OCI Office of the Chief Investigator Transport Safety

Collision of truck with school bus

Exford Road, Exford, Victoria on 16 May 2023

OCI Transport Safety Investigation Report

Bus Occurrence Investigation
BUS/23-809
Final – 08 December 2025

Cover photo: Victoria Police

This investigation was conducted under the *Transport (Compliance & Miscellaneous) Act 1983* (Vic) by the Office of the Chief Investigator (OCI).

OCI is the operating office of Victoria's Chief Investigator, Transport Safety, a statutory position under Part 7 of the *Transport Integration Act 2010* (Vic). The object of the position is to seek to improve transport safety by providing for the independent no blame investigation of transport safety matters consistent with the vision statement and the transport system objectives. The primary focus of an investigation is to determine what factors caused the incident, rather than apportion blame for the incident, and to identify issues that may require review, monitoring or further consideration.

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Addendum

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Executive summary

What happened

At about 1539 on 16 May 2023, a school bus carrying 45 students from Exford Primary School was struck from behind by a tipper truck towing a dog trailer. The truck and trailer were not loaded at the time. The bus had exited the primary school onto Exford Road and, after traveling west for about 800 m, began to turn right into Murphys Road when it was impacted by the truck. The truck had commenced braking but could not stop in the distance available.

The truck's collision with the bus caused the bus to yaw in a clockwise direction and roll onto its left side shattering the left side glazing. Many of the children were injured including 9 who suffered serious injuries requiring hospitalisation. Several other students and the bus driver suffered minor to moderate injuries requiring medical attention either onsite or at medical facilities. The truck driver was not physically injured.

What was found

It was concluded that the driver of the truck did not immediately identify that the bus ahead was slowing to turn right onto Murphys Road. This allowed the gap between the truck and bus to close before the brake application was made. This response by the driver of the truck was probably influenced by an expectation that the bus was continuing straight along Exford Road (not turning) and attentional disengagement or distraction from the driving task.

At the Murphys Road intersection, Exford Road was a sealed-surface single carriageway with a lane in each direction. For westbound vehicles turning right at Murphys Road, following vehicles would either need to wait behind the turning vehicle, or pass on the unsealed road shoulder. Although this configuration was not uncommon, research showed that this type of 'T' intersection had a significantly higher risk of rear-end collision compared to a channelised right-turn arrangement. Comparison of post-incident peak traffic data with Austroads guidelines and probable further increases in traffic volumes in this growth corridor, suggested that changing this intersection to a channelised right turn should be considered.

Post-incident brake testing of the truck and trailer by the National Heavy Vehicle Regulator (NHVR) found a reduced braking performance and a braking imbalance on some axles. This was probably the result of insufficient brake condition monitoring and maintenance between major services. Although failing aspects of the post-incident brake testing, the measured total dynamic deceleration of the truck and trailer was above the minimum required by regulation.

Although seatbelt usage was high, many serious injuries were sustained by children when the bus rolled onto its side. The following pertain to the potential enhancement of the Australian Design Rules for bus occupant protection.

- The torso of a passenger occupying a window seat will move towards the window if that side of the bus impacts the ground during rollover. When the upper anchorage of the seatbelt sash is located at the passenger's shoulder away from the window, research indicated that the torso may then slide out of the sash and towards the window. Many buses have the window seat upper seatbelt anchorage located at the passenger's shoulder away from the window. There was an opportunity to review the requirements for sash anchorage location on buses.
- Bus seatbelts are not optimised to accommodate small body sizes of children. Research has demonstrated reduced rates of injury where seatbelts are adjusted to correctly fit vehicle occupants. Design options have been identified that incorporate features which enable simple adjustments to accommodate different body sizes.
- The side windows of the school bus were not retained during the rollover increasing the potential for partial and full passenger ejection. International research has demonstrated the potential for bus glazing standards that increase the likelihood of window retention.

What has been done as a result

Melton City Council advised that it has commenced a project to construct a channelised right turn treatment for the Exford / Murphys road intersection.

The planned reconfiguration of the intersection was intended to increase the visual prominence of the intersection through the implementation of dedicated turn lanes, enhanced lighting, and clearer signage. The road surface would be rejuvenated with a new, wider pavement and a surface intended to improve skid resistance. Furthermore, the turn lanes would incorporate a wider sealed reserve, providing additional space for turning vehicles outside of through lane traffic.

The council believed this will provide a solution which surpasses the road safety audit recommendation.

The Commonwealth department responsible for the Australian Design Rules advised that a Bus Safety Working Group has been established which brings together industry and government experts to consider options to improve bus safety.

The Victorian Department of Transport and Planning advised that they have raised the bus design issues highlighted in this report at national vehicle safety forums in February 2025 attended by industry and government experts. Further work towards adopting the findings and proposals into future standards was being progressed by the department through the National Bus Safety Working Group.

The Victorian Department of Transport and Planning also acknowledged that route design can influence the safety risks associated with a school bus route. They will consider developing guidance on route risk assessment, including approaches used in other jurisdictions.

Contents

The occurrence

Prior to the incident

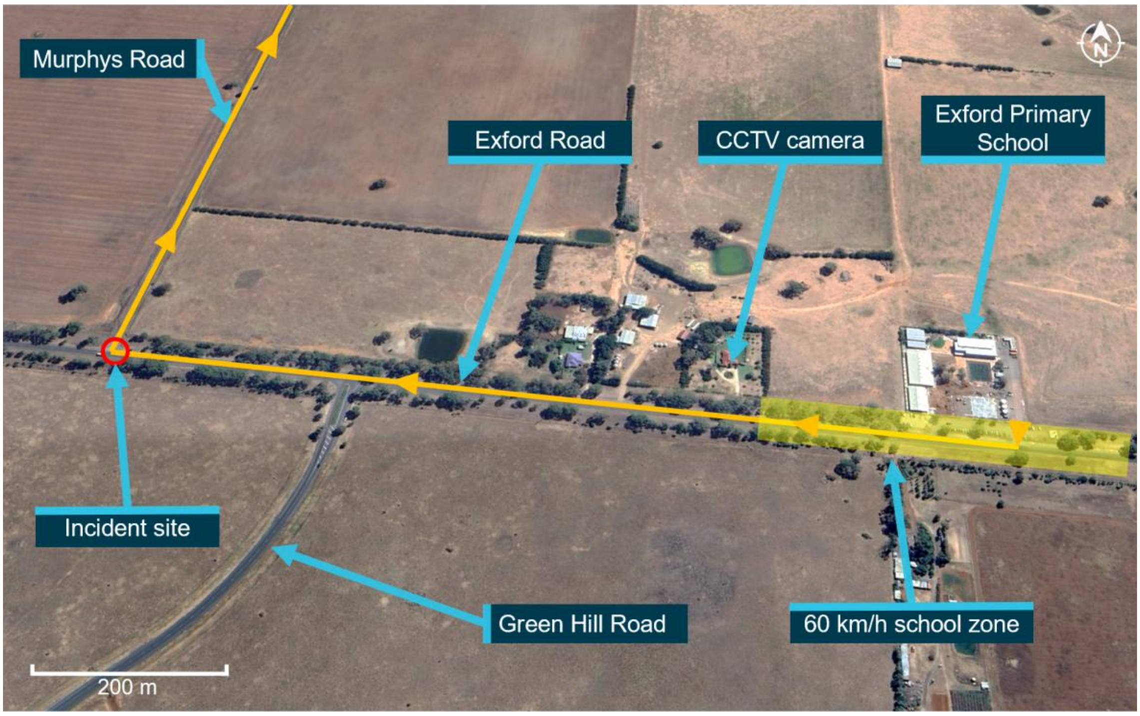
On the afternoon of 16 May 2023, a tipper truck towing a trailer departed a construction site in Kensington at about 1400 local time. The driver had delivered a load of crushed rock to the site, their last scheduled delivery on that day. Both the truck and trailer were empty on departure.

After leaving Kensington, the driver was returning to their home in Moorabool Shire located west of Melbourne. Their route home took them through Exford, a distance of about 37 km from Kensington.

At around 1520, a school bus operated by Christian's Bus Company arrived at Exford Primary School in Exford. The bus was scheduled for the after-school drop-off run, returning students home. The students commenced boarding the bus at about 1530 local time. Once the students were onboard, the bus driver reported checking students were wearing their seatbelts before departing. Onboard the bus were 45 students.

The intended student drop-off route commenced as shown in Figure 1.

Figure 1: The school bus route leaving school



Source: Google Earth Pro annotated by the Office of the Chief Investigator

The incident

At about 1537, the school bus departed the school turning right from the driveway onto Exford Road through a 60 km/h school zone. The restricted zone speed was active in the afternoon from 1430 to 1600 local time. Beyond the school zone, the speed limit increased to 80 km/h.

At the time the bus was on Exford Road opposite the school, the truck was about 110 m behind heading in the same direction. The truck driver reported that they were concentrating on vehicular and pedestrian traffic as they drove through the school zone. At that time of day, Exford Road was busy with parents picking up children from the school, workers returning home and heavy vehicles servicing local construction projects. CCTV footage indicated that when about 270 m from the school driveway and about 650 m from the Murphys road intersection, the bus and truck were travelling at about 70 km/h and their separation was about 5 s or 100 m.

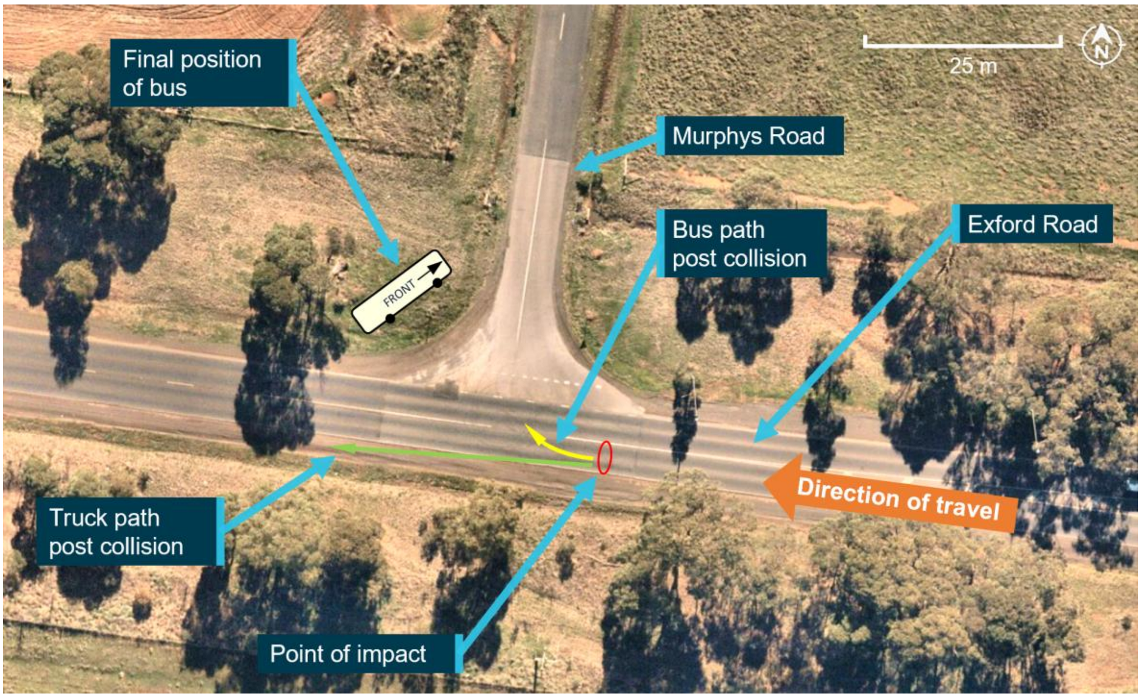
Green Hill Road is a side feeder road that intersected with Exford Road to the left about 250 m before the Murphys Road intersection. Traffic flow from the side road was controlled with a give way sign. The truck driver stated that as they neared the Greenhill Road intersection, a vehicle was approaching from this side road and that their attention was momentarily on the vehicle's movements to confirm its intention to give way.

The bus driver stated that they slowed the vehicle using the bus retarder[1] and service brakes in preparation for making a right turn and then switched on the right-turning indicator light. As the driver commenced the turn, they checked their side rear view mirror and saw that there was a truck behind them closing rapidly. They then attempted to increase the speed of the bus to take the turn.

The truck driver recalled that as the bus slowed, they observed the separation distance ahead closing so they took the foot off the accelerator. Soon thereafter they noticed that the separation distance had closed rapidly and applied the truck brakes. The driver stated that they saw the bus braking lights 'at the last minute' and noticed the bus rear right turning indicator light but could not stop the truck in time to avoid a collision.

At that point, the bus had commenced crossing the opposing lane, with its rear quarter section still in the west bound lane. With the truck brakes applied, it skidded for about 26 m before striking the rear of the bus causing it to yaw in a clockwise direction. The bus then rolled onto its left side and slid across the road surface onto a grass bank northwest of the intersection (Figure 2).

Figure 2: Collision location



Source: nearmap annotated by the Office of the Chief Investigator

A number of children were injured as a result of the bus rollover including 9 who suffered serious injuries requiring hospitalisation. The other students and the bus driver suffered minor to moderate injuries requiring medical attention. Some were transported to hospital for treatment and were released the same evening. The truck driver was not physically injured.

