Rail Accident Investigation Branch

Rail Accident Report

Tram collision at Soho Benson Road, Midland Metro
19 December 2006

Department for Transport

Report 17/2007
June 2007

This investigation was carried out in accordance with:

- the Railway Safety Directive 2004/49/EC;
- the Railways and Transport Safety Act 2003; and
- the Railways (Accident Investigation and Reporting) Regulations 2005.

Any enquiries about this publication should be sent to:

RAIB
The Wharf
Stores Road
Derby UK
DE21 4BA

Email: enquiries@raib.gov.uk
Telephone: 01332 253300
Fax: 01332 253301
Website: www.raib.gov.uk

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Contents

Introduction

1 The sole purpose of a Rail Accident Investigation Branch (RAIB) investigation is to prevent future accidents and incidents and improve railway safety.

2 The RAIB does not establish blame, liability or carry out prosecutions.

3 Access was freely given by Travel Midland Metro (TMM) to their staff, data and records in connection with the investigation.

4 Appendices at the rear of this report contain glossaries explaining the following:

- acronyms and abbreviations are explained in appendix A; and
- technical terms (shown in *italics* the first time they appear in the report) are explained in appendix B.

Summary of the report

5 At 11:51 hrs on 19 December 2006 TMM trams 09 and 10, both returning from Wolverhampton St. Georges to Birmingham Snow Hill, were involved in a collision near Soho Benson Road tram stop. The Midland Metro route and the collision location are shown in Figure 1.

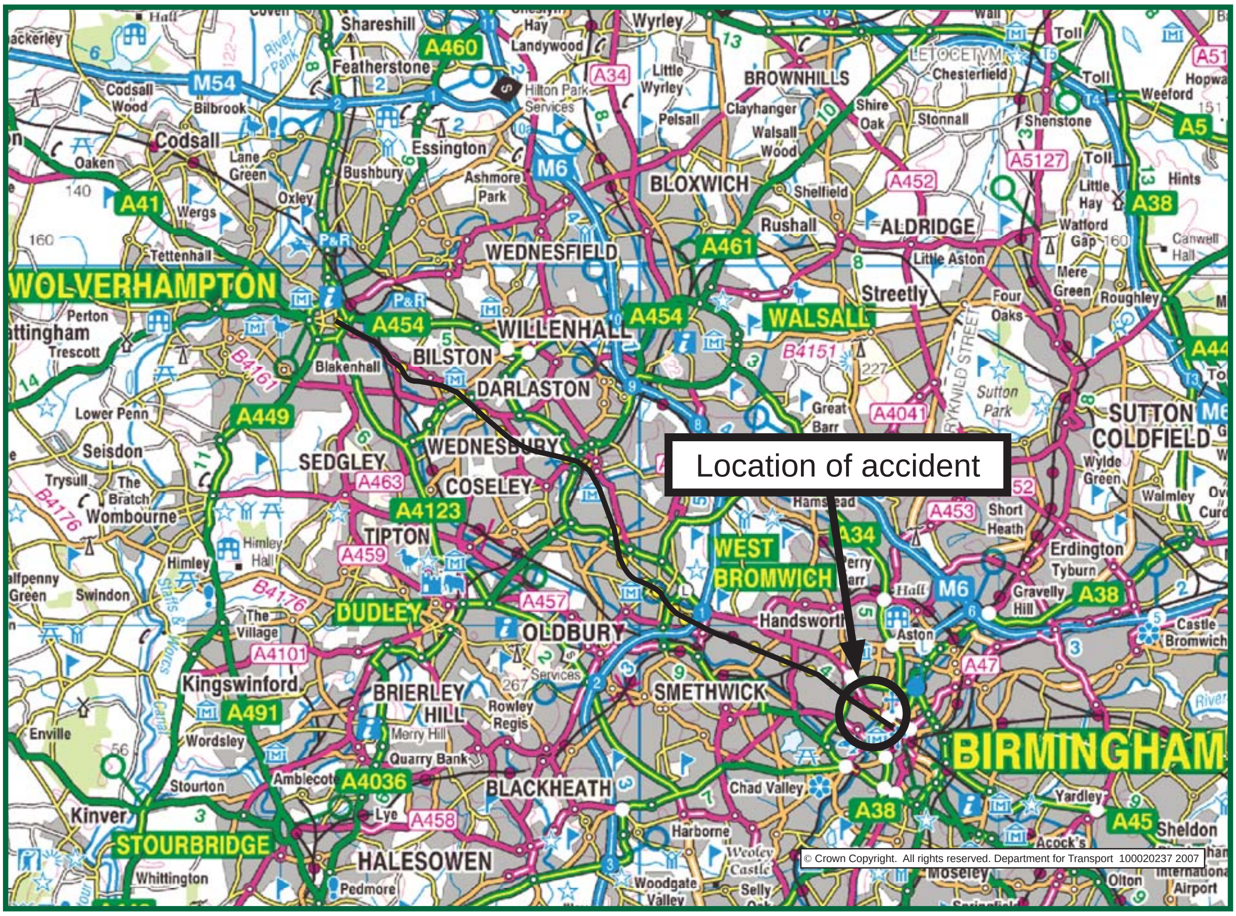


Figure 1: Extract from Ordnance Survey map showing the Midland Metro route and the collision location

