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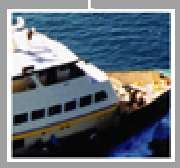


BUS SAFETY INVESTIGATION REPORT

COLLISION BETWEEN TWO STA BUSES IN THE EASTERN DISTRIBUTOR TUNNEL, SYDNEY

25 FEBRUARY 2005

OTSI File Ref: 03531

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OTSI File Ref: 03531 **28 October 2005**	**Office of Transport Safety Investigations** **Level 21, 201 Elizabeth Street** **Sydney NSW 2000**

The Office of Transport Safety Investigations (OTSI) is an independent NSW agency whose purpose is to improve transport safety through the investigation of accidents and incidents in the rail, bus and ferry industries.

Established on 1 January 2004 by the *Transport Administration Act 1988*, the Office is responsible for determining the causes and contributing factors of accidents and to make recommendations for the implementation of remedial safety action to prevent recurrence.

OTSI investigations are conducted under powers conferred by the *Rail Safety Act 2002* and the *Passenger Transport Act 1990*. OTSI investigators normally seek to obtain information cooperatively when conducting an accident investigation. However, where it is necessary to do so, OTSI investigators may exercise statutory powers to interview persons, enter premises and examine and retain physical and documentary evidence. Where OTSI investigators exercise their powers of compulsion, information so obtained cannot be used by other agencies in any subsequent civil or criminal action against those persons providing information.

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Information about OTSI is available on its website or from its offices at

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The Office of Transport Safety Investigations also provides a Confidential Safety Information Reporting facility for rail, bus and ferry industry employees. The CSIRS reporting telephone number is 1800 180 828

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FIGURES and DIAGRAMS

GLOSSARY of TERMS and ABBREVIATIONS

STA	New South Wales State Transit Authority
Carriageway	Paved surface for vehicular traffic
OTSI	Office of Transport Safety Investigations
TIN	Traffic Infringement Notice (Fine)
ABS	Anti-Lock Braking System
RTA	New South Wales Roads and Traffic Authority
CCTV	Closed Circuit Television
Bus Operator	Driver of an STA Bus

EXECUTIVE SUMMARY

The Accident

About 8.30 AM on Friday 25 February 2005, three buses operated by the State Transit Authority (STA) entered the Northbound carriageway of the Eastern Distributor Tunnel (ED), in Sydney, via the Moore Park Road entrance. The traffic level into and within the tunnel was heavy but the general flow of traffic was uninterrupted, although building-up.

As the leading bus approached the rear of the built-up traffic, approximately 500m into the tunnel, the driver changed from the right-hand lane into the middle lane. The second, following, bus remained in the right-hand lane and also began slowing in response to the build-up of traffic. The driver of the third bus, also following and also in the right-hand lane, applied his bus's brakes but failed to stop in time and collided with the rear of the second bus.

The force of the collision threw passengers in both the second and third buses from their seats and most standing passengers were thrown to the floor. The rear window of the second bus shattered, showering some passengers with glass. Sixteen passengers sustained injuries ranging from bruising and lacerations, through to neck and back injuries. Although some passengers were conveyed to hospital, none was admitted.

Findings

Contrary to some media reports, CCTV footage confirms that the accident was not caused by a car changing lanes in front of the leading bus. Although numerous vehicles were observed to cross illegally to the right-hand lane over the unbroken white line separating the entry lane and the through traffic lanes, no vehicle was observed to cut directly in front of the buses which collided.

This rear-end collision occurred because the driver of the third bus failed to maintain a safe buffer between his bus and the STA bus immediately to his front.

The following factors emerged as safety considerations requiring recognition but did not contribute directly to the cause of the accident:

a. The drivers of the two buses involved in the collision were approaching a long, right-hand curve immediately prior to the accident and therefore had a degree of restricted visibility of the build-up of traffic beyond the curve.

b. Traffic conditions within the ED tunnel were, and continue to be, made more difficult by the illegal practice of many drivers crossing unbroken traffic separation lines within the tunnel.

In addition, responses to a survey of 60 STA bus drivers indicate a reluctance to brake suddenly when confronted with the prospect of a collision because of their concern for standing passengers, and a limited appreciation for their bus's emergency braking capability.

Emergency Response

The tunnel operator, Leighton Contractors Pty Ltd, was unaware initially that the two buses had collided and so its response was focused on arranging for the recovery of what it believed were two broken-down vehicles, rather than initiating emergency action that was consistent with responding to an accident. Leightons was further disadvantaged by its inability to communicate with the bus drivers involved in the accident. Similarly, the bus drivers could not communicate with STA. This could have had major consequences for the 116 people involved in the accident if the number and nature of injuries had been greater and/or had the accident resulted in a fire.

The actions of the STA bus drivers involved in the accident, in containing their passengers in their buses, reduced the prospect of further injury from passing traffic on the carriageway.

The Traffic Management Centre acted quickly to alert emergency services and the Police's broadcast communications were used to good effect to overcome the initial communication difficulties.

Recommendations

The following recommendations are made to prevent recurrence of this type of bus accident:

Leighton Contractors Pty Ltd

a. Establish the means to communicate by radio with those services required to respond to emergencies within the tunnel, and

b. Implement a means of deterring drivers from illegal lane changing that is more effective than unbroken lane separation lines.

State Transit Authority

c. Enhance the driver training program to include specific training on bus stopping distances and the critical need for maintaining a safe buffer between buses;

d. Ensure that bus radio communications are effective on all routes, including tunnels;

e. Implement a system which provides emergency guidance to passengers in the event that a driver becomes incapacitated. Such a system might include signage, public address systems, automated announcements and remote radio advisory systems, and

f. Educate its personnel involved in recovery operations about the need to secure and preserve evidence at accident scenes by refraining from interfering with the site condition of safety critical instrumentation, equipment and controls.

New South Wales Police Force

g. Ensure that a police radio monitoring capability is maintained at the Eastern Distributor control room to allow validation of information during emergency communications.