The bus sustained substantial impact damage to its rear engine bay with minor structural deformity as a result of rolling over. The left (near) side windscreen and all left side glazing had shattered due to impact with the road surface. The passengers were evacuated through either the

[1] A retarder is a device fitted to a bus to slow the vehicle down. It is commonly referred to as an 'auxiliary braking device' and is controlled by a switch on the vehicle dashboard and the vehicle brake pedal.

front windscreen, which was peeled back during the rescue, or through the two roof hatches (Figure 3).

Figure 3: Bus final resting position

Source: Victoria Police

The truck suffered impact damage to its front bonnet grill and bumper (Figure 4).

Figure 4: Truck and trailer front view

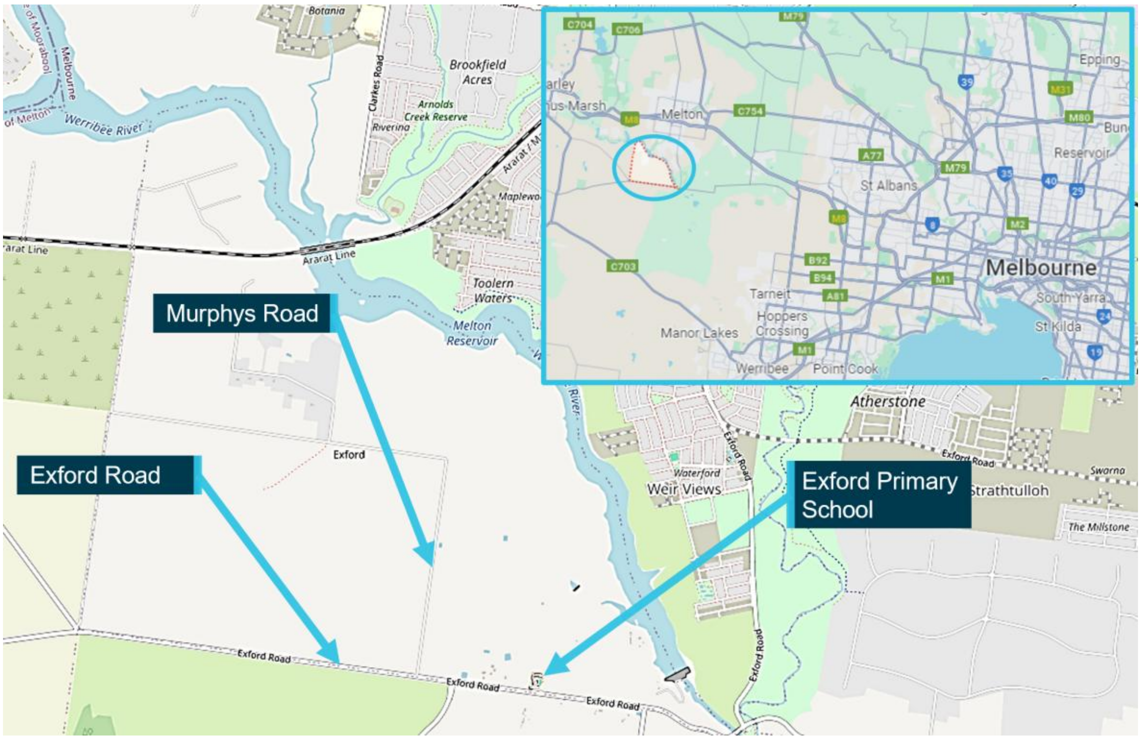
Source: Victoria Police

Context

The location

Exford was about 39 km west of Melbourne, located within the City of Melton local government area (Figure 5). The area was predominately rural with surrounding residential suburbs in Melbourne's West Growth Corridor. The City of Melton's road network spanned over 1450 km.[2]

Figure 5: Location of Exford west of Melbourne



Source: OpenStreetMap and Google Maps annotated by the Office of the Chief Investigator

Exford primary school, on Exford Road, was situated on a 1.2 hectare site bordered by farmland and catered for between 450 and 500 students. The school was set back about 30 m from the road with a gravel driveway outside the school used for parking the school buses during student drop off and pick up. Due to school construction works, the nature strip between Exford Road and the school driveway was used for car parking. The school driveway on Exford Road was about 900 m to the east of the intersection with Murphys Road.

Environmental conditions

Visibility was clear on the afternoon of the incident, with a partly cloudy sky and an average temperature of about 12ºC.[3] No rainfall had been recorded on that afternoon and the road surface was dry.

At the time of the incident the sun was low in the sky, about 16º above the horizon. It was positioned at an azimuth of 310º, which meant it was in front of the bus and truck drivers and 32º to their right as they drove towards Murphys Road intersection. The driver of the truck and other witnesses stated that the sunlight was intermittently shining through the trees on their right side as they neared the intersection.

[2] Rural Interface and Growth Area Road Upgrade Strategy (RIGARUS), Melton City Council. Draft dated July 2024.
[3] Recorded at private weather station IMELTO18 located 2.3 km NW of the incident. Source: Weather Underground.

The road

Road infrastructure

Exford Road, between Exford Primary School and beyond the intersection with Murphys Road, was a sealed bi-directional undivided carriageway with a typical sealed width of 7 m. The road ran in a predominantly east-west direction. This section of road is mainly rural, with farmhouses set back from the road. The reserve between the road and the farm fences was treed on both sides of the road.

Murphys Road was a side road that ran in a predominantly north-south direction and had a typical sealed width of 6 m. The approach to Murphys Road about 95 m east of the intersection is shown in Figure 6**.**

Figure 6: Exford Road approaching Murphys Road

Source: Google Street View annotated by the Office of the Chief Investigator

The road at the incident intersection consisted of a spray seal surface.[4] Although the road surface showed some signs of wear, there were no obvious significant defects. The road shoulder adjacent to the intersection with Murphys Road was unsealed with an average width of 2.5 m. The verge to the left of the shoulder was lined by small shrubs and trees with a road signage post and warning chevron sign opposite Murphys Road (Figure 7).

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4 A spray seal road surface consists of a single layer of bitumen that is sprayed as a hot liquid, which is immediately followed by the application of a single layer of crushed aggregate.

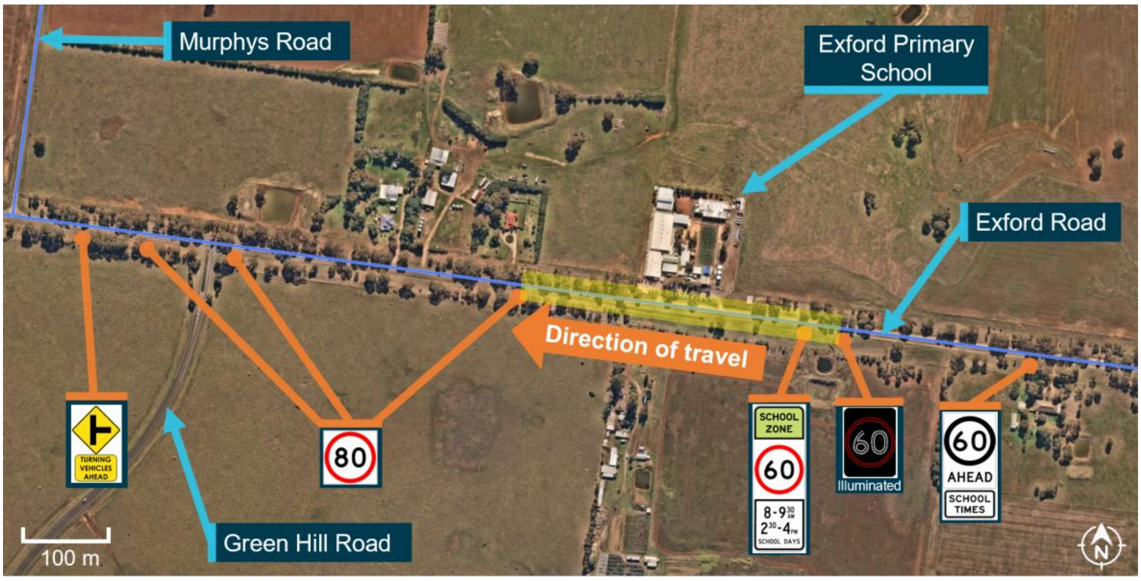
Figure 7: Murphys Road - Exford Road intersection

Source: Google Street View annotated by the Office of the Chief Investigator

Speed limits and signage

A 60 km/h school zone was active outside the school from 0800 to 0930 and 1430 to 1600. The zone spanned about 150 m either side of the school and was denoted by the standard school zone road signage and an illuminated speed sign on either end of the approach. An 80 km/h road speed limit applied either side of the zone. On the approach to the Murphys Road intersection, there was a right turn warning sign positioned about 95 m to the east on Exford Road (Figure 8).

Figure 8: Exford Road signage and school zone



Source: nearmap annotated by the Office of the Chief Investigator

Road design standards

Standards for new roads in Victoria were documented in the Austroads Guide to Road Design (AGRD).[5] In Victoria this guide was supplemented by Department of Transport and Planning (DTP) publications where the department believed there was a need to provide a local jurisdictional position or guidance, or the topic was not sufficiently covered in the Austroads Guides, or further clarification was required.

For existing road assets constructed to standards developed prior to the current guidelines, application of the AGRD and Victorian supplements may be employed during significant maintenance and improvement works projects.

Road management

Both Exford Road and Murphys Road were municipal roads managed by Melton City Council. Exford Road, between the primary school and the intersection with Green Hill Road, was classified as an interface road. Beyond this intersection, Exford Road and Murphys road were classified as rural roads.[6] [7] Both roads were subject to a City of Melton Road Management Plan (RMP)[8] which outlined the councils planned and reactive maintenance regime in compliance with the *Road Management Act 2004* (Vic).

Complementing the RMP, the Melton City Council had developed a draft Rural, Interface, and Growth Area Road Upgrade Strategy (RIGARUS). This draft strategy identified and prioritised various works and policy to be undertaken in the coming years to enable a safe and efficient transport network in the Melton growth corridor. The RIGARUS identified that 'rural roads are handling more traffic due to nearby developments, increasing maintenance, and posing safety risks'.

The draft strategy proposed that potential rural and interface road upgrades were to be prioritised based on existing and modelled traffic volumes, maintenance data, crash data and community feedback.

Crash history

Records from the DTP Road Crash Information System (RCIS) for an 8-year period indicated that there had been no major rear-end type collisions at the intersection of Exford Road and Murphys Road.

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5 The AGRD is a set of guidelines for road design which is published and regularly updated by the association of Australian and New Zealand road transport and traffic authorities (Austroads).

6 Figure 1, Rural Interface and Growth Area Road Upgrade Strategy (RIGARUS), Melton City Council. Draft, July 2024.

7 A rural road is defined as an isolated road with little to no through-traffic and low traffic volumes, typically surrounded by large farmland properties. An interface road is defined as a road in a rural environment being used more frequently by through traffic than a rural road.

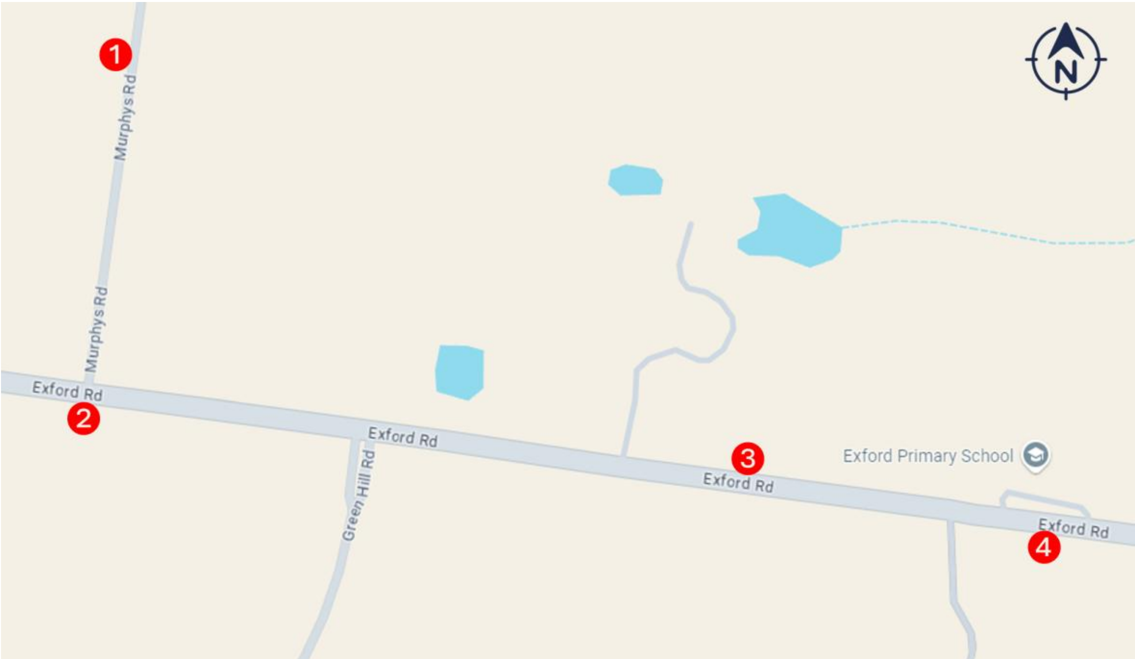
8 A road management plan was developed and published by the City of Melton municipality. Revision 4 of the plan was published 1 June 2021.

Traffic volume surveys

Traffic volume surveys were periodically conducted for Melton City council. Traffic data from 5 surveys of Exford Road and Murphys Road in the afternoon peak hour period from 1500 is summarised in Table 1. The collision occurred during the afternoon peak hour period.