Immediate cause, causal and contributory factors

6 Tram 10 did not stop short of tram 09, which was stationary due to a technical fault.

7 The causal factors were that:

a. tram 10's driver did not modify their driving technique when dazzled by the low lying winter sun; and

b. tram 10's driver was too late in applying the tram's *hazard brake*.

8 The contributory factors were that:

a. tram 10's driver had reduced vision in the direction of travel while dazzled by the low lying winter sun;

b. tram 10's driver became occupied with adjusting a sunblind that would not remain in position to screen sunlight; and

c. the TMM procedure for tram failure did not require a tram to display hazard warning lights while causing an obstruction.

Severity of consequences

9 Passengers and TMM staff sustained minor injuries as a consequence of the collision. Thirteen passengers were taken by ambulance to three local hospitals; all were discharged later the same day. Trams 09 and 10 sustained damage to their cabs.

Recommendations

10 Recommendations can be found in paragraph 104. They relate to the following areas:

- the TMM tram sunblind mechanism;
- the use of hazard warning lights; and
- the assessment of TMM's off-street tram operation.

The Accident

Summary of the accident

11 TMM tram 10, forming the 11:18 hrs service from Wolverhampton to Birmingham, collided with stationary tram 09, forming the 11:10 hrs service from Wolverhampton to Birmingham.

12 Passengers and TMM staff sustained minor injuries as a consequence of the collision. Thirteen passengers were taken by ambulance to three local hospitals; all were discharged later the same day. Both trams sustained damage to their cabs.

The parties involved

13 The Midland Metro is owned by Centro, the West Midlands Passenger Transport Executive. Centro works under the policy and financial guidance of the West Midlands Passenger Transport Authority.

14 The Midland Metro is maintained and operated by TMM under a concession granted by Centro. TMM is part of Travel West Midlands, which is in turn a part of the National Express Group.

Midland Metro system

15 The Midland Metro tramway opened on 30 May 1999. It is double track with a short section of single track near Birmingham. The tramway has 23 tram stops including Wolverhampton and Birmingham terminal tram stops. See Figure 2 for the TMM route and its stops.

16 The tramway is 20 km in length, from Wolverhampton in the north west to Birmingham in the south east. The tramway runs on-street for 2 km from Wolverhampton to Priestfield and off-street along a previously used railway alignment for 18 km from Priestfield to Birmingham.

17 The maximum speeds for off-street and on-street sections are 70 km/h and 50 km/h respectively. The normal frequency of operation is at an interval of eight minutes, and the trams operate on *line of sight* control.