Ministry of Transport

h. Conduct an audit of the STA driver training program to ensure that it places appropriate emphasis on the need for safe driving above all other aspects of bus operation, and

i. Confirm that STA satisfactorily educates drivers on reaction time and hazard avoidance in line with contemporary defensive driving theory and practice.

Roads and Traffic Authority

j. Consult with STA on the viability of developing a public education program aimed at raising the publics', and in particular road users', awareness of the challenges confronting bus drivers in built-up areas.

PART 1 INTRODUCTION

1.1 Appointment

Date of incident: 25 February 2005.

Location: Eastern Distributor Tunnel, Sydney.

Details of incident: Collision Involving STA buses MO2944 and MO2948

Type of inquiry: Bus Safety Investigation, pursuant to Section 46BA of the *Passenger Transport Act, 2002.*

Investigator: The Office of Transport Safety Investigations.

1.2 Terms of Reference

1.2.1 Identify the factors, both primary and contributory, which caused the accident.

1.2.2 Assess the adequacy of driver training, vehicle braking systems and passenger restraint and containment.

1.2.3 Assess the adequacy of the emergency response and management, and the level of safety and protection offered to all involved.

1.2.4 Identify recovery procedures and the implications of disturbing critical evidence during salvage operations.

1.2.5 Advise on any matters arising from the investigation that would enhance the safety of bus operations.

1.3 Methodology

1.3.1 The purpose of the investigation is to determine the circumstances surrounding the incident and provide information to prevent the recurrence of similar events.

1.3.2 The investigation is not intended to attribute blame or liability. However, relevant factual information has been included to support the analysis and conclusions. Some information may reflect on the performance of individuals and organisations and how their actions contributed to the outcomes of the matter under investigation.

1.3.3 A systemic approach has been adopted to identify immediate, long-term and organisational issues. The investigation identified and analysed the issues relevant to the terms of reference and makes a number of recommendations.

PART 2 FACTUAL INFORMATION

The Accident

2.1 About 8.30 AM on Friday 25 February 2005, three buses operated by the State Transit Authority (STA) entered the Northbound carriageway of the Eastern Distributor Tunnel (ED), in Sydney, via the Moore Park Road entrance. The traffic level into and within the tunnel was heavy but the general flow of traffic was uninterrupted, although building-up.

2.2 As the leading bus approached the rear of the built-up traffic, approximately 500m into the tunnel, the driver changed from the right-hand lane into the middle lane. The second, following, bus remained in the right-hand lane and also began slowing in response to the build-up of traffic. The driver of the third bus, also following and also in the right-hand lane, applied his bus's brakes but failed to stop in time and collided with the rear of the second bus.

2.3 The force of the collision threw passengers in both the second and third buses from their seats and most standing passengers were thrown to the floor. The rear window of the second bus shattered, showering some passengers with glass. Sixteen passengers sustained injuries ranging from bruising and lacerations, through to neck and back injuries. Although some passengers were conveyed to hospital, none was admitted.

Location

2.4 The Eastern Distributor Tunnel, operated by Leighton Contractors Pty Ltd, is a 1.7km long double deck tunnel, with the Northbound carriageway running directly above the Southbound carriageway. The collision occurred in the lane adjacent to the Eastern wall of the Northbound tunnel, approximately 500m in from the Moore Park Road entrance to the tunnel, as depicted in Figure 1 (not to scale).

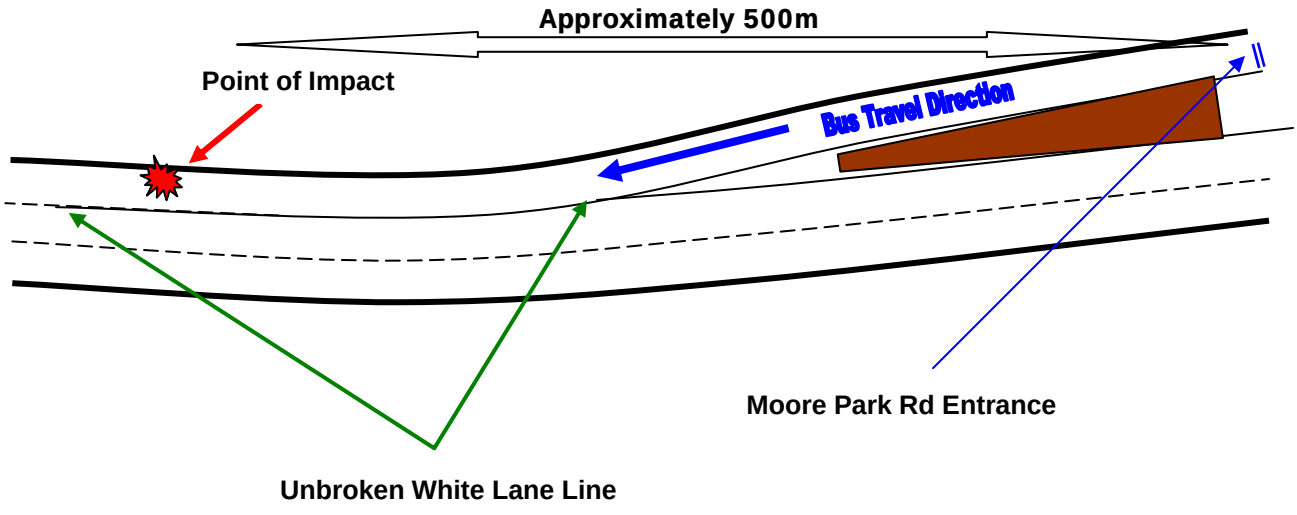

Figure 1 Sketch of Tunnel Carriageway

The Vehicles

2.5 The two buses involved in the collision, registered as MO2948 and MO2944, are Mercedes Mk IV models built in 1986. Both are diesel powered with automatic transmissions and full air braking systems. The buses are licensed to carry a maximum of 43 seated and 27 standing passengers, and ticketing records indicate that they were carrying 54 and 60 passengers respectively.