Table 1: Surveyed vehicle volumes for afternoon peak period

Survey location	**Murphys Rd – northward (Vehicles / hr)**	**Exford Rd – westward (Vehicles / hr)**
Location 1 – surveyed 17 March 2020 (Murphys Road traffic count survey)	8	
Location 2 – surveyed 13 July 2023 (Exford / Murphys Road traffic turn survey)	8#	252
Location 3 – surveyed 03 May 2023 (Exford Road traffic through count survey)		297[9]
Location 4 – surveyed 13 July 2023 (Exford Road / Exford Primary School traffic turn survey)		324
Location 4 – surveyed 05 May 2024 (Exford Road traffic through count survey)		383



all vehicles were turning right from Exford Road.

Source: Melton City Council

[9] The afternoon peak total traffic volume on Exford Road (both directions) measured at location 2 in July 2023 was 527 vehicles/hr

This data indicated that the average number of vehicles per hour turning into Murphys Road from Exford Road during this period of surveys had not appeared to increase. The average traffic volume travelling west on Exford Road during the afternoon peak hour appeared to have increased from the survey point prior to the incident through to the latest data point in May 2024. This is believed to be consistent with the increased residential development in the area.

The surveys also determined the average traffic mix to be around 87% light vehicles, which were defined as vehicles up to 5.5 m in length.

Road *Safety Audits*

The Melton City Council Traffic and Transport Team planned for a Road Safety Audit (RSA)[10] to be carried out on 2 major road corridors each year. The audits were conducted by independent accredited[11] auditors as a proactive measure to identify potential road safety issues on existing road assets. Identified findings were presented to the council for review and further action where deemed necessary.

An existing conditions RSA was commissioned by Melton City Council for Exford Road in March 2023. This audit made a number of recommendations although no findings were made against the intersection of Exford Road and Murphys Road.

After the school bus collision incident in May 2023, a further existing conditions RSA was conducted with a site inspection in August 2023 that led to a final report in October 2023. For this audit the focus was narrower than the previous audit and covered only the intersection of Exford Road and Murphys Road where the incident occurred.

The audit made a number of findings and recommendations. Those with potential relevance to the incident are summarised below:

- The Exford Road pavement surface was flush (or worn). A recommendation was made to investigate the skid resistance of the pavement surface and resurface if necessary.
- The intersection was inconspicuous from the Exford Road approaches due to the roadside tree line at the verge of the road concealing the opening of the intersection. A recommendation was made to consider various physical and visual controls such as kerb installation and additional warning signage.
- The southern shoulder on Exford Road at the intersection was unsealed making it difficult for vehicles to pass to the left of vehicles turning right into Murphys Road. Roadside signage on the shoulder was also highlighted as a potential hazard to passing vehicles. A recommendation was made to consider widening Exford Road at the intersection, providing a right turn lane treatment and relocate signage.

The Melton City Council accepted these recommendations and advised that improvements works on the intersection addressing the findings were planned.

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[10] A road safety audit is an independent formal, robust technical assessment of road safety risks associated with road transport assets. They can be conducted on proposed or existing roads in line with the procedures set out in the Austroads Guide to Road Safety Part 6: Road Safety Audits (2022).

[11] In Victoria, Road Safety Auditors must be accredited and included in a list administered by the DTP.

The school bus

Bus type and configuration

The bus was built for Bacchus Marsh Coaches in February 2009 by Coach Design, a Brisbane based passenger coach manufacturer (Figure 9). It was operated by Christian's Bus Company who acquired Bacchus Marsh Coaches in 2019. Built on a Volvo B7R 2 axle chassis with a 6.4 m wheelbase, the high-floor bus measured 12.5 m in length and 2.4 m in width. The vehicle had a Gross Vehicle Mass[12] (GVM) of 18 t, although at the time of the incident the bus was not loaded to full capacity.

The transmission fitted to the bus incorporated a hydrodynamic retarder[13] that provided braking force supplementary to the service brakes. The retarder was energised via a switch on the driver console and engaged when the service brake pedal was depressed. The retarder was disengaged by either pressing the bus accelerator pedal or switching it off from the driver console. When the retarder alone was used to slow the bus the rear brake lights did not illuminate, nor were they required to.

Figure 9: Volvo B7R bus similar to the incident vehicle

Source: Wongm's Rail Gallery

It was configured with a 57-passenger seating capacity over 14 seating rows, each seat being fitted with a lap-sash retractable seatbelt.[14] The bus had 2 emergency double exit windows, 2 emergency exit roof hatches and a front service door that doubled as an emergency exit (Figure 10). The windscreen of the coach and most of the side glass panels were constructed from laminated automotive safety glazing.[15] The emergency exit window panels were constructed from tempered automotive safety glazing.[16]

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12 The maximum laden mass of a motor vehicle as specified by the manufacturer.

13 A hydrodynamic retarder helps control vehicle speed by using the viscous drag of a fluid to create braking force.

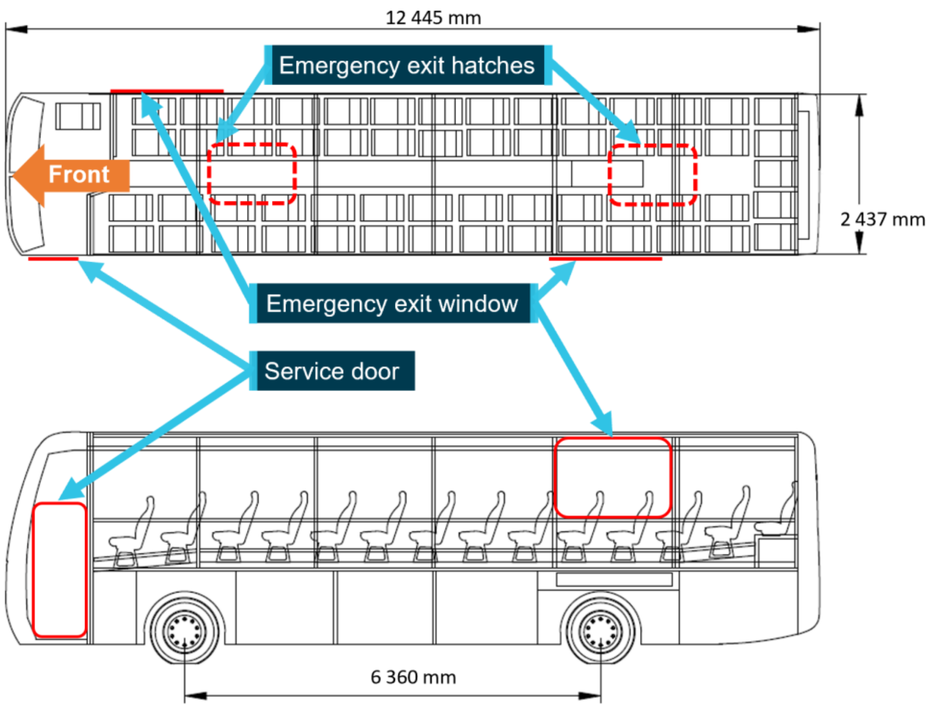
14 A lap-sash seatbelt is a seatbelt assembly combining a lap strap designed to provide pelvic restraint, and a torso strap designed to provide upper torso restraint.

15 Glazing consisting of two layers of glass held together by an interlayer of plastic material. The glazing was marked as compliant with AS/NZ 2080.

16 Glazing consisting of a single layer of glass which has been subjected to special treatment to increase its mechanical strength and to condition its fragmentation after shattering. The glazing was marked as compliant with ECE R 43.

The bus was contracted by the DTP under the School Bus Program (SBP) for student transport to and from Exford Primary school. Consistent with Victoria's road safety legislation[17], the SBP required the bus to be fitted with warning signs and high-mounted flashing warning lights at the front and rear which operated while the bus was stationary at bus stops.

Figure 10: Volvo B7R bus configuration



Source: Christians Bus Company, annotated by the Office of the Chief Investigator

Construction standards

At the time of its manufacture, the bus was required to comply with applicable national vehicle standards under the *Motor Vehicle Standards Act 1989* (the Act). Under the Act, the national standards known as the Australian Design Rules (ADRs), set out minimum design standards for vehicle safety, anti-theft and emissions.

The bus was constructed to comply with the applicable occupant protection requirements:

- ADR 59/00 -Standards for Omnibus Rollover Strength which specified the design requirements for bus superstructures to ensure that they withstand forces encountered in rollover crashes. This included the preservation of a 'survival space' to protect occupants from possible collapse of the passenger coach structure around them in the event of a roll-over.
- ADR 68/00 - Occupant Protection in Buses which specified the requirements for the provision of seatbelts and the strength of seatbelt anchorages, seat and seat-anchorage strength, and provisions for protecting occupants from impact with seat backs and accessories on the seat. Through this design rule, 3-point seatbelts became mandatory in eligible heavy omnibus category vehicles.[18]

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[17] Part 8, Division 18 - Road Safety (Vehicles) Regulations 2009.

[18] ADR 68/00 Occupant Protection in Buses did not apply to 'Route Service Omnibuses', or omnibuses with less than 17 'Seats' including the driver and crew, or vehicles in which all passenger 'Seats' have a 'Reference Height' of less than 1.0 m.

These standards were introduced progressively through to mid-1994. They formed the foundation of a safety package that significantly improved bus design for occupant protection.

Roadworthy and maintenance

The *Bus Safety Act 2009* (Vic)[19] required an annual safety inspection. The incident bus was last inspected and issued with a Bus Certificate of Roadworthiness on 28 March 2023 in accordance with regulation.

Maintenance records provided by the operator showed that the bus was regularly serviced with the last service performed just prior to the issue of the Bus Certificate of Roadworthiness.

Post incident inspection

The rollover led to plastic deformation of the bus structural roll hoops although with minimal intrusion into the passenger space. All glazing panels on the left side of the bus had fractured and separated from the bus frame due to contact with the road surface on rollover (Figure 11).

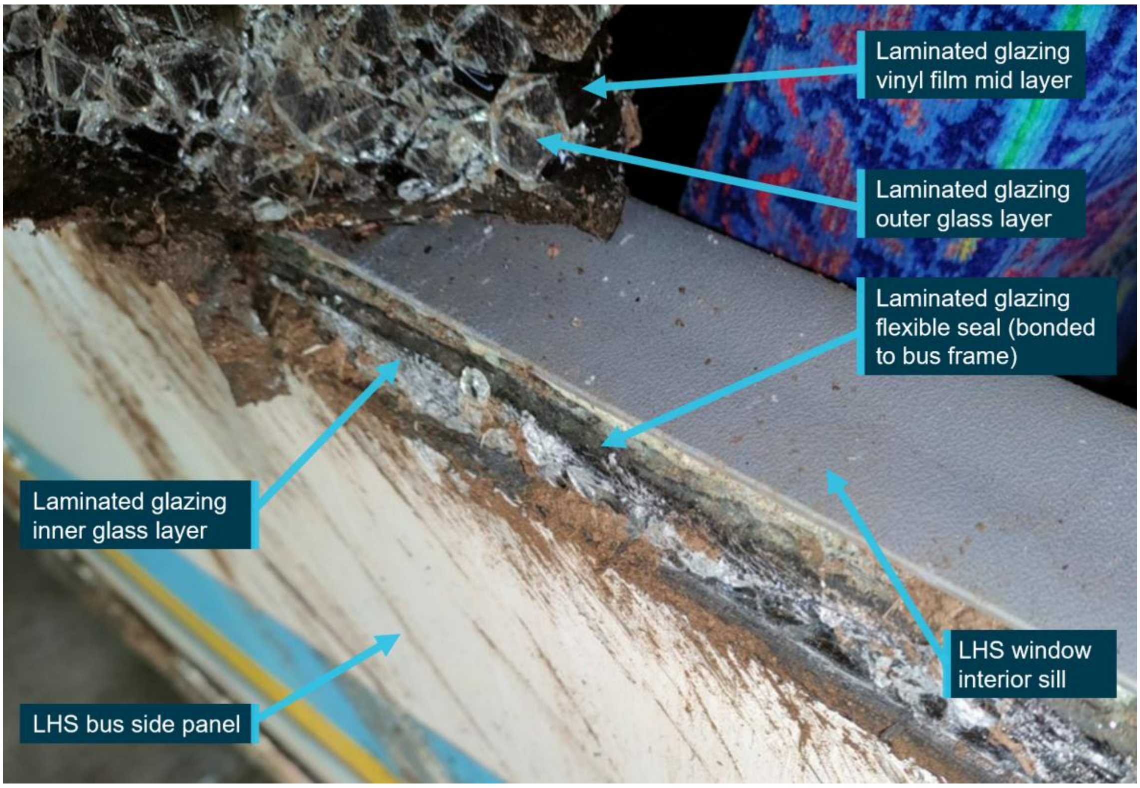
Inspection of the laminated side glazing remnants on the LHS of the bus indicated that the glazing had sheered from the flexible bonding strips once the inner layer of glass had fractured (Figure 12). There was no requirement in the current Australian Design Rules to ensure glazing remained intact in a bus roll-over type incident.

Figure 11: Damage to left side and rear of bus

Source: Victoria Police, annotated by the Office of the Chief Investigator

19 Division 3—Bus inspections and safety audits, *Bus Safety Act 2009*.

Figure 12: Side glazing fracture surfaces on the left side of the bus



Source: Office of the Chief Investigator

All glazing panels on the right side of the bus remained intact. The windscreen glazing on both sides had fractured and the left side windscreen bonding was separated from the frame as a result of passenger rescue (Figure 13).