Figure 2: TMM route and its tram stops

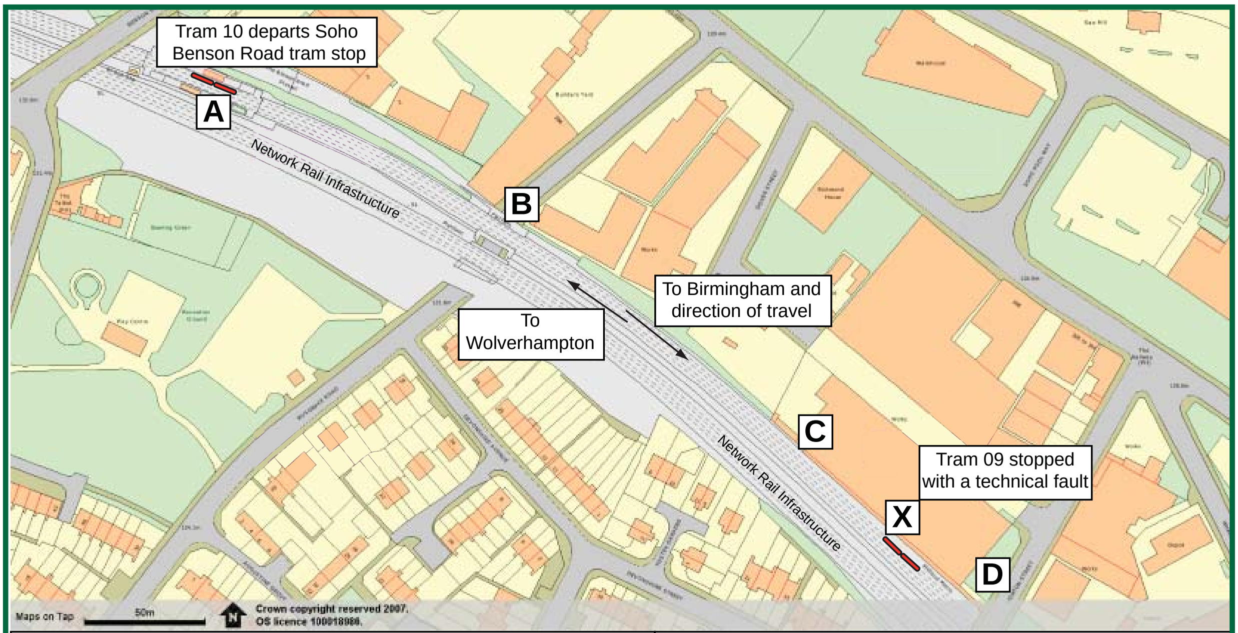
The location

18 The collision occurred between Soho Benson Road (Soho) and Jewellery Quarter tram stops, at a location 62 metres north west of Norton Road overbridge. This location is 18 km from Wolverhampton. See Figure 3.

Trams

19 The trams comprise two saloon units joined by an articulation unit. They have driving cabs at each end, raised seating areas immediately behind both cabs and a low floor. The trams operate from a 750 V DC overhead line equipment electrical supply and have a maximum speed of 70 km/h.

20 Tram braking is provided by three separate systems: (i) friction braking; (ii) *electric braking* and (iii) *magnetic track braking*. The braking systems are called to operate by the position of the *traction brake controller* (TBC) selected by a driver. If a driver selects the hazard brake position at speed, all three systems operate simultaneously.



Ref.	Description	Distance (metres)	Time (secs)	Speed (km/h)
A	Leading cab of tram 10	321	37	0
B	Musgrave Road underbridge	195	13	51
C	Brake application	45	4	64
X	Trailing cab of tram 09	0	0	24
D	Norton Street overbridge	62	N/A	N/A

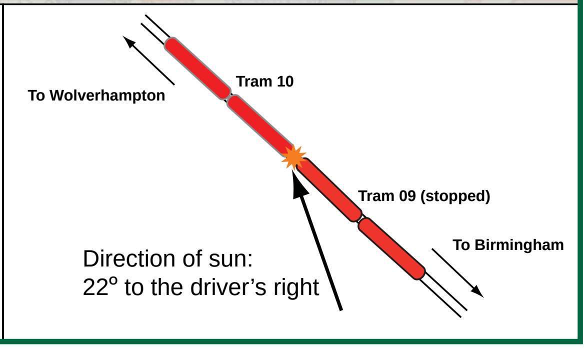


Figure 3: Location of the collision

21 At the time of the collision all communication between the control centre and tram drivers was by mobile phone following the failure of the radio system earlier in 2006.

External circumstances

22 The weather on the day of the collision was dry, sunny and still with a trackside temperature of 15 degrees Celsius. As a consequence: (i) the railhead was clean, dry and good adhesion conditions prevailed at the wheel-rail interface; (ii) visibility was good away from the direction of the low lying winter sun.

Events preceding the accident

23 Tram 09 had departed Handsworth Booth Street (Handsworth) five minutes late at 11:41 hrs when it developed a technical fault. The fault caused an automatic application of the *service brake* and brought the tram to a halt.

24 Tram 09's driver contacted the control centre using the cab mobile phone. The driver discussed the fault with the control centre and attempted to clear it by shutting down and restarting the tram as instructed. The driver did not use the tram's hazard warning lights to warn other trams of the obstruction.

25 Another technical fault occurred after tram 09 was restarted and as a result the tram was shut down and restarted a second time; on this occasion all faults cleared. During this time the driver made two further calls to the control centre; the first to advise that the tram had another fault and continued to cause an obstruction, the second to advise that the tram had resumed its journey. Tram 09 resumed its journey nine minutes behind schedule.

26 Tram 10 was running two minutes behind schedule. It was thus one minute behind tram 09 after Handsworth tram stop. See Figure 4 for a chronology of events up to and including the collision.

27 The control centre contacted tram 10 as it approached the Hawthorns and after tram 09 had twice reported its faults. The control centre advised tram 10's driver to "…beware when you approach Winson Green, we've got tram 09 in front of you...you might find him on the stop". The control centre neither advised tram 10's driver of tram 09's correct location near Handsworth nor of the minimal time interval to tram 09 ahead.