2.6 A description of the design and construction features of the Mercedes Mk IV bus is attached at Appendix 1.

Drivers

2.7 The drivers of the second and third buses had joined the STA in July 2001 and March 1999 respectively and held the requisite MR licences.

Emergency Response

2.8 The tunnel operator observed the two buses, stationary, on CCTV camera at 8.45AM, approximately four minutes after the collision. The operator then initiated a traffic management plan which involved changing variable message signs and the lane closure indicators to alert other tunnel users. The operator also contacted a towing operator located at Zetland and the RTA Traffic Management Centre (TMC) at 8.51AM. The TMC advised the operator that the stationary buses had in fact collided. A tow truck and the first ambulance subsequently arrived at the accident site at 8.55AM.

2.9 The collision was recorded on CCTV about 8.42AM. The first ‘000’ call, made from a passing motorist, was despatched over the police radio at 8.51AM. Numerous police vehicles acknowledged the call, including a rescue unit from Zetland. The first police vehicle arrived at the scene at 9.07AM, by which stage ambulance personnel were already on site.

PART 3 ANALYSIS

Traffic and Conditions

3.1 Figure 2 provides an indication of the sequence of events leading up to the collision, as recorded on CCTV footage provided by the tunnel operator. Camera No. 47, oriented North, captured, albeit at almost the limits of its range, the following sequence of events.

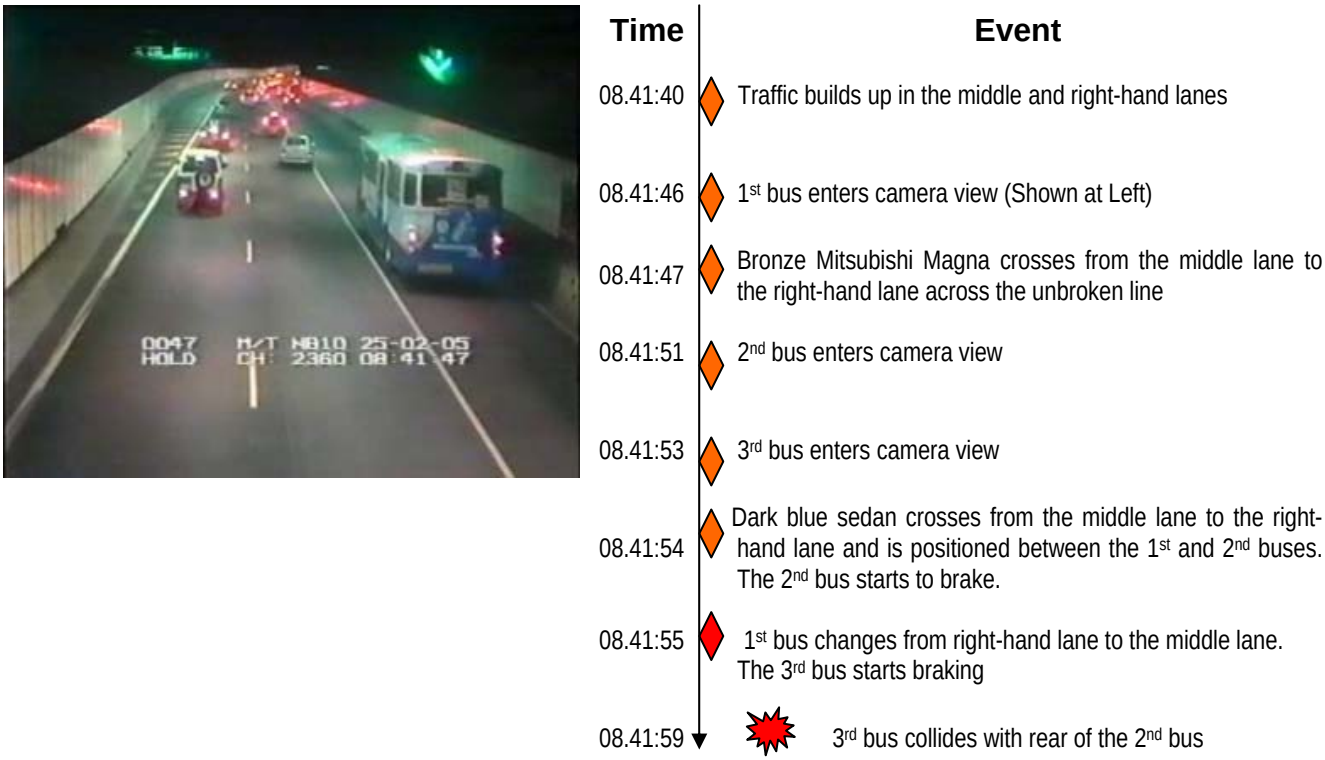

Figure 2 Sequence of Events

3.2 The CCTV footage provides evidence that:

3.2.1 Traffic was building-up as the first of the three buses entered the tunnel. A bronze Mitsubishi Magna crossed over the unbroken separation line in front of this bus but had no effect on its progress.

3.2.2 The second and third buses entered the tunnel and a dark blue sedan crossed the unbroken separation line from the middle lane to the right-hand lane into the gap between the first and second buses. Almost immediately, the first bus crossed from the right-hand lane to the middle lane, increasing the size of the gap in which the dark blue sedan was travelling. The second bus commenced braking in response to the built-up traffic.

3.2.3 When the third bus entered the tunnel, its speed appeared to match the speed of the traffic in neighbouring lanes. The second bus braked as described above, and the third bus braked suddenly but impacted with the rear of the second bus.

3.2.4 The impact between the third and second bus appeared to be at low speed, but an accurate analysis of the closing speed could not be made because of the camera angle and its distance from the incident.

Mechanical Condition of the Buses

3.3 The buses involved in the collision were examined in situ by OTSI. The dash-mounted air pressure gauges on the third bus indicated that it had a full supply of compressed air for braking. Furthermore, the brake pedal was fully depressed, indicating that the brakes were fully applied at the time of impact, and was jammed in this position due to collision damage. See Figure 3.