Figure 13: Undamaged right side of bus

Source: Victoria Police, annotated by the Office of the Chief Investigator

The bus was fitted with a series of LED rear indicator and stop / tail lamps. The lamps were positioned on the rear of the bus in both the lower and upper rear corners (Figure 11). Post incident inspection of these lamps concluded that there was no evidence to suggest that they were not operational at the time of the incident.

All seats and seatbelts were inspected post incident. The seats and seat anchorages did not show any signs of significant deformation or separation. Most of the seatbelt assemblies were in an operable condition although a number were observed to have been damaged as a result of the crash and some had been cut during the extraction of the passengers at the incident scene.

School bus operations

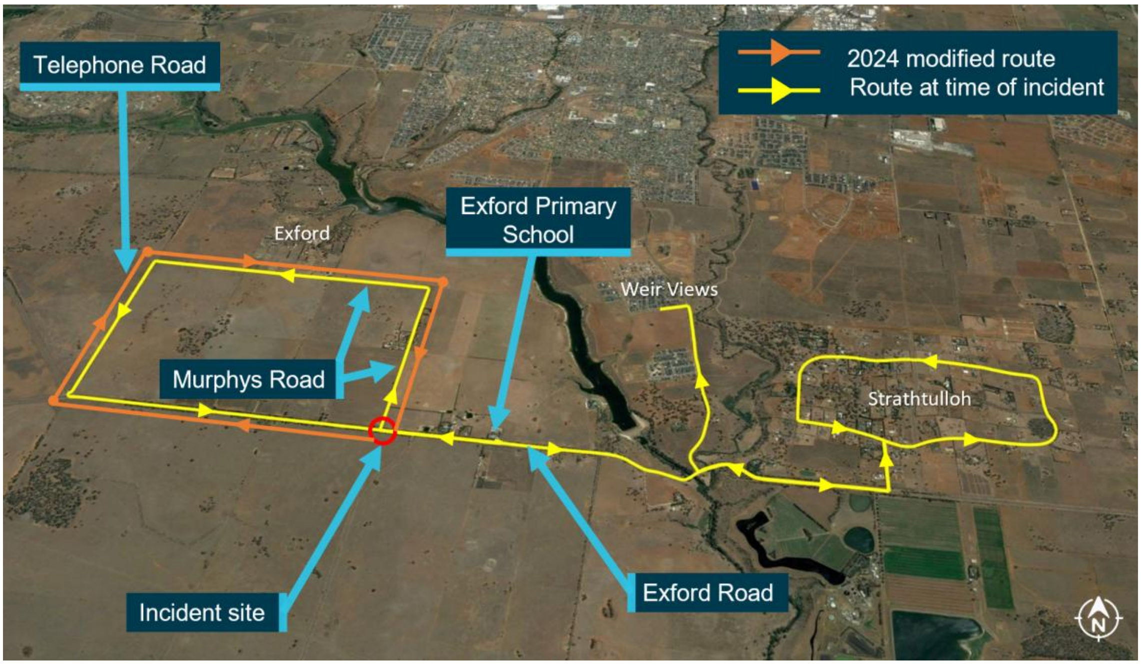
School bus program

The bus service transporting the Exford Primary School students was a state government service managed under the School Bus Program (SBP). The program operated in rural, regional and outer-suburban locations. Policy and procedures for the SBP were set and administered by the Department of Education (DE) and operationalised with the coordinating and client schools. Contracts with bus operators were managed by the DTP under the School Bus Service Contracts.

Under the SBP, school bus routes were typically developed by the bus operator in conjunction with the local coordinating school principal or their delegate. Services were designed around eligible students requiring bus transportation to and from school. The DTP and the DE were responsible for the final approval of the bus route.

The Exford Primary school bus route being operated on the day of the incident is depicted in Figure 14. This version of the route was approved by the DTP and the DE in January 2020 and included a student pick-up and drop-off location in Murphys Road.

Figure 14: School bus route



Source: Google Earth Pro annotated by the Office of the Chief Investigator

After the incident, the bus route was amended to remove the circuit around Murphys Road. This was because a pickup / drop-off point on Murphys Road was no longer required. In early 2024, the route was modified again to reinstate the Murphys Road circuit, but this time in a clockwise direction to avoid turning right at the incident intersection from Exford Road (Figure 14).

School bus specifications

The School Bus Service Contract for the school bus servicing Exford Primary School specified that the contract bus was to be maintained, equipped and operated to comply with all State's requirements relevant to the operation of a bus service. The regulations and act relevant to bus safety were:

- Bus Safety Regulations 2010.
- Road Safety (Vehicles) Regulations 2009.
- *Bus Safety Act 2009.*

Under the *Bus Safety Act 2009*, buses were required to comply with the requirements specified in the Australian Design Rules (ADRs) for a passenger omnibus. This therefore mandated minimum occupant protection standards and the fitting of seatbelts if the bus type was required to comply with ADR 68/00.

Seatbelt usage

The road rules in Victoria[20] specified that passengers 16 years old or older travelling in a motor vehicle must wear a seatbelt if the seating position has one. Drivers of motor vehicles, excluding bus drivers, must make sure that passengers under 16 years old are wearing a seatbelt or child restraint.

Under these rules, the driver of the school bus was not required to ensure that each passenger was wearing a seatbelt. However, the driver stated that they regularly reminded the school students to fasten their seatbelts when they entered the bus and on the afternoon service they would check to ensure all students had their seatbelts fastened prior to departure.

Exford Primary School had a procedure in place for the arrangement of students utilising the school bus transport services. For the afternoon drop-off service, this procedure included a requirement for a school staff member on bus duty to walk the bus aisle to confirm that all students have put their seatbelt on. The school bus would only depart once checks had been completed. These checks were typically done with the assistance of the bus driver. The process developed by the school was not required in any policy administered by the DE.

The bus driver stated that on the day of the incident they had checked that the students were wearing seatbelts prior to departing the school. Accounts from witnesses that were first on the scene of the incident described some passengers still suspended by their seatbelts and that a number of seatbelts were cut to aid their release.

The school bus driver

The bus driver was an employee of the bus operator since May 2006 driving various school bus routes, charter services and route service buses. They had been driving the Exford school bus route for the past 2 ½ years. They held an appropriate Victorian heavy vehicle driver's licence and a Driver Accreditation Certificate to operate the bus.

The driver typically drove the morning and afternoon school runs. In addition to the regular school runs, the company provided bus services for school excursions.

On the day of the incident, the bus driver reported to the bus depot at 0730 and after completing the bus pre-departure checks commenced the Exford Primary School pick-up run. Later that morning the driver drove the bus on a school excursion for Bacchus Marsh Primary School from 1050 to 1430. The scheduled Exford Primary School student drop-off run followed from 1430. This was a typical day for the driver with adequate breaks from driving duties for rest and meals during the day. There was no evidence to suggest the driver was fatigued.

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[20] Road Safety Road Rules 2017, Part 16—Rules for persons travelling in or on vehicles.

The school bus passengers

The passengers on the school bus were 45 students from Exford Primary school. They ranged in age from 5 to 11 years. As a result of the incident, 9 of the children suffered injuries that required hospital treatment. The remaining students either attended hospital for assessment and were not admitted or were assessed by paramedics at the incident site. Of the 9 children that suffered injuries requiring hospitalisation, a number were trapped inside the bus having been partially ejected with limbs entrapped underneath the bus structure as it lay on its left side. The bus driver suffered minor injuries.

Post incident inspection of the school bus indicated that all seatbelts that had not been cut during passenger extraction could be clipped into their buckles and retractors were functional. Although witness accounts recalled all passengers wearing seatbelts when the bus departed, it could not be ascertained that all were still wearing a seatbelt at the time of the incident.

The truck and trailer

Configuration

The truck and trailer configuration consisted of a 2010 model year Mack Superliner CLXT 6X4 Tipper 3 axle rigid truck towing a 2016 model year Maxitrans 4 axle dog trailer[21] with a tipper body. The combination length was about 20 m. At the time of the incident, both the truck and trailer were not carrying any load and the combination weighed about 19.5 tonne (Figure 15).

Figure 15: Truck trailer combination

Source: Office of the Chief Investigator. Vehicle mass data from the NHVR.

The tipper truck

The Mack Superliner tipper truck was owned and operated by L & J Cartage in Victoria. The vehicle was purchased by the company in 2018. Since purchase, the vehicle had not been issued with any defect notices and had not been required to undergo additional roadworthy certificate checks.

Damage sustained by the truck was consistent with a heavy frontal impact. The impact had deformed the front bumper had pushed the bonnet structure rearward impacting the driver side windscreen (Figure 16).

The brake system on the truck consisted of air activated drum brakes with standard actuators / chambers to the front axle and spring brake actuators / chambers to the rear axles.

The drum brake slack adjusters[22] fitted on all axles were grounded type automatic adjusting units which are designed to maintain proper brake lining-to-drum clearance during normal operation.

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21 Dog trailer: a trailer than has 1 axle group or a single axle at the front that is being steered by connection to a towing vehicle by a drawbar and 1 axle group or a single axle at the rear.

22 A slack adjuster is the mechanical lever linking the brake-chamber push rod to the brake activation shaft. An automatic slack adjuster is designed to automatically maintain proper brake lining-to-drum clearance during normal operation.

When operating correctly, they automatically adjust for brake lining wear. The brake linings on each of the drum units had sufficient friction material.

A visual inspection of the steering, suspension and tyre systems did not identify any pre-accident defects likely to have been relevant to the incident.

Figure 16: Mack tipper truck frontal damage

Source: Office of the Chief Investigator

The dog trailer

The Maxitrans 4-axle dog trailer (Figure 17) was also owned and operated by L & J Cartage. The trailer was purchased by the company in 2017 with a Victorian roadworthy certificate. In the 12 months prior to the incident, the trailer had not been issued with any defect notices and had not been required to undergo additional roadworthy certificate checks.

There was no visible damage to the trailer as a result of the collision.

The brake system on the trailer consisted of air activated drum brakes with standard actuators / chambers on the front axle and spring brake actuators / chambers on the rear axles. The slack adjusters fitted on all axles were linked-type automatic adjusting units. The brake linings on each of the drum units had sufficient friction material. The front axle left side brake lining retaining spring had dislodged rendering the brakes on this wheelset inoperative. An air leak was also reported from the regulator at the air reservoir tanks.

A visual inspection of the tow hitch coupling, suspension and tyre systems did not identify any pre-accident defects.

Figure 17: Maxitrans 4-axle dog trailer

Source: Office of the Chief Investigator

Vehicle maintenance

Records provided by the truck operator indicated that both the tipper truck and tipper trailer had been serviced by a heavy vehicle specialist maintenance service in Laverton. The tipper truck underwent a regular service at intervals around 20,000 km and the last general service was carried out 12 weeks prior to the incident. At the time of the incident, the truck had travelled 19,866 km since its last service.

Records for the trailer show that the last service carried out was 14 weeks prior to the incident. At that time, repairs had been carried out on the front axle brakes.

Between services, general truck and trailer mechanical checks were performed by the driver. This included general visual checks and greasing of driveline components.

Brake testing

After the initial brake system inspection, the tipper truck was connected to a compressed air supply[23] and tested in an unladen condition on a portable roller brake tester (RBT) operated by technicians from the National Heavy Vehicle Regulator (NHVR). Dynamic testing on the RBT was intended to verify the functionality of the truck braking system, measuring braking force and balance. Performance standards were specified by the Heavy Vehicle (Vehicle Standards) National Regulation[24] and the National Heavy Vehicle Inspection Manual (NHVIM).[25]

Testing of the truck found:

- axle 1 (front steer axle) met the requirements for balance and brake efficiency performance
- axle 2 had a measured brake imbalance, low service brake efficiency performance and an air leak from the left brake actuator

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23 Due to collision damage, the tipper truck engine was inoperable and could not supply compressed air to the brake system. To enable testing, an external compressed air supply was connected to the truck brake system.

24 Heavy Vehicle (Vehicle Standards) National Regulation as applied through the National Heavy Vehicle Inspection Manual (NHVIM).

25 National Heavy Vehicle Inspection Manual - Version 3.0 October 2021. © National Heavy Vehicle Regulator (2021).

- axle 3 had a measured brake imbalance.

The truck tests concluded that the brake system on some axles failed to meet both the minimum deceleration requirement[26] and the brake force balance requirement[27]. Despite the deficiencies measured on axles 2 and 3, the truck total dynamic deceleration was measured at 5.1 m/s^2 which exceeded the minimum required peak deceleration rate of 4.4 m/s^2 set by the standards.

The unladen dog trailer was then connected to a compressed air supply and tested in a similar manner on the RBT. Testing of the trailer found:

- axle 1 had a measured brake imbalance and low service brake efficiency performance
- axle 2 had a measured brake imbalance
- axle 3 met the requirements for balance and brake efficiency performance
- axle 4 met the requirements for balance and brake efficiency performance.

The trailer tests concluded that the brake system on some axles failed to meet both the minimum deceleration requirement and the brake force balance requirement: Despite the deficiencies measured on axles 1 and 2, the trailer total dynamic deceleration was measured at 5.1 m/s^2 which exceeded the minimum required peak deceleration rate of 4.4 m/s^2 set by the standards.

The truck driver

Licence and experience

The truck driver obtained their heavy vehicle driving licence in 2000, starting with medium rigid trucks and progressively upgrading to heavy rigid then heavy combination and tipper trucks. They were employed by L&J Cartage in 2005 and since then have been driving heavy combination vehicles similar to one they drove on the day of the incident.