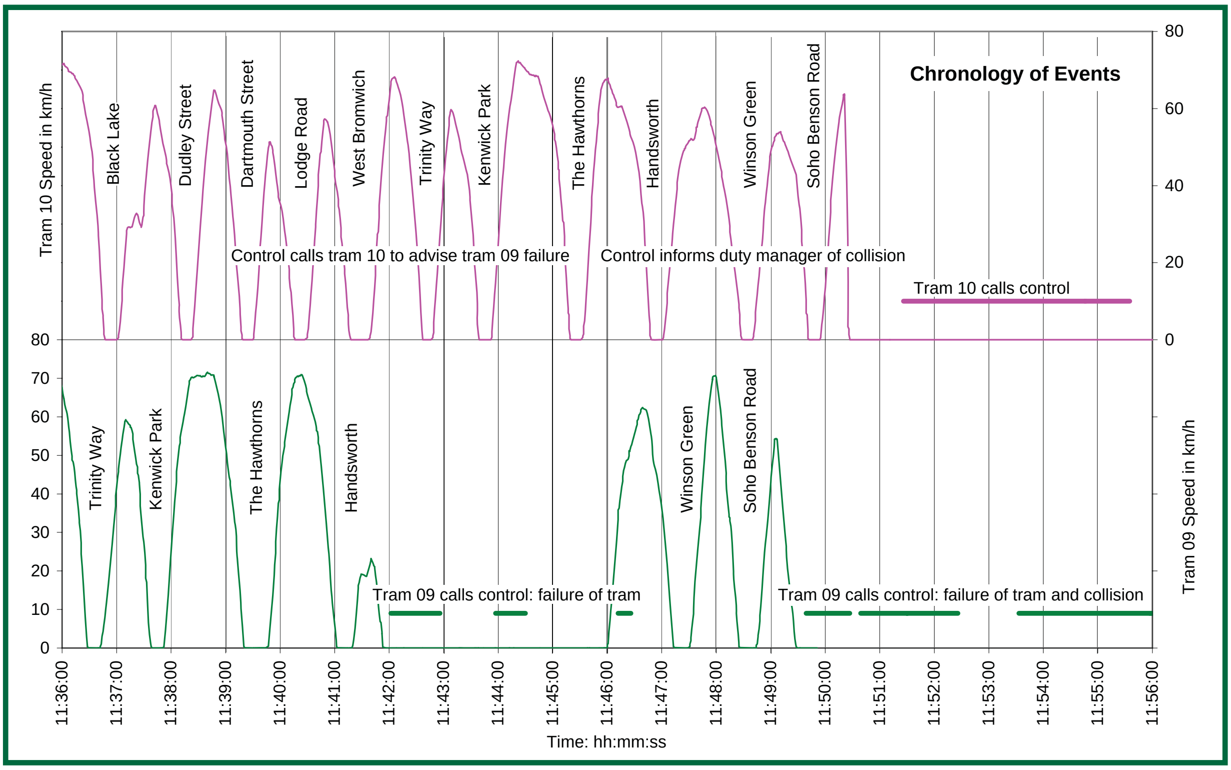


Figure 4: Chronology of events up to and including the collision

Events during the accident

28 After tram 09 departed Soho nine minutes late at 11:49 hrs the original fault reoccurred and caused an automatic application of the service brake that brought the tram to a halt 62 metres north west of Norton Road overbridge. See Figure 3. At this location, tram 09 was obscured from trams departing Soho due to right hand track curvature and vegetation on Network Rail infrastructure at Musgrave Road underbridge. See Figure 5.

29 Tram 09's driver called the control centre using the cab mobile phone and waited for the call to be answered. The driver did not use the tram's hazard warning lights to warn other trams of the obstruction.

30 Up to this time tram 10's driver had not seen tram 09 ahead at any time in its journey, even when the time interval between trams reduced to one minute.