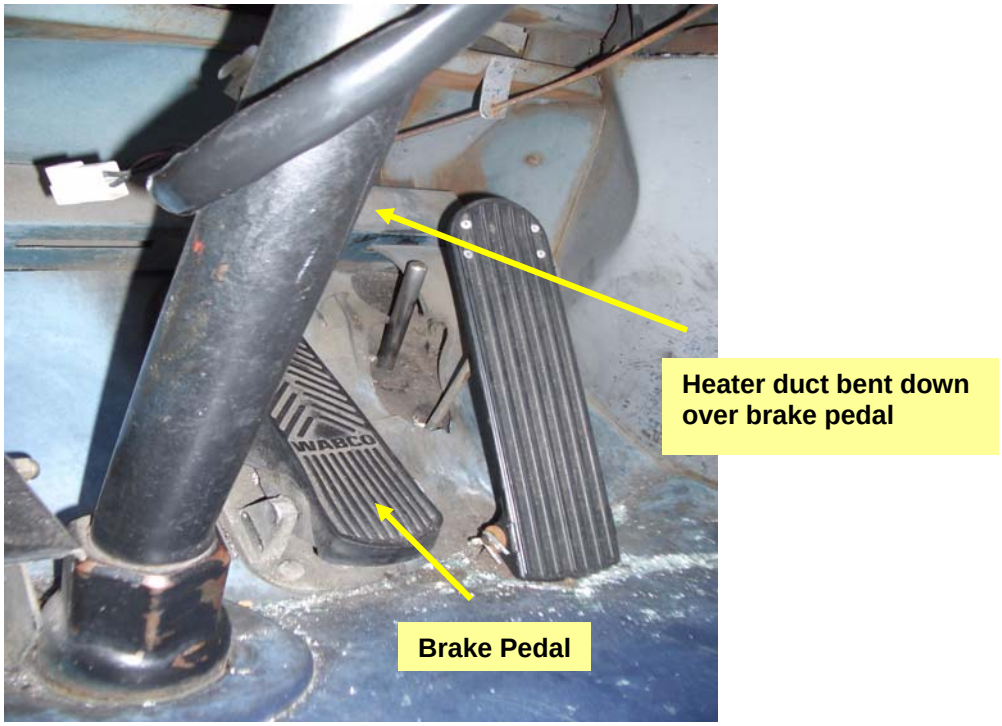

Figure 3 Brake Pedal Position

3.4 This bus was later subjected to a dynamic braking test on a brake roller testing machine. The test confirmed that the braking system worked efficiently, with the braking levels exceeding the required standards in both force and balance.

3.5 A description of the Mercedes Mk IV braking system is attached at Appendix 2.

3.6 The brake lights on the second bus were examined. Those globes not destroyed in the collision were either functioning or had indications of 'hot breaks' (see Figure 4) consistent with the globe filament being illuminated at the time of the collision. CCTV footage confirmed this to be the case.

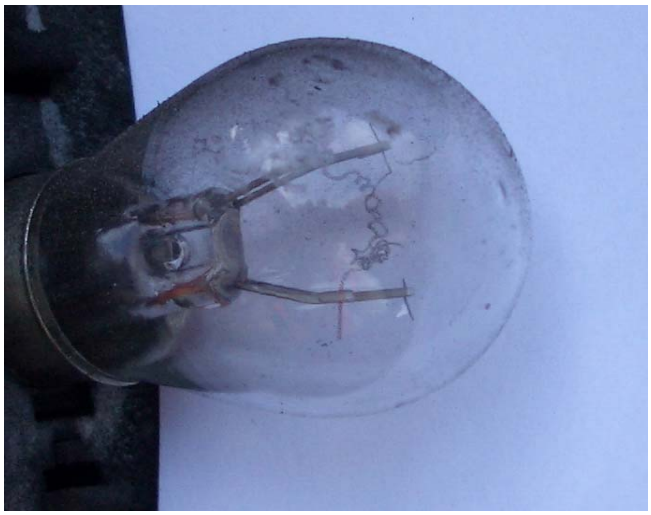

Figure 4 Stop light filament showing 'hot break' deformation

3.7 The vehicle inspection, test results and servicing records indicated that both buses were roadworthy at the time of the collision. OTSI observes that such a conclusion might have been more difficult to reach had it not prevented an STA recovery crew from attempting to release the linkage between the brake pedal and brake valve on the third vehicle, in order to release the brakes, during the recovery of the buses.

Competency Issues

3.8 On joining STA, drivers undergo a 19 day period of training. The first four days focus on induction requirements and theory of bus operations. The next eight days are spent driving a bus under the guidance of a driver trainer who holds a NSW Roads and Traffic Authority (RTA) driver trainer certification. OTSI notes that drivers already holding an MR class licence, or higher, must complete this training. At the satisfactory completion of the training, those trainees not already holding a licence, are issued with an MR class licence.

3.9 During the eight day training period, driving competencies are constantly assessed, with trainees required to demonstrate bus handling capabilities on public roads. Any identified weaknesses result in a trainee being required to undergo additional training.

3.10 On completion of the practical driving component of the course, trainees are observed for a further five days of actual bus operations where their capacity to interact with passengers is also scrutinised. Six weeks later, a further assessment is made of the trainee. If the trainee has performed satisfactorily, he/she is then subject to a month's probation during which time their performance may be the subject of further scrutiny. Thereafter, a driver will only be required to undertake retraining, revalidation or re-assessments if their performance attracts adverse attention following a reported or actual driving incident. Discreet random driving assessments are carried out on an ongoing basis, normally being conducted by driver trainers not associated with the bus operator's depot.

3.11 OTSI notes that with effect January 2006 all STA Drivers will be required, on an annual basis, to participate in a two-day Driver Skills Maintenance Program.

3.12 Data provided by STA reveals that it has in the order of 3500 drivers. There were a total of 3519 collisions in 2004. STA records show that the driver of the third bus MO2944 had been involved in 14 driving incidents since 1999 and that he had been deemed at fault by STA on ten of those occasions. The driver had been required to undergo retraining on two occasions. The driver of the second bus MO 2948 which was hit from behind, had been involved in 10 incidents and been deemed at fault on four of those occasions. Both drivers were reassessed following the collision in the ED Tunnel.