The driver held a current Victorian heavy vehicle driver's licence appropriate for driving the heavy combination truck and trailer. They had been driving the incident vehicle for about three months prior to the collision with the school bus. Their route to and from work took them past the school. The driver stated that they did not typically drive past Exford primary school during school hours and they had no knowledge of the school bus route.

Fitness for duty

In the three months prior to the incident, the driver was engaged in carting crushed rock from a quarry in Bulla, Victoria, to a construction site in Kensington – a journey of about 25 km. They typically worked a Monday to Friday week, leaving home at about 0530 to be at the quarry by 0700 and completed work for the day by about 1530, arriving home at about 1700. Multiple runs between the quarry and the construction site were staggered during the day with down-time periods of up to an hour waiting to load and unload the tipper and trailer.

Interview evidence indicated that the truck driver had obtained adequate sleep on the night prior to the day of the collision. During the working day, they had not engaged in physically nor mentally demanding work. They reported having had regular breaks and had eaten and hydrated throughout the day. They had finished work early that day and reported feeling well and alert. There was no compelling evidence to indicate that the effects of fatigue were present either leading up to or at the time of the collision.

Tests conducted after the incident indicated that the driver did not have a level of alcohol or drugs in their system in contravention of the *Road Safety Act 1986*.

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26 Minimum average deceleration rate ≥ 2.8 m/s2 and a minimum peak deceleration rate ≥ 4.4 m/s2.

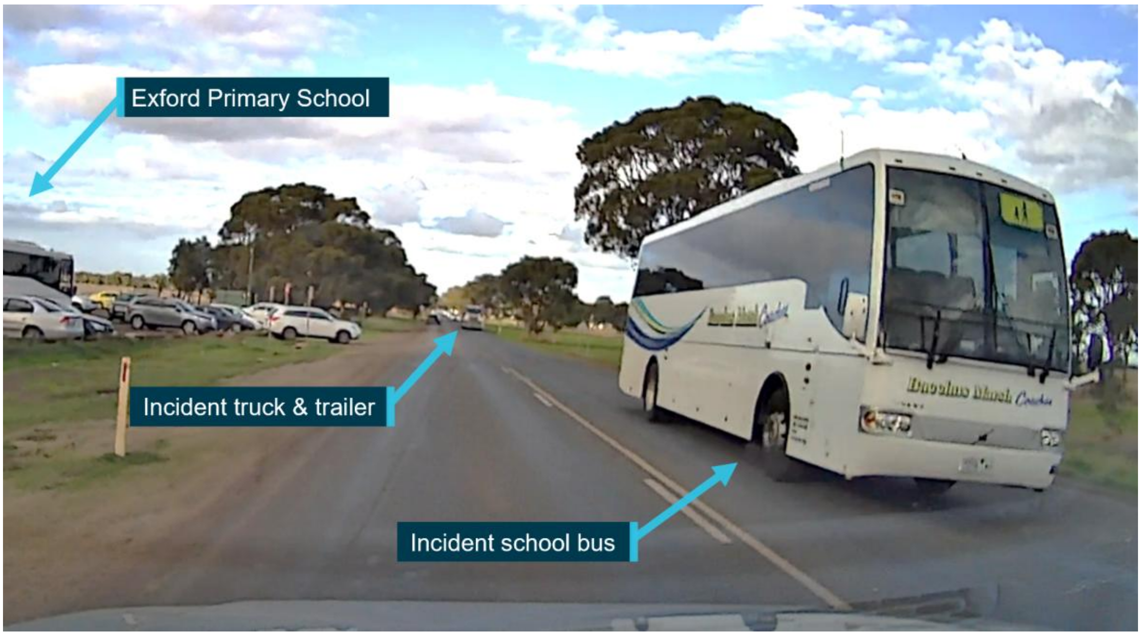
27 Imbalance if there is more than 30% difference in the brake performance between the wheels on the same axle.

Recorded information

Witness dashcam footage

A vehicle traveling in the opposite direction on Exford Road approaching the primary school was equipped with a forward and rearward facing camera that recorded high definition (HD) video. Footage from the camera shows the school bus travelling away from Exford Primary School on Exford Road with the incident truck and trailer approaching from behind. At that point, the speed limit in the school zone was 60 km/h and the truck was travelling about 110 m behind the school bus (Figure 18).

Figure 18: School bus departing primary school



Source: Victoria Police, annotated by Office of the Chief Investigator

CCTV footage

A CCTV camera was situated approximately 650 m east of the intersection of Exford Road and Murphys Road. The camera captured footage of the school bus and following truck before the collision at Murphys Road intersection. Analysis of the footage concluded the speed of both vehicles to be about 70 km/h. The vehicle separation was measured to be about 5 seconds or 100 m.

Bus GPS

The school bus was fitted with a modular GPS fleet tracking device that recorded vehicle position, speed, heading and vehicle behaviour events.[28] Data points from the tracker were recorded at 19 second intervals just prior to the collision.

The data records showed that at 15:39:24[29] the bus was traveling at 74 km/h when located about 100 m east of the Murphys road intersection. Then at 15:39:36 an 'extreme G' event was recorded which signified the collision between the bus and truck.

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28 Vehicle behaviour events such as when the vehicle is stopped, moving, idling, and extreme deceleration events measured by an onboard accelerometer.

29 Eastern standard time.

Similar occurrences

Under the *Transport (Compliance & Miscellaneous) Act 1983* (Vic), the Office of the Chief investigator (OCI) had conducted investigations into three similar occurrences involving bus rollovers. The primary focus of these investigation was to determine what factors caused the incident, rather than apportion blame for the incident, and to identify issues that may require review, monitoring or further consideration.

On 21 September 2022, a B-double truck collided with the rear of a passenger coach at Pentland Hills, near Bacchus Marsh. The impact caused the coach to leave the Western Freeway, career down an embankment and roll onto its side resulting in serious injuries to a number of passengers. The coach side glazing had fractured during the rollover and the more seriously injured passengers had been ejected from the passenger compartment. Amongst other findings the investigation found that although not all passengers were wearing seatbelts, the use of seatbelts by most bus passengers probably limited the number of severe injuries and reduced the likelihood of fatality. Findings from this investigation identified opportunities for the review of occupant protection standards for passenger coaches, the review of anti-ejection safety countermeasures and the consideration of mandating seatbelt reminder systems.[30]

On 14 October 2017, a passenger coach travelling from Mildura to Ballarat left the Sunraysia highway at Tanwood and rolled onto its side. The rollover resulted in injuries to multiple passengers and 2 fatalities. Amongst other findings the investigation found that passengers not wearing seatbelts suffered higher levels of significant injury. Findings from this investigation identified opportunities for the passenger transport industry to consider the introduction of systems to influence greater passenger compliance with respect to the wearing of seatbelts.[31]

On 16 April 2009, a passenger coach traveling from Warrnambool, Victoria to Mount Gambier, South Australia left the highway, rolled on its side and landed on a grass embankment. The rollover resulted in injuries to 8 passengers and 3 fatalities of which one was of an infant. The coach side glazing had fractured during the rollover and the 3 fatally injured passengers were either partially or fully ejected from the passenger compartment. Amongst other findings the investigation found that the many of the passengers were not wearing seatbelts and the coach was not fitted or provided with child safety harnesses. Findings from this investigation identified opportunities for government and industry to review the requirement for child safety harnesses on long-distance road coaches and for coach operators to consider a program of education to encourage a higher seatbelt wearing rate.[32]

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30 Bus Occurrence Investigation BUS/22-1519. Office of the Chief Investigator.

31 Bus Safety Investigation report No 2017/06. Office of the Chief Investigator.

32 Transport Safety Investigation report No 2009/06. Office of the Chief Investigator.

Safety analysis

Introduction

At about 1539 on 16 May 2023, a school bus carrying students from Exford Primary School was struck from behind by a tipper truck towing a dog trailer. The bus had exited the primary school on Exford Road and commenced the after-school drop-off run with 45 students onboard. After traveling about 800 m, the bus began to turn right into Murphys road when the truck collided with the rear of the bus causing it to yaw in a clockwise direction and roll onto its left side. The bus rollover resulted in serious injuries requiring hospitalisation of several students.

The operation of the bus along Exford Road and then turning onto Murphys Road was consistent with the after-school bus route. There was no evidence to suggest that there was anything unusual with the operation of the bus. This analysis discusses:

- the collision sequence
- truck driver performance-shaping factors
- road infrastructure
- school bus route
- braking system of the truck-trailer combination
- heavy vehicle event data recorders
- occupant protection in buses.

The collision sequence

The bus's speed and slowing sequence is not known with certainty. The bus was probably travelling at between 70 and 80 km/h along Exford Road prior to slowing for the right turn into Murphys Road. Its driver could not recall whether the bus came to a complete stop or was rolling at the intersection. The bus driver reported engaging the retarder[33] to slow the bus followed by applying the brakes before commencing their turn while observing the truck approaching from behind.

Road tyre marks from the truck indicated that the truck's brakes were fully active for at least 26 m prior to the truck's impact with the bus. This physical evidence is consistent with the truck driver's recollection of making a heavy brake application after recognising that the bus was slowing to turn right into Murphys Road.[34] The truck driver recalled initially observing the bus slow down and then seeing the right turn indicator at the last moment. The driver recalled initially taking power (throttle) off in response to the reducing gap to the bus.

The speed of the truck approaching the intersection and truck braking performance on the day are not known with certainty. Assuming the truck was travelling at the road speed limit of 80 km/h at the time of brake application, its speed at impact was probably around 50 to 55 km/h.[35] About 50 m braking distance would probably have been required to stop from 80 km/h.

Truck driver performance-shaping factors

Overview

It is concluded from the available evidence that the combination of human response (observe cues, comprehend their meaning and apply brakes and steering to evade/avoid collision) and

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33 When the driver console retarder switch is on, the retarder is engaged by a short press of the brake pedal.

34 The right-turn indicator was operating prior to impact although the precise timing of its activation is unknown.

35 Assumes a deceleration of 5.1 m/s^2 estimated from post-incident testing.

vehicle braking response exceeded the available time and distance between the truck and bus. This section examines factors influencing human performance.

The ability to process information is subject to limitations based on finite cognitive resources available to attend to information or perform tasks at any given time. In general, if a person is focussing on one particular task, then their performance on other tasks will be degraded.[36]

In the context of a truck driver slowing in response to cues from road traffic ahead, the extent of performance degradation may depend on factors such as:

- driver experience and knowledge (task competence)
- the influence of fatigue, drugs, alcohol or a medical condition
- the conspicuity of the vehicle ahead including its lights indicating braking and turning
- the truck driver's expectations of the likely behaviours of the vehicle ahead
- the truck driver's focus of attention at that point in time and the existence of any distractions.

Driver experience and knowledge

No adverse factors were identified with the truck driver's experience or knowledge. The truck driver was experienced in operating truck-trailer combinations and was familiar with the vehicles being used on the day of the collision. The driver also demonstrated an understanding of safe following distances for heavy vehicles. About 650 m before the collision, the truck was observed to be following the bus at a safe separation of about 100 m or 5 seconds.

Driver fatigue and medical condition

No adverse factors were identified with the truck driver's physical condition. Although normal end-of-shift tiredness was probably present, there was insufficient evidence to conclude the presence of fatigue at a level likely to significantly influence performance. There was no evidence identified to indicate drugs, alcohol or a medical condition had influenced the performance of the truck driver.

Conspicuity of the bus and its light signals

Visual factors that can affect conspicuity include contrast and glare.[37] The bus was white in colour, suggesting a good contrast against the sky and surrounding vegetation, and the truck driver recalled being aware of its presence ahead. Conspicuity of the bus itself was therefore not a factor. The bus's brake and turn indicator lights were also assessed as operable, although the sequence and timing of their application in not known. The bus driver's reported use of the retarder would have also meant that the bus was probably slowing[38] prior to the steady illumination of the rear brake lights activated by the service brakes.

Considering glare, the sun was low in the sky and about 32° to the right of the driver's straight-ahead view. The truck driver and other drivers in the area at the time described observing of the sun through the trees. Although there was insufficient evidence to quantify its influence, a sun flickering effect had the potential to compromise the driver's perception of the bus's brake lights and turning signal lights.

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36 Kahneman, D. (2011). Thinking Fast and Slow. Farrar, Straus & Giroux: New York.

37 Gray, R. & Regan, D. (2007). Glare susceptibility test results correlate with temporal safety margin when executing turns across approaching vehicles in simulated low-sun conditions. Ophthalmic & Physiological Optics, 27, 440-450.

38 Field testing indicated the retarder would slow the bus at a rate below the guiding threshold specified for brake light activation in electric vehicles when vehicle speed is retarded during electrical regeneration without the use of service brakes. Although the initial application of the retarder required pressing the brake pedal, the brake lights would only momentarily illuminate and would extinguish once the brake pedal was released.

Driver expectancy

In the context of vehicle following behaviours, expectancy bias refers to:

- the influence of preconceived notions or expectations of how a driver gauges the appropriate following distance behind the vehicle in front, and
- how much attention they will pay towards watching out for cues such as a slowing vehicle, brake lights and turning signals.

For instance, if a driver expects the vehicle in front to brake suddenly, they might increase their following distance as a precaution. Conversely, if they assume that the road ahead is clear and there is no imminent risk, they may reduce the following distance.

The truck driver was a frequent user of Exford Road and they could not recall having previously encountered a bus turning right off Exford Road onto Murphys Road. It is probable that the driver's expectation that the bus would continue along Exford Road influenced their late observation of cues to indicate the bus was slowing, braking and turning.