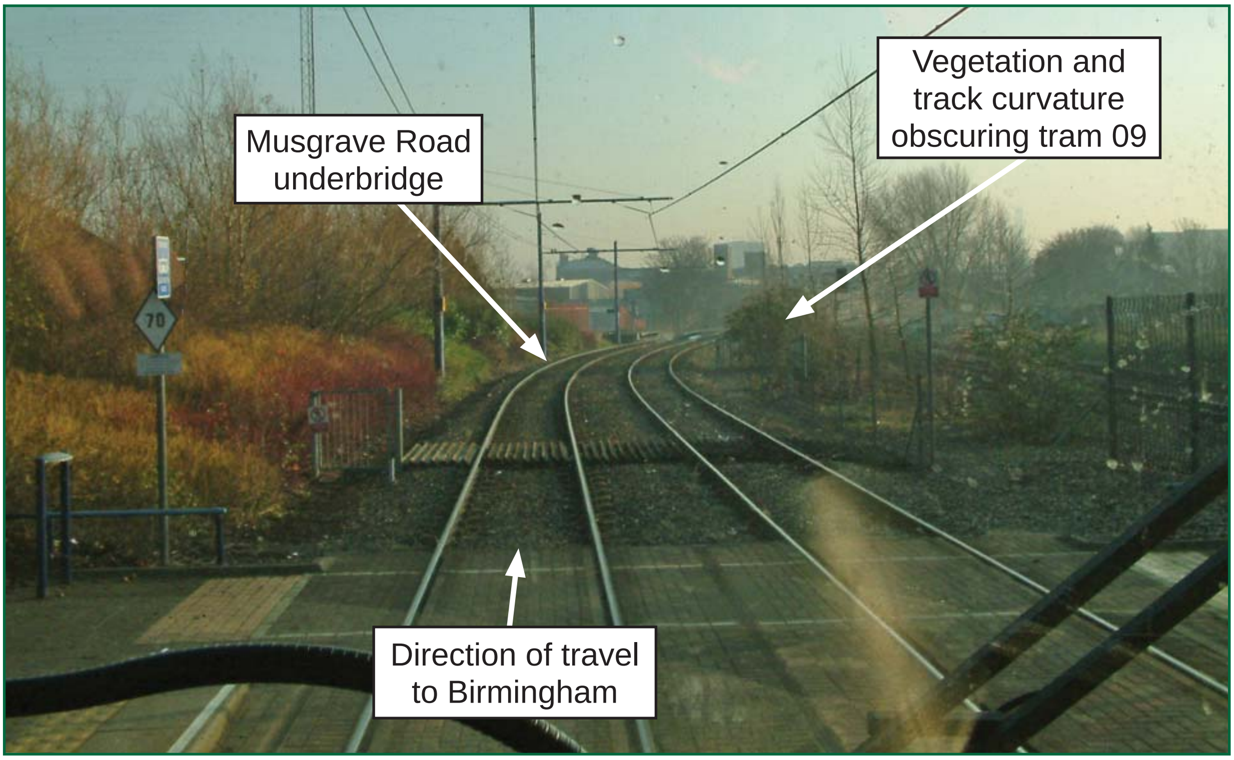


Figure 5: Tram 09 and the collision location obscured from tram at Soho

31 Tram 10 departed Soho at 11:50 hrs, passing Musgrave Road underbridge at 51 km/h and accelerating. The tram was 195 metres and 13 seconds from impact with stationary tram 09 when the driver was dazzled by the low lying winter sun. The driver reached to deploy the sunblind to improve visibility.

32 When the driver deployed the sunblind a 'wedge' of ticket roll paper fell from the mechanism. The driver released the traction brake controller (TBC) and, using both hands, attempted to reinsert the wedge into the mechanism with the sunblind in the required position. The tram continued to accelerate as the TBC remained in a position that demanded traction from the tram.

33 After three seconds an audible warning sounded to alert the driver that an automatic brake application would occur within two seconds unless pressure was reapplied to the TBC. The driver took hold of the TBC, cancelled the audible warning and sighted tram 09 ahead as the sunblind retracted involuntarily. The driver then pulled the TBC fully back to apply the tram's hazard brake. The driver heard some passengers scream at the tram's sudden deceleration.

34 Nine seconds elapsed between the driver being dazzled and tram 10's hazard brake application, by which time tram 10 was travelling at 64 km/h and was 45 metres and 4 seconds from impact with stationary tram 09.

35 Tram 10 had slowed to 24 km/h when it collided with stationary tram 09, both trams coming to rest 0.9 metres from the point of collision.

36 The control centre answered the call from tram 09's driver shortly before the collision. Tram 09's driver saw tram 10 in the offside rear view mirror and described its approach and collision to the control centre as they occurred.

37 Tram 09's driver advised the control centre that tram crew and passengers were injured as a consequence of the collision and that the emergency services were required. Tram 10's driver subsequently called the control centre to pass on the same information.

Consequences of the accident

38 Passengers and TMM staff sustained minor injuries as a consequence of the collision; 13 passengers were taken by ambulance to three local hospitals. All were discharged the same day.