3.13 In this instance, the CCTV footage reveals that there was little prospect of the driver of the third bus avoiding the collision when the second bus braked. He had entered the tunnel at close to the speed limit; had allowed little separation between his bus and the second bus and was unable to move into the centre lane to avoid the rear end collision because there was no gap for him to do so.

3.14 STA recommends its drivers maintain a four second 'buffer' zone between vehicles, which at 80km/h equates to a distance of approximately 89m. The RTA is even more conservative, recommending a 100m gap between vehicles, which provides an even greater buffer at speeds up to 90km/h. Notwithstanding these recommended buffers, the CCTV footage captures numerous vehicles crossing the unbroken separation line between the centre and right hand lanes, indicating that it is virtually impossible for bus drivers to maintain the recommended buffer distances because vehicular traffic moves to fill these gaps when they appear.

3.15 Drivers of heavy vehicles face a dilemma in the tunnel. If they travel at a speed slower than that being observed by the majority of drivers, in an attempt to maintain the recommended separation distances, other drivers typically move quickly to fill the gap and in the process often cut in front of the bus, requiring the bus driver to brake suddenly. This dilemma is perhaps greatest as a bus driver enters the tunnel; the greater the speed differential between through traffic and merging traffic, the greater the hazard becomes as vehicles attempt to merge or change lanes. If however, the bus driver moves at the same speed as other drivers, there is little prospect of creating the separation distance.

3.16 OTSI noted that the bus drivers they interviewed had had little training in emergency braking and no opportunity to carry-out emergency braking on a bus with a simulated full passenger load. Therefore, they were uncertain as to distances required to bring their buses to an emergency stop. The drivers also expressed concern about the distractions associated with having standing passengers on board and about the consequences of emergency braking for such passengers.

3.17 To investigate these issues further, OTSI conducted a survey in which drivers were asked to respond to arrange of questions, targeting both their driving experience and behaviour, using one of the following descriptors: ***Never***, ***Rarely***, ***Sometimes***, ***Often*** or ***Always***. Of the 60 drivers who responded:

3.17.1 75% indicated **Always** taking longer to stop with a standing load of passengers .

3.17.2 52% indicated **Always** being reluctant to brake heavily when carrying standing passengers.

3.17.3 47% indicated **Always** feeling better when driving a bus in which all passengers were seated.

3.17.4 30% indicated **Often** feeling better when driving a bus in which all passengers were seated.

A copy of the Survey questionnaire is attached at Appendix 3 and a detailed summary of responses is shown Figure 5 below.

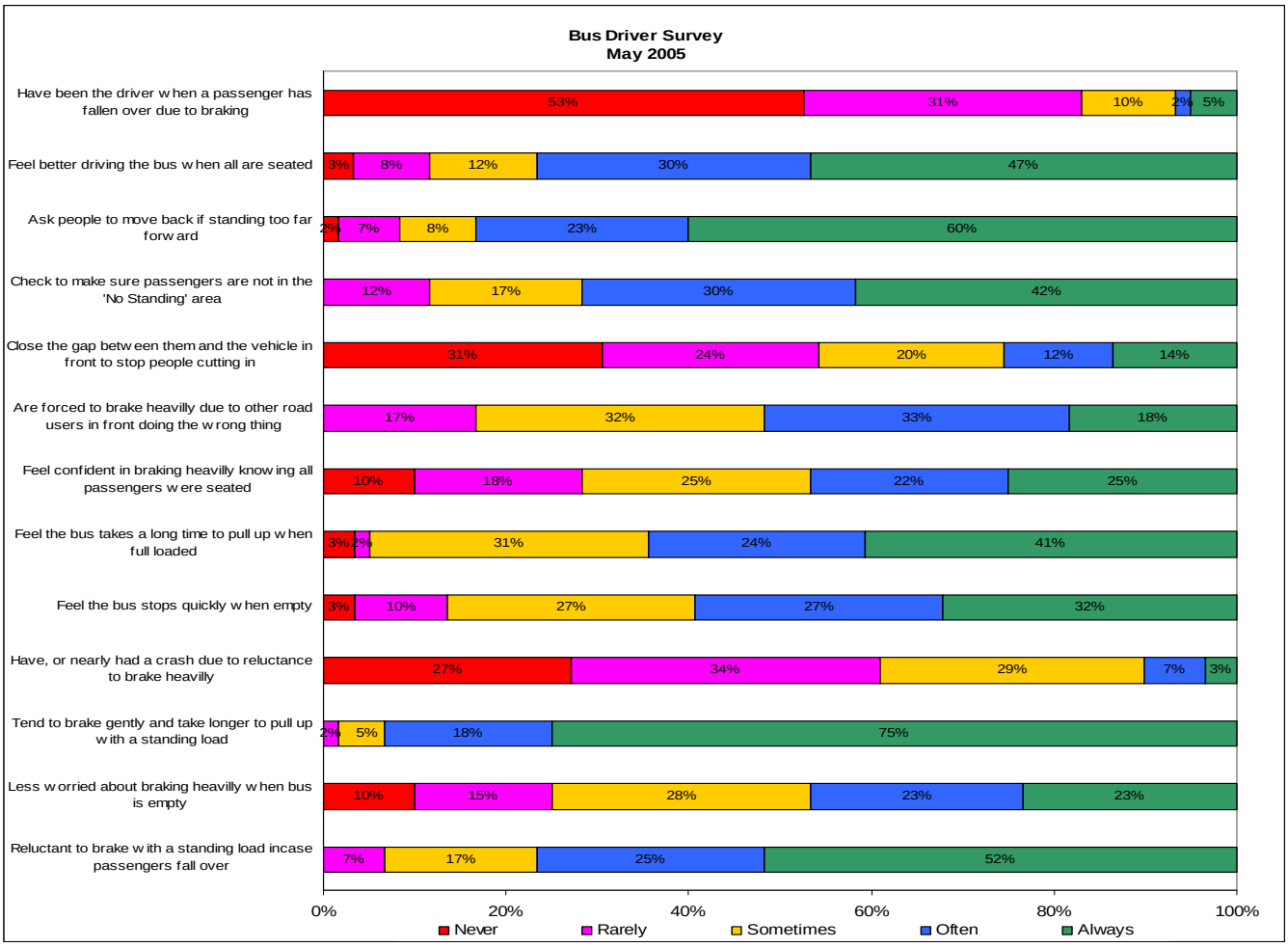

Figure 5 Bus Driving Survey

3.18 These results indicate that as well has being presented with the very real challenge of maintaining separation in areas like the tunnel, bus drivers may be reluctant to brake heavily at the earliest opportunity when confronted with a problem ahead. The obvious implication is that such reluctance results in even less stopping distance.