Driver attention and distraction

Attentional disengagement (mind wandering)

Although driver distraction is widely acknowledged as impeding performance of driving tasks, it is important to recognise that people can also become unintentionally inattentive to driving tasks without the presence of a competing activity.[39] Attentional disengagement can occur when attention momentarily shifts away from the external environment, even though the individual continues to show well practiced automatic responses.[40] [41] In situations where tasks are protracted, unvarying, familiar, repetitive or undemanding, one can fall into a more intuitive, automatic mode of thinking, akin to 'autopilot' for the mind.[42] [43]

The truck driver was on their way home from work, on a very familiar route that they routinely took on their commute to and from work sites. They described being aware of heightened risk around the school due to many vehicles moving in and out of the school parking area and entering the traffic flowing along Exford Road. However, after exiting the 60km/h school zone, the driver then started to build speed and probably became less actively engaged in identifying, assessing and managing the emerging hazards around them.

Distraction

Distraction can be understood as a type of inattention, where a person's attention is diverted from their primary task by a compelling event or object. Although an in-cab distraction was possible, there was no compelling evidence identified to indicate such a distraction.

There was evidence identified of two potential distractions external to the cab. The truck driver reported observing a car approaching Exford Road from their left along Green Hill Road which was located about 250 m before the Murphys Road intersection. Their attention was diverted momentarily to assess whether the car driver would stop to give way. It was in the moments following this side-event that the truck driver first observed that they were rapidly gaining on the school bus.

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39 Regan, M.A., Hallett, C., and Gordon, C.P. (2011). Driver distraction and driver inattention: Definition, relationship and taxonomy. Accident Analysis and Prevention, 43, 1771-1781.

40 Smallwood, J. & Schooler, J.W. (2006). The Restless Mind. Psychological Bulletin, 132 (6), 946-958.

41 Cheyne, J.A., Soman, G.J.F., Carriere, J.S.A., and Smilek, D. (2008). Anatomy of an error: A bidirectional state model of task engagement/disengagement and attention-related errors. Cognition, 111, 98-113.

42 Cheyne, Soman, Carriere and Smilek, (2008).

43 Kahneman, D. (2011).

The other potential external distraction was the previously described sun, low in the sky and flickering through trees on the right side of Exford Road. The extent to which this may have directly or indirectly distracted the driver from the driving task could not be quantified.

Summary of probable influencing factors

Based on the available evidence, it is concluded that the driver of the truck did not immediately identify that the bus ahead was slowing to turn right onto Murphys Road. This was probably due to an expectation that the bus was continuing straight along Exford Road (not turning) and attentional disengagement or distraction from the driving task. The driver's attention on the driving task was possibly impacted by the driver's view of the sun flickering through trees.

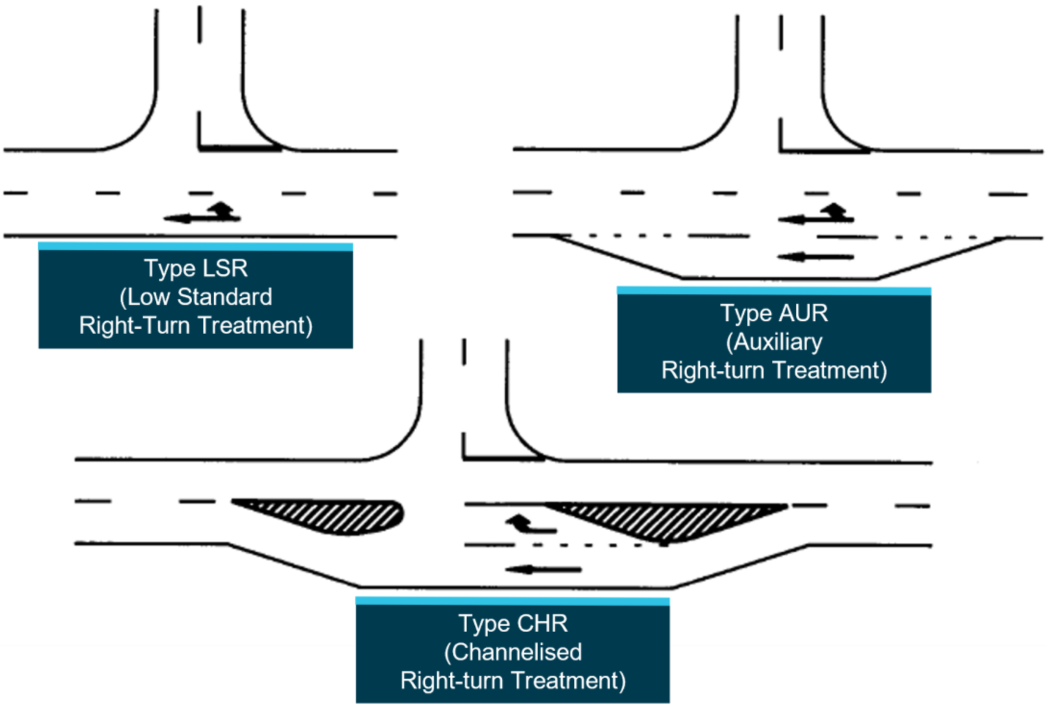
Road infrastructure

Road configuration for right turn

The Exford Road – Murphys road intersection was a basic unsignalised T-intersection with traffic from Murphys road controlled by a give way sign. Westbound traffic on Exford Road travelled on a single lane with the option to proceed straight or turn right at Murphys Road. The unsealed shoulder of Exford Road was occasionally used by vehicles continuing straight and passing vehicles waiting to turn right.

A study of the relationship between unsignalised intersection geometry and accident rates in Queensland[44] considered alternative T-intersection configurations (Figure 19). The study found that intersections with a Channelised Right-turn (CHR) record a 98 percent lower Rear-End-Major vehicle accident rate than intersections with a Low Standard Right-Turn (LSR) configuration. The study also found that Intersections with a CHR had a 97 percent lower rate than intersections with an Auxiliary Right-turn (AUR) treatment.

Figure 19: T-Intersection configurations for right-turns



Source: Arndt (2003) annotated by Office of the Chief Investigator

44 Arndt, O. K., Troutbeck, R. (2003) Relationship Between Unsignalised Intersection Geometry and Accident Rates. PhD Thesis, Queensland University of Technology, March 2003.

The study findings support the conclusion that a CHR reduces the risk of rear end collisions compared to LSR and AUR treatments. This is due to the treatment forcing through traffic to deviate through an alignment which can also be designed to suit operating speeds.

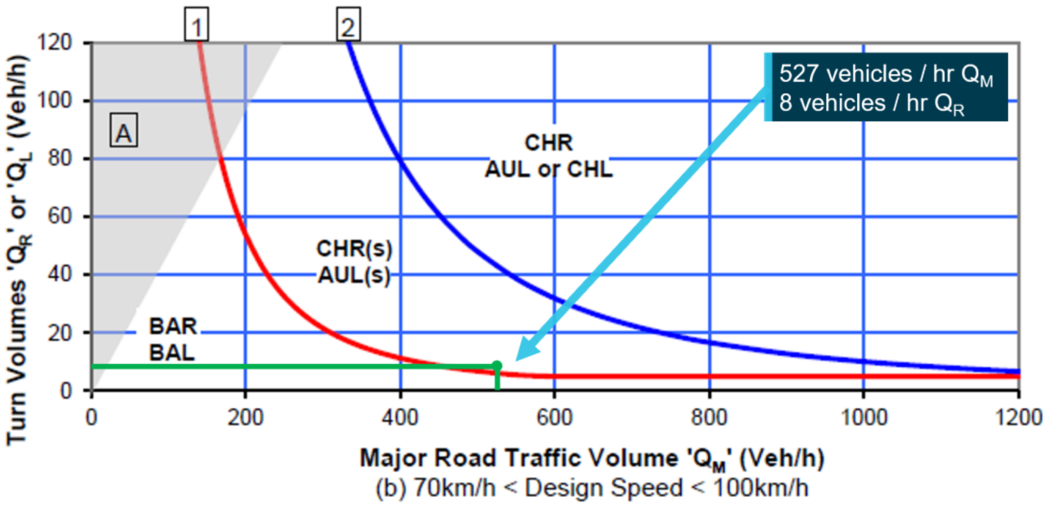
Guide to traffic management

The Queensland research and further analysis by Arndt et al (2006)[45] was adopted by the Guide to Traffic Management published by Austroads. Part 6 of the guide[46] outlines the selection of intersection types to promote efficient and safe traffic movement for road users using a Safe System approach. This is a nationally agreed guideline and has been adopted by all jurisdictions, including Victoria. For existing intersections, the guideline is typically applied where major works were planned to address traffic safety or congestion concerns.

Selection of the appropriate intersection type is complex and considers many factors including safety and operational performance. To provide guidance on determining the need for auxiliary lanes at T-intersections, criteria have been developed using mathematical models that account for design traffic speed and traffic volume per hour in peak periods.[47] Although these criteria are intended to guide design of intersections for new roads, the guidelines permit their use 'as a reference for intervention levels when upgrading existing intersection turn treatments'.

A traffic survey was conducted by the Melton City Council in July 2023, after the collision. The survey measured traffic volumes passing through the Exford / Murphys road intersection in both the morning and afternoon peak periods. The afternoon hourly peak data for traffic turning right from Exford Road is plotted in green on the turn treatment warrant that would apply to the intersection (Figure 20).

Figure 20: Turn treatment warrants – major road unsignalised intersections



Source: Austroads Guide to Traffic Management Part 6: Intersections, Interchanges and Crossings Management, Figure 3.25(b), annotated by Office of the Chief Investigator
BAR = basic right-turn treatment (equivalent to LSR in Figure 19)
BAL = basic left-turn treatment
CHR(s) = short channelised right-turn treatment; AUL(s) = short auxiliary left-turn treatment
CHR = channelised right-turn treatment; AUL = auxiliary left-turn treatment; CHL = channelised left-turn treatment.

The data measured at the 2023 survey indicates that traffic volumes were at the threshold in the Austroads guidelines to consider a short channelised right-turn treatment (CHR(s)) at the Murphys

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45 Arndt, O. K. (2006) New Warrants for Unsignalised Intersection Turn Treatments, 22nd ARRB Conference – Research into Practice, Canberra Australia, 2006.

46 Guide to Traffic Management Part 6: Intersections, Interchanges and Crossings Management, Edition 4.0 published by Austroads April 2020.

47 Turn treatment set of criteria or conditions are referred to as warrants in the Austroad guidelines.

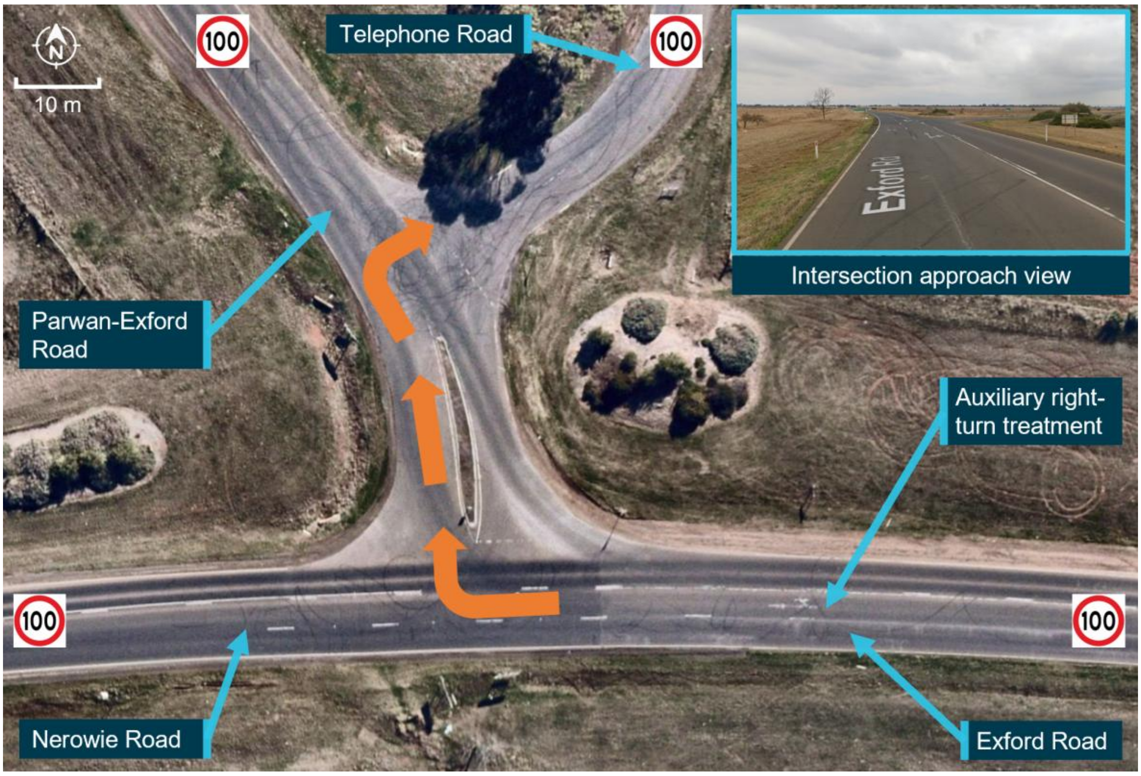
Road intersection. Consideration for upgrade would be consistent with probable continued increases in traffic volumes in this growth corridor.