39 Trams 09 and 10 sustained damage to their cabs. See Figures 6 - 9.

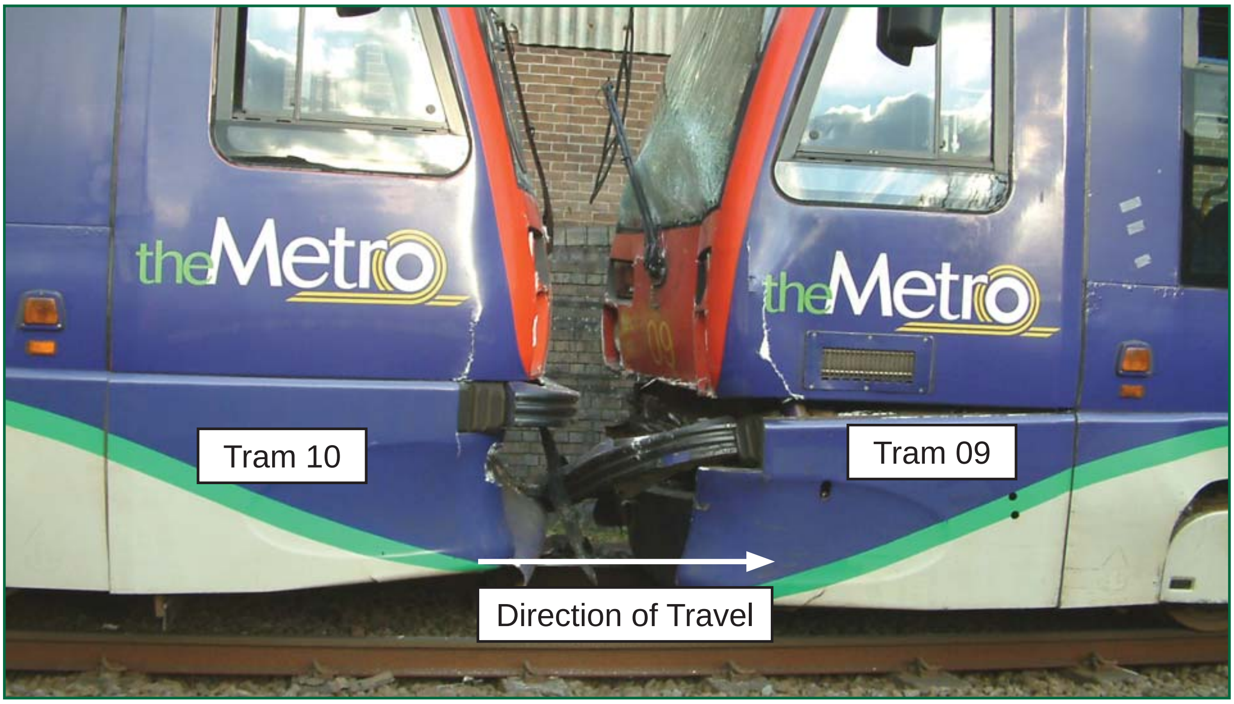


Figure 6: Trams 10 and 09 after the collision

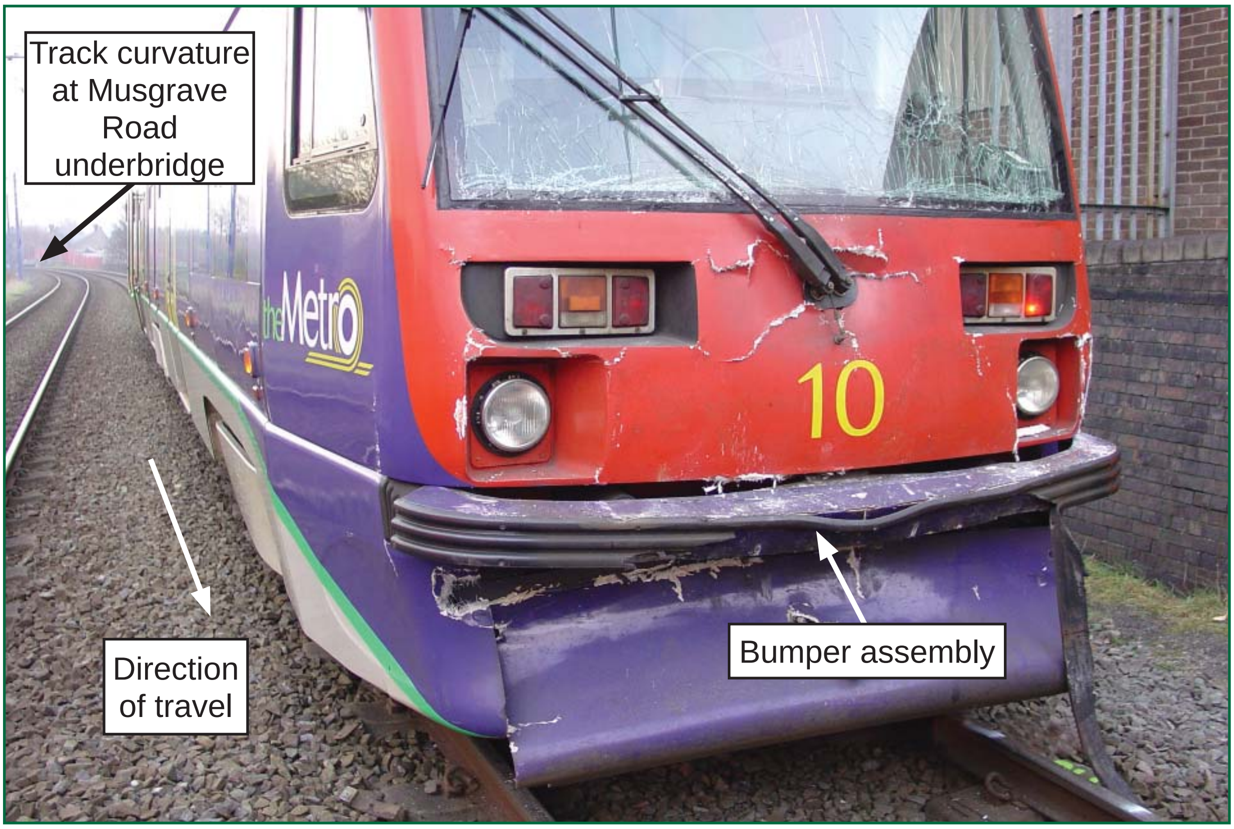


Figure 7: Tram 10 damage to cab

Figure 8: Tram 09 damage to cab

Figure 9: Inside tram 10's cab

Events following the accident

40 A motorcycle paramedic arrived on site approximately ten minutes after the collision, followed two to three minutes later by more paramedics, the British Transport Police (BTP) and the Fire and Rescue Service.

41 Passengers were taken back to Soho tram stop, the majority on foot along the *cess*, the infirm and injured by a tram operating on the adjacent line. A nearby community centre was used to accommodate those requiring attention and awaiting ambulances. Other passengers continued their journeys.

42 The drivers were breath tested by BTP at the collision site – normal procedure at an accident - and '*for cause*' tested in accordance with TMM's Drugs and Alcohol (D & A) policy at the depot. Both drivers' test results were negative.

43 Trams 09 and 10 were removed from site by 17:30 hrs and tram operation restored by 17:45 hrs on the day of the collision.

Analysis

Identification of the immediate cause

44 Tram 10 did not stop short of tram 09 which was stationary due to a technical fault.

Discounted factors

<u>Braking irregularity</u>

45 Office of Rail Regulation (ORR) guidance on tramways[1] paragraph 353 (b) states that '[Trams] should have a hazard brake with a retardation rate of at least 2.5 m/s^2'. The retardation rate of tram 10, calculated from the tram's data recorder, was 3.0 m/s^2 from hazard brake application until collision. See Figure 10.

46 With the exception of its sunblind mechanism tram 10 had performed satisfactorily; there was no evidence of abnormal operation prior to the collision. After the collision the tram was the subject of post-accident examination and brake testing. No faults were found. Tram braking performance did not contribute to the accident.

47 The railhead was clean and dry. Good adhesion conditions prevailed at the wheel-rail interface and did not contribute to the accident.

