigate all transport safety incidents and accidents or matters that are reported. The Chief Investigator focuses the agency's resources on those investigations considered most likely to enhance bus, ferry or rail safety by providing new safety lessons and insights that may be shared.

Many accidents result from individual human or technical errors which do not involve safety systems so investigating these in detail may not be justified. In such cases, OTSI will not generally attend the scene, conduct an in-depth investigation, or produce an extensive report.

OTSI may request additional information from operators or review their investigation reports which may lead to several activities, such as the release of a Safety Advisory or Alert to raise industry awareness of safety issues for action.

OTSI investigators normally seek to obtain information cooperatively when conducting an investigation. However, where it is necessary to do so, OTSI investigators may exercise statutory powers to conduct interviews, enter premises and examine and retain physical and documentary evidence.

Publication of the investigation report

OTSI produces a written report on every investigation for the Minister for Transport, as required under section 46BBA of the *Passenger Transport Act 1990*.

Investigation reports strive to reflect OTSI's balanced approach to the investigation, explaining what happened and why in a fair and unbiased manner. All Directly Involved Parties in the investigation are given the opportunity to comment on the draft investigation report.

The final investigation report will be provided to the Minister for tabling in both Houses of the NSW Parliament in accordance with section 46D of the *Passenger Transport Act 1990*. The Minister is required to table the report within seven days of receiving it.

Following tabling, the report is published on the OTSI website — www.otsi.nsw.gov.au — and information on the safety lessons promoted to relevant stakeholders.

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