School bus route

Route options

The school bus drop-off route was designed to include Murphys Road to service students residing on that road. On the approved school bus route, the bus would turn right into Murphys Road and travel in an anticlockwise loop before rejoining Exford Road to travel east. In the months after the collision, the Murphys Road loop was first excluded from the route (due to there being no student drop-offs) and then later reestablished in the opposite direction with the bus turning right at Parwan-Exford Road (Figure 21) and travelling in a clockwise loop to re-enter Exford Road from Murphys Road.

Figure 21: Bus route post incident



Source: nearmap and Google Street View annotated by the Office of the Chief Investigator

This modified clockwise loop replaced the right turn at Murphys Road. The right turn at Parwan-Exford Road turn was on a section of Exford Road with 2 westbound lanes and so afforded vehicles travelling behind a turning vehicle to pass to the left. The new right turn road was a higher (100 km/h) speed zone posing other risks. The original and subsequent route options highlight the different characteristics and risk profiles present with different route options.

Processes and risk assessment

The School Bus Program (SBP) policy published by the Department of Education (DE) provided guidance on bus route road suitability. The policy stated that the Department of Transport and Planning (DTP) and bus operators were responsible for ensuring roads used by school buses were suitable for use in all weather conditions.

Requests for a new school bus service were made by the coordinating school in conjunction with the school bus operator on a specified form[48] submitted to the DE. In the form, a description of the proposed route was recorded. For route roads other than Class A, B, C or M[49], endorsement by a municipal engineer was required stating the roads to be used were suitable and safe to operate a school bus in all weather conditions. This information was also required where an application was made to vary or extend an existing route.[50]

A School Bus Program User Guide was also provided by DE as an online resource for users of the program.[51] There were no documented guidelines or processes identified which would support optimising route design for traffic safety risks.

Truck braking system

Truck-trailer combination condition and performance

The slack adjusters fitted to the truck and trailer drum brake systems were designed to automatically compensate for brake lining wear. Although they were intended to ensure the drum brakes were kept in adjustment, they required regular maintenance to ensure they operated as intended. This becomes particularly critical for a vehicle operated in conditions such as quarries where contamination from dust and road grime can impact performance.

A reduction in braking effectiveness and an imbalance of braking force across an axle in this type of drum brake system can be the result of several factors. Common faults include incorrectly indexing automatic slack adjusters and system air leaks. These faults were found in both the truck and trailer in post-incident inspections and brake tests. Between major servicing, brake systems must be inspected and maintained within the manufacturer specified adjustment and free from air leaks to meet roadworthiness requirements.

Despite the deficiencies in brake effectiveness and balance measured on some axles, the total dynamic deceleration measured by the portable roller brake tester (RBT) for both truck and trailer exceeded the minimum requirement of 4.4 m/s^2 set by the National Heavy Vehicle Regulator.

Implementation of new technologies

The truck involved in this collision was manufactured prior to the 2014 implementation of several new technologies through the Australian Design Rules for heavy vehicles. These rules introduced requirements for new technologies such as antilock braking systems (ABS),[52] Variable Proportioning (VP) braking systems,[53] Electronic Stability Control (ESC)[54] and Roll Stability Control (RSC).[55] These safety advances were introduced to improve braking and dynamic stability of heavy vehicles.

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48 Form 8: Application for a New School Bus Service or Feeder Service. Department of Education – updated Jan 2023.

49 Class A road is a major arterial road; Class B road is a secondary arterial road; Class C road is a local road; Class M road is a major arterial road that is typically a multi-lane highway.

50 Form 9: Application for Variation or Extension of an Existing Route. Department of Education – updated Jan 2023.

51 School Bus Program User Guide. January 2023 (https://content.sdp.education.vic.gov.au/media/school-bus-program-user-guide-pdf-2267).

52 Antilock braking systems (ABS) automatically prevent wheel skidding due to lock-up during heavy braking. Heavy trailers fitted with ABS were also required to have automatic brake adjustment devices fitted.

53 Variable Proportioning (VP) braking systems fitted to heavy trailers automatically adjust the braking force to the axles based on the load in the trailer.

54 Electronic Stability Control (ESC) fitted to trucks is an extension of the ABS braking system designed to detect the risk of a rollover and automatically decelerate the vehicle using reduced engine power and braking of individual wheels in response.

55 Roll Stability Control (RSC) fitted to trailers is an extension of the ABS braking system designed to detect the risk of a rollover and automatically decelerate the vehicle using braking of individual wheels in response. RSC was mandated on trailers greater than 10 tonnes Gross Trailer Mass.

Further, in 2022, Australian Design Rule 97/00 – Advanced Emergency Braking for Omnibuses, and Medium and Heavy Goods Vehicles was introduced. This new standard specified requirements for Advanced Emergency Braking (AEB)[56] systems for new omnibuses and goods vehicles greater than 3.5 tonnes Gross Vehicle Mass[57]. The primary aim of AEB is to avoid or mitigate the severity of rear-end in-lane collisions. The AEB system uses information from various sensors and cameras to monitor the road environment in front of the vehicle. If a collision with the vehicle ahead is predicted, the system will warn the driver and can activate emergency braking.

Heavy vehicle event data recorders

In addition to advances in vehicle brake technologies, new regulations are being developed in Europe[58] to mandate event data recorders (EDRs) in heavy vehicles.[59] These devices capture data such as speed, steering and brake application immediately before and after a crash event. This data may be valuable to help provide a better understanding of the circumstances in which crashes and injuries occur. Future implementation of these requirements in Australia is under review.

Occupant protection in buses

Overview

Significant improvements have been made to bus occupant safety in Australia over the last 3 decades with the mandating of standards for bus rollover strength, occupant protection and the installation of lap-sash retractable seatbelts in eligible buses.[60] Bus travel is now commonly considered to be a comparatively safe transport mode. In Australia, research conducted by the University of Sydney concluded that ‘bus travel is overall, the safest form of land passenger transport for all passengers and the safest for school children between five and 16 years old (excluding train travel)’.[61] This finding was also supported by research undertaken in Victoria by the Monash University Accident Research Centre in 2022.[62]

School buses operating on rural, regional and outer suburban roads in Victoria are generally operated under the School Bus Program (SBP) administered by the Victorian State Government. It has been reported that over 90 percent of buses operating in this program have seatbelts installed, and the remaining buses are due to be replaced in the coming years. The incident bus was operated under the SBP and had lap-sash retractable seatbelts fitted to all seating positions.

Although serious bus crashes are rare, when they do occur significant injuries or fatalities may result. Rollover crashes, in particular, often result in more severe injuries with occupants at risk of partial or full ejection as well as impacts with the bus interior or other passengers. This section discusses:

- location of seatbelt sash upper anchorage

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[56] Advanced Emergency Braking (AEB) is a braking system which can automatically detect a potential forward collision and activate the vehicle braking system to decelerate the vehicle with the purpose of avoiding or mitigating a collision.

[57] ADR 97/00 Advanced Emergency Braking for Omnibuses, and Medium and Heavy Goods Vehicles does not apply to omnibus specially designed with spaces for standing passengers, or ‘Articulated Omnibuses’, or a vehicle that has four of more ‘Axles’, or a vehicle that is ‘designed for off-road use’.

[58] UN Regulation No 169 – Uniform Provisions Concerning the Approval of Event Data Recorders (EDR) for Heavy-Duty Vehicles.

[59] UN Regulation No 169 will apply to medium and heavy buses and trucks.

[60] ADR 68/00 Occupant Protection in Buses does not apply to ‘Route Service Omnibuses’, or omnibuses with less than 17 ‘Seats’ including the driver and crew, or vehicles in which all passenger ‘Seats’ have a ‘Reference Height’ of less than 1.0 metre.

[61] Hensher, D.A. (2002). ‘How Safe are Buses carrying School Children?’. Institute of Transport Studies, University of Sydney.

[62] Ibrahim, M.N.; Logan, D.B.; Koppel, S.; Fildes, B. Fatal and Serious Injury Rates for Different Travel Modes in Victoria, Australia Sustainability 2022, published 8 February 2022.

- seatbelt fit for school children
- bus anti-ejection glazing.

Location of seatbelt sash upper anchorage

Historically, the utilisation of seatbelts has been considered the most effective means to prevent ejection from a motor vehicle accident (Miller et al., 2020).[63] However, studies by the US National Transportation Safety Board (NTSB) on bus safety[64] found that in crash simulations of lateral impacts and rollovers, the occupant's upper torso was predicted to move in the direction opposite to the lateral force. Further, the upper torso was predicted to slide out of the seatbelt sash away from the sash upper anchorage point.

The position of the sash belt upper anchorage relative to the bus side windows may therefore be important in reducing the risk of a passenger partial ejection. This would suggest a seatbelt orientation that positioned the seatbelt sash across the passenger shoulder closest to the bus side windows. The seatbelt sashes on the incident bus were positioned in the centre of the 2- passenger seat assemblies. This configuration met all regulatory requirements.

Seatbelt fit for school children

The restraining performance of seatbelts in rollovers was further documented in a study published by the National Library of Medicine. The study found that although seatbelts have been cited as 99.8% effective in eliminating full ejections, their effectiveness in eliminating partial ejections may be as low as 38% (Funk et al., 2012).[65]

Seatbelt effectiveness in a vehicle collision is influenced by how well the restraint fits across the pelvic and shoulder regions of the passenger. A study of seatbelt system performance in vehicle rollovers noted that shoulder sash belts may slip off due to potential factors such as improper fit and clothing type (Hu et al., 2009).[66] The risk of improper fit of seatbelts is increased where seatbelts designed to accommodate adults are used to restrain smaller occupants and children. Studies of the limitations of seatbelts designed for adult anthropometry used to restrain children have found that children under 12 years of age are likely to experience markedly poorer seatbelt fit when transitioning from a booster seat to an adult seatbelt (Klinich et al., 1994 and 2016).[67] [68]

Current Victorian road rules state that all children under 16 years of age, when travelling in a motor vehicle in Victoria, must be restrained in a suitable restraint that is properly adjusted and fastened.

Restraint suitability is typically determined by the age and size of the child. Transport Victoria[69] provides practical advice to meet the road rule requirements:

- children from the age of 4 years to under 7 years must be restrained in a forward-facing child car seat with an inbuilt harness or in a booster seat when they outgrow the forward-facing seat

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63 Miller, B., Smedley, J., Carhart, M., Sharpe, S., & Krishnaswami, R. (2020). Evaluation of Laminated Side Glazing and Curtain Airbags for Occupant Containment in Rollover. SAE Technical Paper 2020-01-0976.

64 NTSB/SIR–99/04 PB98–917006; Highway Special Investigation Report: Bus Crashworthiness Issues; September, 1999.

65 Funk, J. R., Cormier, J. M., Bain, C. E., Wirth, J. L., Bonugli, E. B., & Watson, R. A. (2012). Factors affecting ejection risk in rollover crashes. Annals of Advances in Automotive Medicine, 56, 203-211.

66 Hu, J., Chou, C. C., & Yang, K. H. (2009). Finite Element Investigation of Seatbelt Systems for Improving Occupant Protection during Rollover Crashes. SAE International Journal of Passenger Cars - Mechanical Systems, 2(1), 904-913.

67 Klinich, K. D., Pritz, H. B., Beebe, M. S., & Welty, K. A. (1994). Survey of Older Children in Automotive Restraints and Booster Seats. (Technical Paper 94222). SAE Transactions: Journal of Passenger Cars-Mechanical Systems, Vol. 103.

68 Reed M. P, Klinich K. D. Predicting vehicle belt fit for children ages 6-12. Traffic Inj Prev. 2016.

69 Department of Transport and Planning, https://transport.vic.gov.au/ /Road-rules-and-safety/Child-car-seats-and-restraints/Child-car-seat-and-restraint-road-rules.

- children from the age of 7 years to 16 years must be restrained in a booster seat or forward-facing child car seat with an inbuilt harness or in an adult seatbelt when the lap sash seatbelt properly fits them.[70]

For buses with more than 12 seats, these rules do not apply and children are not required to be restrained in child restraints or booster seats. Transport Victoria recommends the use of child restraints and booster seats in buses, where possible. Otherwise, children must use the seatbelts where provided.

Buses built to meet the requirements of ADR 68 - Occupant Protection in Buses must have at least 6 seating positions provided with child restraint anchor fittings[71] to enable the installation of child seats or anchored booster seats. Despite the availability of suitable anchorage points on these buses, there are several factors that inhibit the practical use of child restraint systems on school buses. Among these factors are the impractical time to install / remove devices each journey, incompatibility of some systems with standard bus seats, concerns with inhibiting emergency evacuation and potential to reduce the bus seating capacity where a child seat may prevent the practical use of a nearby seat.

Development of appropriate occupant protection measures for children in school buses was undertaken by the US National Highway Traffic Safety Administration (NHTSA) over three decades. In a report to US congress on school bus safety crashworthiness research,[72] the administration reported that properly used lap/shoulder seatbelt systems are particularly effective in reducing ejection in rollover crashes.

The seatbelt systems tested in this research had adjustable features that provided a means for the seatbelt system to be adjusted to safely and comfortably fit a wide range of age/size passengers. Adjustability allowed for the sash portion of the seatbelt to be positioned for appropriate fit on a smaller child optimising the systems restraining performance (Figure 22). This better fit was also reported to increase comfort levels by avoiding the sash crossing the neck of a smaller child and reduce the tendency for misuse.[73]

Figure 22: 6YO Child test dummy with adjusted seatbelt

Source: NHTSA and School Transportation News, annotated by Office of the Chief Investigator

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70 Transport Victoria advises that achieving a good seatbelt fit usually happens when children are 145 cm tall and can pass the 'five step test' outlined in Victoria's early childhood road safety education program (https://childroadsafety.org.au/cars/five-step-test/).