3.19 The drivers who responded to the survey also suggested the need for:

3.19.1 a public awareness campaign focusing on increasing the awareness of other road users, including pedestrians, to the challenges of operating a bus in the Sydney area;

3.19.2 stricter enforcement of bus lane and bus stop restrictions;

3.19.3 a public education program to increase awareness of the breadth of the bus driver'' role, and

3.19.4 carriage of seated passengers only.

3.20 Notwithstanding the challenges confronting him within the ED tunnel on the day of the accident, the Police considered the driver of the third vehicle to have been at fault and issued him with a traffic infringement notice (TIN) for negligent driving.

Emergency Response

3.21 The tunnel operator was alerted to the presence of two stationary buses within the tunnel by CCTV at 8.45AM, approximately four minutes after the collision, and acted quickly to alert other tunnel users of the problem. However, they did not appreciate that a collision had occurred; indeed even when the first ambulance arrived on site, the operator was still unaware of the collision. The tunnel operator only became aware of the accident during communication with the TMC, approximately 10 minutes after the event. In effect, this meant that the on-site response was left to the two involved bus drivers for 14 minutes until the tow truck and the first ambulance arrived. It also meant that there was no was no physical barrier between the bus occupants and the flowing traffic for 14 minutes. When the tow truck arrived at the scene, it was immediately used to block the middle and right-hand lanes to provide a safety corridor for the ambulance.

3.22 The drivers of the second and third buses had the presence of mind to contain their passengers in their buses and fortunately there was no pressing urgency to evacuate. While there are emergency exit doors situated at approximately 120m intervals along the Eastern side of the tunnel carriageway, and the nearest exit was in very close proximity to the buses, the passengers would have had to have exited from the left hand side of the buses to get to the emergency tunnel exits located on the right hand side of the tunnel. This could have exposed them to oncoming traffic in the middle lane. The configuration of the ED Tunnel, and its emergency exits, is shown at Figure 6.