71 Child restraint anchor fitting allows the attachment of a child seat or booster seat attaching clip to the vehicle.

72 School Bus Safety: Crashworthiness Research. Research and Development – NHTSA. April 2002.

73 Seatbelt misuse was defined as where the shoulder portion of the seatbelt is incorrectly placed under a child's arm or behind their back when they find it uncomfortable or if the belt system restricts movement.

Following extensive research and consultation, NHTSA finalised several changes to the Federal Motor Vehicle Safety Standard (FMVSS) 222 School bus passenger seating and crash protection and the associated standards for seatbelts and seatbelt anchorages.[74] Among these changes was the requirement for school bus seatbelts to incorporate a torso belt height adjuster. This feature enabled the simple adjustment of the seatbelt assembly to properly fit a broad range of passenger sizes.[75]

School buses in the USA are operated on a dedicated service with buses designed and used solely for transport of school children. This arrangement allows for the tailoring of occupant protection systems for a specific bus design.[76] By contrast, school children in Victoria are transported in a variety of bus designs that are often not dedicated solely for school transport and may be used for general charter work.

A seatbelt system with height adjustable torso strap that caters for a broad range of passenger sizes from children through adults has the potential to be utilised in buses both for school use and charter work. This would enable the correct fitting of a lap/sash seatbelt to smaller children in buses where it is not feasible to use either an appropriate child restraint or booster seat.

In this incident, serious injuries were sustained by the partial ejection of a number of children wearing seatbelts that were not adjustable to enable a proper fit according to the passenger's body size. The seatbelt sash orientation in the centre of the bus twin seat design may also not have been optimal for reducing the risk of partial ejection. The NHTSA school bus seatbelt research and associated clauses from FMVSS vehicle standards should be considered for potential application in Australia along with a review of sash orientation for seatbelts in buses.

Bus anti-ejection side glazing

While lap-sash seatbelts can reduce the likelihood of a passenger being ejected or partially ejected from a bus in a rollover accident, they do not eliminate the risk. In this incident, passengers suffered serious injuries from being partially ejected from the vehicle as a result of the collision. All were probably wearing a lap-sash seatbelt.

According to the National Center for Statistics and Analysis (2023)[77] in the US, between 2012 and 2021, a total of 998 fatal school-transportation-related accidents occurred, with rollover leading to the second highest number of occupant fatalities after frontal collisions. Research in Europe highlighted similar findings from studies of accidents involving buses showing that the main cause of severe and fatal injuries is partial or full ejection or projection from seats (Grasas et al., 2001. Ferrer et al, 2002).[78] [79]

Occupant ejections from derailed passenger carriage rollovers is also a concern in the rail industry. Rail accident investigations on the UK mainline found that passengers ejected from bodyside windows during a rollover were more likely to receive a fatal injury. In those circumstances a loss of integrity of the window system led to a loss of passenger containment. Consequently, a research program to develop new requirements for train windows in passenger rail vehicles was instigated by the UK Rail Safety and Standards Board (RSSB). Amongst other

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74 FMVSS 210 Seat belt assembly anchorages, and FMVSS 209 Seat belt assemblies.

75 Figures 4 and 5 of FMVSS 210 – Seat belt assembly anchorages. § 571.210 49 CFR Ch. V (10–1–23 Edition).

76 The NHTSA requires lap/sash seatbelts on school buses with a GVM < 4500 kg, but allows individual states to decide whether to require seatbelts on larger school buses.

77 National Center for Statistics and Analysis. (2023, June). School-transportation-related crashes: 2012–2021 data (Traffic Safety Facts. Report No. DOT HS 813 477). National Highway Traffic Safety Administration.

78 Dr.-Ing. Grasas C., Ferrer I. (2021). Application of accident reconstruction in the assessment of the use of seat belts in buses. IDIADA Automotive Technology SA.

79 Ferrer I., de Miguel J. L. (2021). Assessment of the use of seat belts in buses based on recent road traffic accidents in Spain. International Technical Conference on the Enhanced Safety of Vehicles (ESV) – Paper 222.

recommendations, the summary report proposed new performance requirements for rail carriage window systems to meet the necessity for passenger containment.[80]

Studies by the US National Transportation Safety Board (NTSB) on passenger coach safety led to a recommendation[81] that the National Highway Traffic Safety Administration (NHTSA) expand its research 'on current advanced glazing to include its applicability to motorcoach occupant ejection prevention, and revise window glazing requirements for newly manufactured motorcoaches based on the results of this research'.

Since this recommendation, the NHTSA has developed a new Federal Motor Vehicle Safety Standard (FMVSS) No. 217a, Anti-ejection glazing for bus portals. In the new standard, NHTSA stated that the 'Performance requirements would apply to side and rear windows, and to glass panels and windows on the roof to mitigate partial and complete ejection of passengers from these windows and to ensure that emergency exits remain operable after a rollover crash'. The effective date for new standard in the United States was December 30, 2024 with a compliance date of October 30, 2027. This change complements the introduction of seatbelts to certain buses through Federal Motor Vehicle Safety Standard 208 (FMVSS 208) which regulates automotive occupant crash protection and FMVSS 222 School bus passenger seating and crash protection.

Despite seatbelts being fitted to the majority of buses in Australia built after 1 July 1994, passenger partial and full ejections from bus rollover accidents still occur leading to serious or fatal injuries. Seatbelts may not prevent partial / full ejection in all cases. NHTSA anti-ejection glazing research and proposed standards should be considered for potential application in Australia.

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80 Requirements for train windows in passenger rail vehicles. RSSB research report, 2007.

81 National Transportation Safety Board, Safety Recommendation H-99-45 through -54, NOV 2, 1999.

Findings

OCI investigation report findings include ‘contributing factors’ and ‘other factors that increased risk’ (factors that did not meet the definition of a contributing factor). Report findings also include ‘other safety-related findings’ to provide important summary information.

These report findings should not be read as apportioning blame or liability.

Contributing factors

- The brake application on the truck was too late to avoid a collision with the bus. The late observation and reaction to the bus slowing for the right turn was probably due to the truck driver’s expectation that the bus would be continuing straight on Exford Road and attentional disengagement or distraction from the driving task.

Other factors that increased risk

- The intersection at Murphys Road was configured as a low standard right-turn (LSR) for west-bound traffic on Exford Road. This configuration had a higher risk of rear-end collision compared to a channelised right-turn (CHR).
- The brakes on the truck and trailer were not adequately maintained and did not meet manufacturer’s specified adjustment. This resulted in reduced braking effort and braking imbalance on some axles.

Other safety-related findings

Road infrastructure

- A traffic survey conducted after the collision indicated that west-bound afternoon peak traffic volumes met the lower threshold in the Austroads Guide to Traffic Management to consider a short channelised right-turn (CHR(s)) at the Murphys Road intersection. Consideration for this change would be consistent with probable further increases in traffic volumes in this growth corridor.

Australian Design *Rules*

The following findings pertain to the potential enhancement of the Australian Design Rules for bus occupant protection.

- Serious injuries were sustained by children when the bus rolled onto its left side. In such a rollover scenario, the torso of a passenger occupying a left-side window seat will move towards the window when the side of the bus impacts the ground. The upper anchorage of the seatbelt sash on the incident bus was located at the passenger’s shoulder away from the window. Research indicates that the torso may then slide out of the sash and towards the window. Many buses have the upper sash anchorage located at the passenger shoulder away from the window. Consideration should be given to positioning the upper sash anchorage at the passenger shoulder closest to the bus side windows.
- Serious injuries were sustained by several children wearing seatbelts that were not an optimal fit. International research has demonstrated significant reduced rates of injury where occupants are restrained by correctly adjusted seatbelts. Design options have been identified that incorporate features which enable simple adjustment to properly fit a broad range of passenger sizes.

- The side windows of the school bus were not retained during the rollover increasing the potential for partial and full passenger ejection. International research has demonstrated the potential for bus glazing standards that increase the likelihood of window retention.

Bus route design

- Route design can influence the safety risks associated with a school bus route. There were no documented guidelines or processes identified which would support optimising route design for traffic safety risks.

Safety actions

Directly involved parties and affected agencies were provided with a draft report and invited to provide safety actions they had carried out or were planning to carry out in relation to findings relevant to their organisation.

Recommendations are not made to organisations where appropriate safety action has been taken or is being progressed.

Road infrastructure

Findings

The following findings pertain to the intersection of Murphys Road with Exford Road:

- The intersection at Murphys Road was configured as a low standard right-turn (LSR) for west-bound traffic on Exford Road. This configuration had a higher risk of rear-end collision compared to a channelised right-turn (CHR).
- A traffic survey conducted after the collision indicated that west-bound afternoon peak traffic volumes met the lower threshold in the Austroads Guide to Traffic Management to consider a short channelised right-turn (CHR(s)) at the Murphys Road intersection. Consideration for this change would be consistent with probable further increases in traffic volumes in this growth corridor.

Safety action taken by Melton City Council

Melton City Council advised that it has commenced a project to construct a channelised right/left turn treatment for the Exford / Murphys road intersection.

The project will provide:

- increased visual prominence of the intersection by way of turn lanes, lighting and signage
- a new wider pavement and renewed surface at the intersection to improve skid resistance
- a wider road reserve incorporated in the turn lanes to provide additional space for turning vehicles
- a design that surpasses the road safety audit recommendation.

Safety action taken by the Victorian Department of Transport and Planning

The Department of Transport and Planning advised that both Exford Road and Murphys Road are municipal roads which are under the care and management of the Melton City Council. The department supported the Melton City Council in seeking funding through the Commonwealth Government's 2024-25 Black Spot Program to upgrade the intersection of Exford Road and Murphys Road. Melton City Council has been successful in securing the required funding and will deliver the intersection improvements.

Australian Design Rules

Findings

The following findings are made in relation to design rules for occupant protection in buses:

- Serious injuries were sustained by children when the bus rolled onto its left side. In such a rollover scenario, the torso of a passenger occupying a left-side window seat will move towards the window when the side of the bus impacts the ground. The upper anchorage of the seatbelt sash on the incident bus was located at the passenger's shoulder away from the window. Research indicates that the torso may then slide out of the sash and towards the window. Many buses have the upper sash anchorage located at the passenger shoulder away from the window. Consideration should be given to positioning the upper sash anchorage at the passenger shoulder closest to the bus side windows.
- Serious injuries were sustained by several children wearing seatbelts that were not a proper fit. International research has demonstrated significant reduced rates of injury through well fitted seatbelts. Design options have been identified that incorporate features which enable simple adjustment to properly fit a broad range of passenger sizes.
- The side windows of the school bus were not retained during the rollover increasing the potential for partial and full passenger ejection. International research has demonstrated the potential for bus glazing standards that increase the likelihood of window retention.

Safety action taken by the Victorian Department of Transport and Planning

The Department of Transport and Planning supported the recommendations for improved seatbelt design (including upper sash anchorage location and torso belt height adjuster) and window glazing into future ADRs, as both have the potential to prevent occupant ejection in a bus rollover event.

The ADRs are administered by the Commonwealth Department of Infrastructure, Transport, Regional Development, Communications and the Arts under the Commonwealth Road Vehicle Standards Act 2018. DTP raised the design matters proposed by the Chief Investigator at national vehicle safety forums in February 2025 attended by representatives from the Commonwealth, the National Heavy Vehicle Regulator (NHVR), state and territory road authorities, and peak vehicle industry groups. DTP proposed that further work towards adopting the findings and proposals into future standards be progressed through the National Bus Safety Working Group.

DTP remains committed to advancing bus safety standards, including the recent implementation of visual and audible seatbelt warnings under ADR 68/01. They will continue to advocate for improvements to the ADRs to address the matters raised by the Chief Investigator.

Safety action taken by the Commonwealth Department of Infrastructure, Transport, Regional Development, Communications and the Arts

The Department of Infrastructure, Transport, Regional Development, Communications and the Arts advised that in response to this and other significant bus crashes in Victoria and NSW,[82] the Assistant Minister for Infrastructure and Transport convened a bus safety roundtable to consider options to reduce the likelihood and severity of bus crashes. The roundtable was attended by representatives of states and territories, the bus manufacturing industry, bus operators and user representatives. Following the roundtable, the Department of Infrastructure, Transport, Regional Development, Communications and the Arts established the Bus Safety Working Group, which brings together bus manufacturers, operators, state and territory regulators and the department's vehicle standards experts to consider options to improve bus safety. The working group is

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82 Passenger coach rollover, Greta NSA on 11 June 2023.

currently examining seatbelt requirements with a view to improving seatbelt use in buses. It has also undertaken initial considerations of occupant protection issues.

Changes so far implemented as a result of this work include the introduction of requirements for audible and visual signage to be added in buses and coaches where 3-point seatbelts are fitted to remind passengers to fasten their seatbelts while seated.

Additionally, since the incident, the Australian Design Rules have been amended to include new requirements for lane departure warning systems, reversing technologies and advanced emergency braking for heavy vehicles.

Bus route design

Finding

The following finding is made in relation to guidance for bus route design:

- Route design can influence the safety risks associated with a school bus route. There were no documented guidelines or processes identified which would support optimising route design for safety risks.

Safety action taken by the Department of Transport and Planning

Victoria's Department of Transport and Planning acknowledged the potential influence of route design on safety risks associated with a school bus route and advised that consideration would be given to developing guidance regarding route risk assessment.