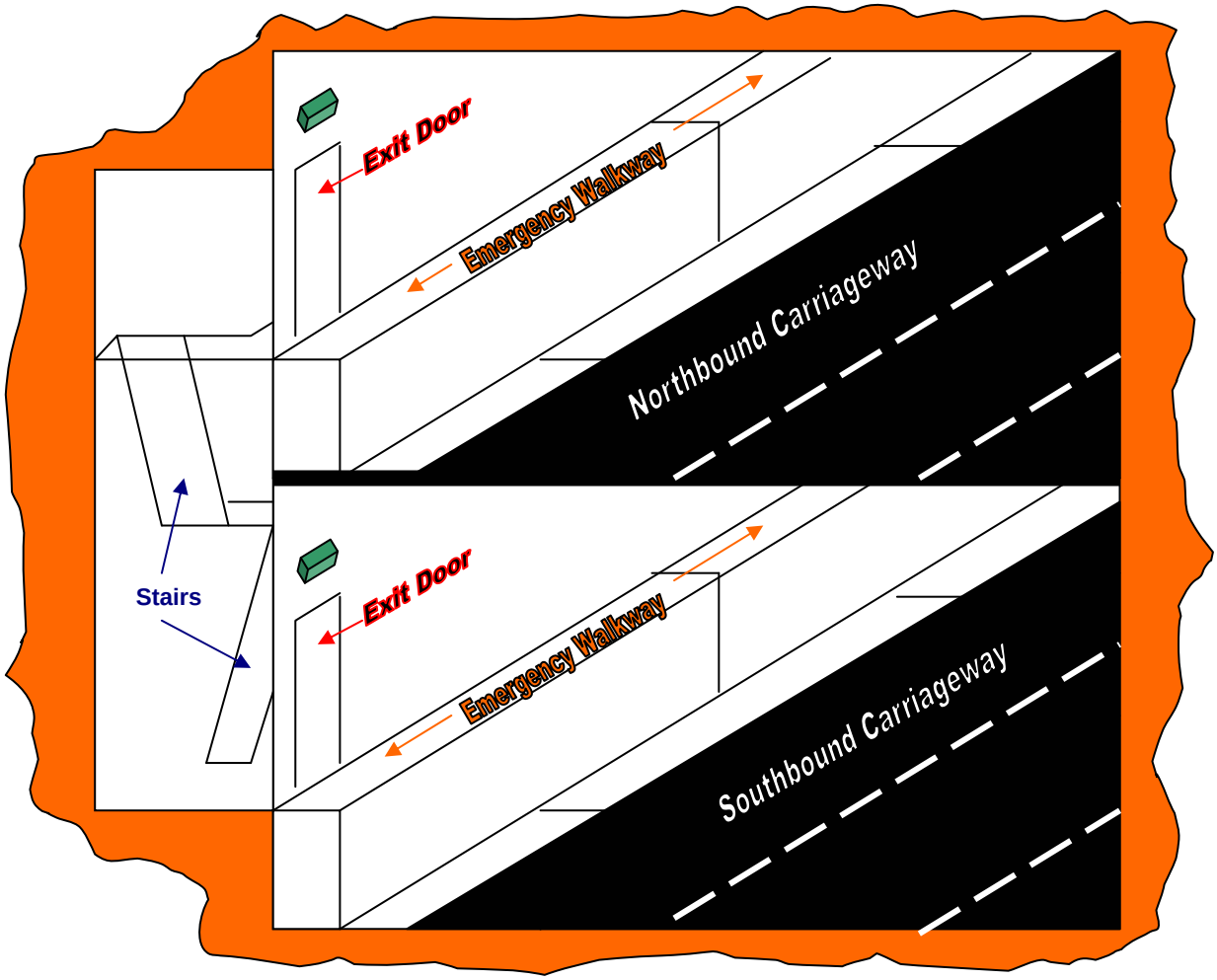

Figure 6 Eastern Distributor Tunnel Configuration and Emergency Exits

3.23 Had the bus drivers been able to communicate with STA or the tunnel operator, the tunnel operator might have appreciated their predicament sooner. However, the bus drivers could not communicate with STA from inside the tunnel and did not have the means to communicate with the tunnel operator. Fortunately, a number of the involved agencies, including the tunnel operator, were monitoring information being broadcast via police radio and this did help to clarify the emergency response requirements.

PART 4 FINDINGS

Causation

4.1 The accident occurred because the driver of the third bus failed to maintain a safe buffer between his bus and the STA bus immediately to his front.

Safety Factors

4.2 The following factors emerged as safety considerations requiring recognition but did not contribute directly to the cause of the accident:

4.2.1 The drivers of the two buses involved in the collision were approaching a long right-hand curve immediately prior to the accident and therefore had some degree of restricted visibility of the build-up of traffic beyond the curve.

4.2.2 Traffic conditions within the tunnel were, and continue to be, made more difficult by the illegal practice of many drivers crossing unbroken traffic separation lines within the tunnel.

4.3 In addition, responses to a survey of 60 STA bus drivers indicate a reluctance to brake suddenly when confronted with the prospect of a collision because of their concern for standing passengers, and a limited appreciation for their bus's emergency braking capability.

Emergency Response

4.4 The tunnel operator, Leighton Contractors Pty Ltd, was unaware initially that the two buses had collided and so its response was focused on arranging for the recovery of what it believed were two broken-down vehicles, rather than initiating emergency action that was consistent with responding to an accident. Leightons was further disadvantaged by its inability to communicate with the bus drivers involved in the accident. Similarly, the bus drivers could not communicate with STA. This could have had major consequences for the 116 people involved in the accident if the number and nature of injuries had been greater and/or had the accident resulted in a fire.

4.5 The actions of the STA bus drivers involved in the accident, in containing their passengers in their buses, reduced the prospect of further injury from passing traffic on the carriageway.

4.6 The Traffic Management Centre acted quickly to alert emergency services and the Police's broadcast communications were used to good effect to overcome the initial communication difficulties.

Part 5 RECOMMENDATIONS

5.1 The following recommendations are made to prevent recurrence of this type of bus accident:

Leighton Contractors Pty Ltd

5.1.1 Establish the means to communicate by radio with those services required to respond to emergencies within the tunnel, and

5.1.2 Implement a means of deterring drivers from illegal lane changing that is more effective than unbroken lane separation lines.

State Transit Authority

5.1.3 Enhance the driver training program to include specific training on bus stopping distances and the critical need for maintaining safe buffers between buses;

5.1.4 Ensure that bus radio communications are effective on all routes, including tunnels;

5.1.5 Implement a system which provides emergency guidance to passengers in the event that a driver becomes incapacitated. Such a system might include signage, public address systems, automated announcements and remote radio advisory systems, and

5.1.6 Educate its personnel involved in recovery operations about the need to secure and preserve evidence at accident scenes by refraining from interfering with the site condition of safety critical instrumentation, equipment and controls.

New South Wales Police Force

5.1.7 Ensure that a police radio monitoring capability is maintained at the Eastern Distributor control room to allow validation of information during emergency communications.

Ministry of Transport

5.1.8 Conduct an audit of the STA driver training program to ensure that it places appropriate emphasis on the need for safe driving above all other aspects of bus operation, and

5.1.9 Confirm that STA satisfactorily educates drivers on reaction time and hazard avoidance in line with contemporary defensive driving theory and practice.

Roads and Traffic Authority

5.1.10 Consult with STA on the viability of developing a public education program aimed at raising the publics', and in particular road users', awareness of the challenges confronting bus drivers in built-up areas.

Part 6 APPENDICES

Appendix 6.1 Design and Construction Features of Mercedes Mk IV Bus

1. The Mercedes Mk IV Bus is a full chassis vehicle, with the engine, driveline and suspension and bodywork mounted on a steel chassis. As buses are designed for the purpose of maximum passenger load, they have virtually flat frontal and rear areas. Seating is provided from the front windscreen (driver) up to the rear bulkhead of the bus, with the rear seat directly above the engine compartment and the seat back mounted against the rear bulkhead.

2. This design feature eliminates the provision of substantial crumple zones such as those built in to modern passenger cars of the monocoque design. The impact of this design on bus crashworthiness is that passengers may be seated close to the point of impact when involved in a rear-end collision. Furthermore, little energy is absorbed by the vehicle chassis, meaning much of the deceleration encountered during a collision is transferred to the load, and in the case of passenger vehicles, to the occupants.

3. Crumple zones absorb impact energy through the distortion of body work, dissipating the energy through sound and heat. Flat frontal and rear ends on buses do not allow for this engineering enhancement.

4. In a rear-end collision such as the subject of this report, the people in greatest danger are those seated closest to the impact zone, being the passengers at the rear of the bus that is struck from behind, and the driver of the bus which crashes into the vehicle in front of it.

5. The positions of vulnerability in rear-end collisions are depicted in the photographs below which are taken from the scene of the Eastern Distributor Tunnel collision.

Appendix 6.2 Mercedes Mk IV Braking System

1. An engine driven compressor supplies pressurised air to reservoirs which store compressed air for braking applications. The brake pedal operates a valve which directs a regulated charge of air to the brake chambers for each wheel. The further the brake pedal is depressed, the higher the volume and pressure of air sent to the brake chamber. Two gauges on the dash panel indicate the air available at the reservoir and the air pressure being applied to the system.

2. The braking system consists of four wheel drum brakes, with individual brake chambers activating the brake shoes via 'S' cams and automatic slack adjusters. This system is typical of the air braking systems on heavy vehicles.

3. In addition, the braking system utilises a four channel anti-lock braking system (ABS) which utilises a sensor to detect individual wheel rotation. If the ABS system detects a lock-up of an individual wheel, air pressure to the corresponding brake chamber is bled off to allow the locked wheel to continue rotating. This cycle is repeated until adhesion with the road surface is achieved, the vehicle is stopped, or the brakes are released.

4. The design purpose of ABS is to allow a driver to maintain control of a vehicle under heavy braking by preventing wheel lock-up or 'skid'. During wheel lock-up, vehicle control is lost due to the steering wheels and/or non-steering wheels becoming ineffective as they slide along the road surface rather than roll. Wheel lock-up can often result in a condition of understeer, oversteer or a combination of both. ABS maintains rolling friction, thereby allowing the driver to brake heavily while steering and maintaining the vehicle on course by preventing rear wheel lock-up. ABS is therefore of greatest benefit on slippery road surfaces.

5. The automatic transmission has three forward gears and one reverse gear, with push button selection at the driver's console. Integral to the transmission is a two stage hydraulic retarder which activates when the brakes are applied. The retarder assists in slowing the bus by providing a retardant force through the vehicle drive line. The retarder is an enhancement to the braking performance of the vehicle, not a separate braking system capable of stopping the vehicle.

Appendix 6.3 Bus Driving Survey Questionnaire

otsi
THE OFFICE OF TRANSPORT SAFETY INVESTIGATION

The Office of Transport Safety Investigations

BUS DRIVING SURVEY

The Office of Transport Safety Investigations (OTSI) has been established as an independent body with statutory powers to investigate rail, bus and ferry accidents and incidents. OTSI investigates incidents under a "no blame" philosophy, with the sole aim of creating a safer public transport system through the recommendation of safety improvements identified through incident investigations.

To assist in the investigation of a bus collision that occurred on Friday 25 February, OTSI has developed a short survey designed to enable an investigation team to gain an insight into general driving behaviours of bus drivers.

This survey aims to obtain drivers' views on how they use the bus brakes, along with some ideas regarding safety improvements.

Please complete this survey with your own views. Your responses will remain anonymous.

Instructions

Please circle the appropriate numbers, or fill in the spaces as required. If you wish to write extra comments you are encouraged to write on the survey or to enclose extra pages.

Most questions can be answered by circling the appropriate number on a five-point scale, where 1 is the most negative, 3 the neutral, and 5 the most positive response.

For example:

1	2	3	4	5
never	rarely	sometimes	often	always

If you do not find the exact answer that fits your case, use the one that is closest to it. Try to avoid neutral answers if possible.

Section One - Driving Experience (fill in the space)

1) Your gender? M F (circle)

2) Your age _____

3) Total years driving experience? _____

4) Number of years driving buses? _____

5) How experienced are you on the following bus types : **(Please circle number)**

		Never Driven	Rarely Driven	Driven Sometimes	Often Driven	Driven Most
a)	**Mercedes Mk2**	**1**	**2**	**3**	**4**	**5**
b)	**Mercedes Mk3**	**1**	**2**	**3**	**4**	**5**
c)	**Mercedes Mk4**	**1**	**2**	**3**	**4**	**5**
d)	**Mercedes Mk5**	**1**	**2**	**3**	**4**	**5**
e)	**Scania**	**1**	**2**	**3**	**4**	**5**
f)	**Volvo**	**1**	**2**	**3**	**4**	**5**
g)	**Articulated**	**1**	**2**	**3**	**4**	**5**
h)	**MAN**	**1**	**2**	**3**	**4**	**5**
i)	**Other (please state type)** _____	**1**	**2**	**3**	**4**	**5**

Section Two – Braking

	(circle the number)	**Never**	**Rarely**	**Some-times**	**Often**	**Always**
6)	With a standing load of passengers, I am worried about braking heavily in case passengers fall over and get injured.	**1**	**2**	**3**	**4**	**5**
7)	When the bus is empty, I am less worried about braking heavily.	**1**	**2**	**3**	**4**	**5**
8)	I tend to brake gently and take longer to pull up with a standing load.	**1**	**2**	**3**	**4**	**5**
9)	I have had, or nearly had, a crash because I have been worried about braking heavily.	**1**	**2**	**3**	**4**	**5**
10)	The bus stops quickly when it is empty.	**1**	**2**	**3**	**4**	**5**

	(circle the number)	Never	Rarely	Some-times	Often	Always
11)	The bus takes a long time to stop when it is fully loaded.	**1**	**2**	**3**	**4**	**5**
12)	If I knew that all passengers were seated safely, I would brake more heavily in an emergency.	**1**	**2**	**3**	**4**	**5**
13)	I am forced to brake heavily due to other road users doing the wrong thing in front of me.	**1**	**2**	**3**	**4**	**5**
14)	To stop vehicles pulling in between my bus and the vehicle in front, I close the gap.	**1**	**2**	**3**	**4**	**5**
15)	I check to make sure that passengers are not standing in the 'no standing' area.	**1**	**2**	**3**	**4**	**5**
16)	If I notice people standing too close to the front of the bus, I ask them to move back.	**1**	**2**	**3**	**4**	**5**
17)	I feel better driving the bus when all passengers are seated.	**1**	**2**	**3**	**4**	**5**
18)	I have been the driver when a passenger has fallen over due to braking.	**1**	**2**	**3**	**4**	**5**

Section Three - Safety improvement suggestions

6) Do you have safety improvement suggestions? (Please write down your ideas)

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Thank you for filling in this survey. Please contact Mike Lee at OTSI on 8263 7225 if you would like further information regarding this survey.