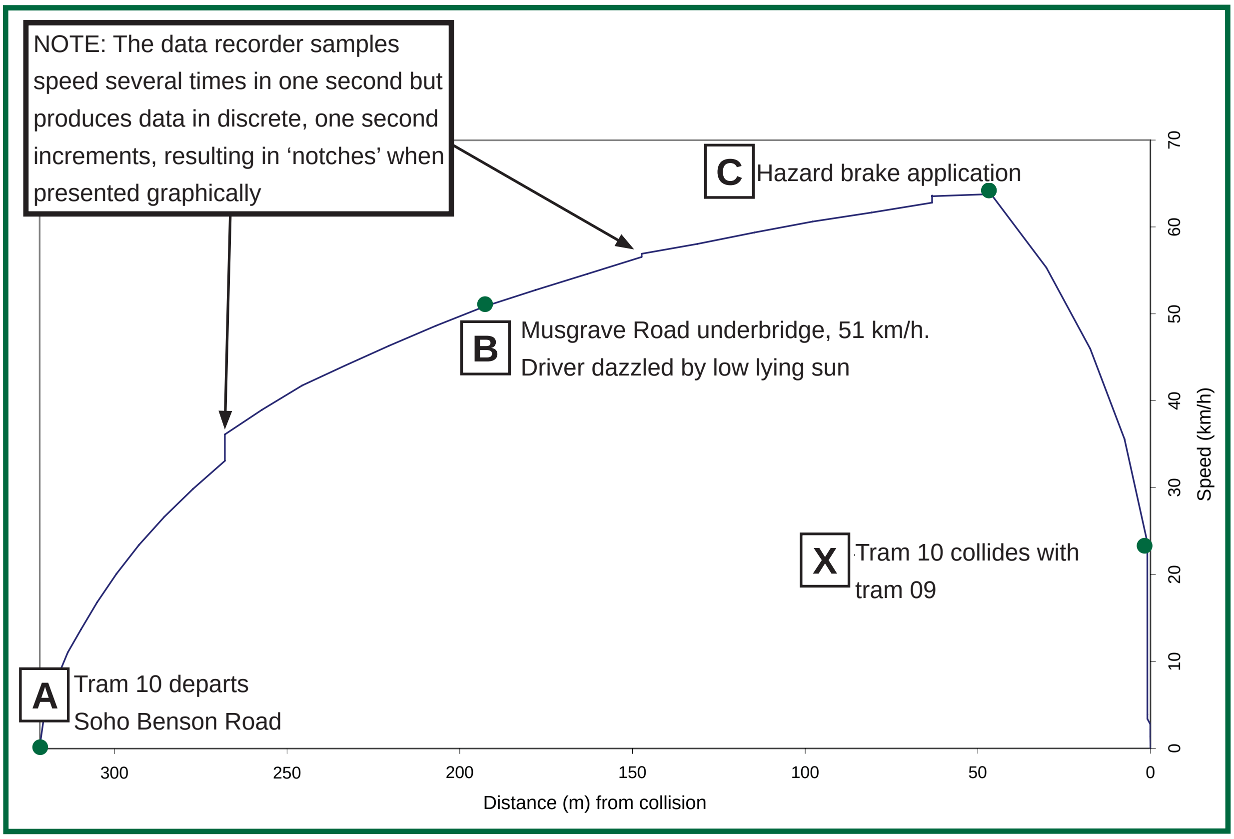


Figure 10: Tram 10 data recorder analysis from Soho Benson Road tram stop to the collision

[1] Guidance on Tramways. Railway Safety Publication 2, Published 2006.

Tram 10 driver's competence and fitness for duty

48 The driver was certified medically fit for duty in January 2005, passed out to drive TMM trams in March 2005 and was routinely re-assessed as competent to continue to drive trams on 27 September 2006. The driver signed on for duty at 06:14 hrs on the morning of 19 December 2006, returning to work after two rest days.

49 The driver's assessed competence and fitness for duty were neither causal nor contributory factors.

Identification of the causal factors

50 A site survey and reconstruction confirmed that in good visibility, a Birmingham bound tram driver has an uninterrupted line of sight from Musgrave Road underbridge to the location of stationary tram 09, Norton Road overbridge and beyond. See Figure 3.

51 Tram 10 was 195 metres distant from tram 09 as it crossed Musgrave Road underbridge at 51 km/h. If tram 09 had been sighted at this location and a hazard brake application made, tram 10 would have come to a halt and avoided collision by approximately 100 metres.

52 At this time tram 10's driver had reduced vision in the direction of travel while dazzled by the low lying sun, did not see tram 09 ahead and did not 'modify driving technique accordingly [to ensure] that speed, acceleration and braking [were] suitable for the conditions' as required by TMM's procedure for *progressive driving*[2].

53 Instead the driver released the TBC and attempted to adjust the sunblind to the required position. Sunblind adjustment and response time can account for no more than six seconds. However, the hazard brake application was not made until nine seconds had elapsed. Had tram 09 been sighted and the hazard brake applied after six seconds the tram would have come to a halt and avoided collision by approximately 50 metres.

54 The causal factors were that:

a. tram 10's driver did not modify their driving technique when dazzled by the low lying winter sun; and

b. tram 10's driver was too late in applying the tram's hazard brake.

Identification of contributory factors

Driver's reduced vision

55 The weather on 19 December 2006 was dry and sunny. Visibility was good away from the direction of the low lying winter sun. In three days it would be the winter solstice and the year's shortest day, the day on which the sun is at its lowest in the sky.

56 At 11:51 hrs the sun's position was 22 degrees to the driver's right in the direction of travel and, at a vertical angle of 13 degrees, low in the sky. The driver's line of sight turned toward the direction of the sun as tram 10 accelerated south around vegetation and the right hand track curvature at Musgrave Road underbridge. See Figure 3. At this time the driver, dazzled by the low lying winter sun, reached for the sunblind and did not see tram 09 ahead.

[2] TMM Procedure OPS-007 Progressive Driving Techniques Issue 03 May 2002 Paragraph 4.6.

57 A contributory factor was that tram 10's driver had reduced vision in the direction of travel while dazzled by the low lying winter sun.

Sunblind did not satisfactorily deploy

58 When deployed, the sunblind is supported by an extended scissor mechanism comprised of six pinned links. When retracted, the mechanism closes and the sunblind rolls into its housing. The sunblind is maintained in position by clamping force and friction at the link pin pivots; its position should not be susceptible to involuntary disturbance.

59 TMM trams are fitted with two sunblind types identified in this report as types I and II.

60 Sunblind type I, the original equipment, has a scissor mechanism with cranked links, fibre discs at its pivots, a heavy gauge blind and a thumbscrew to adjust clamping force and, in turn, the force that is required to deploy or retract the blind. See Figure 11.

61 Sunblind type II is used as a replacement for type I and has a scissor mechanism with flat links, rivet fastened pivots, a thin gauge blind and no device to adjust clamping force; the force that is required to deploy or retract the blind. See Figure 12.

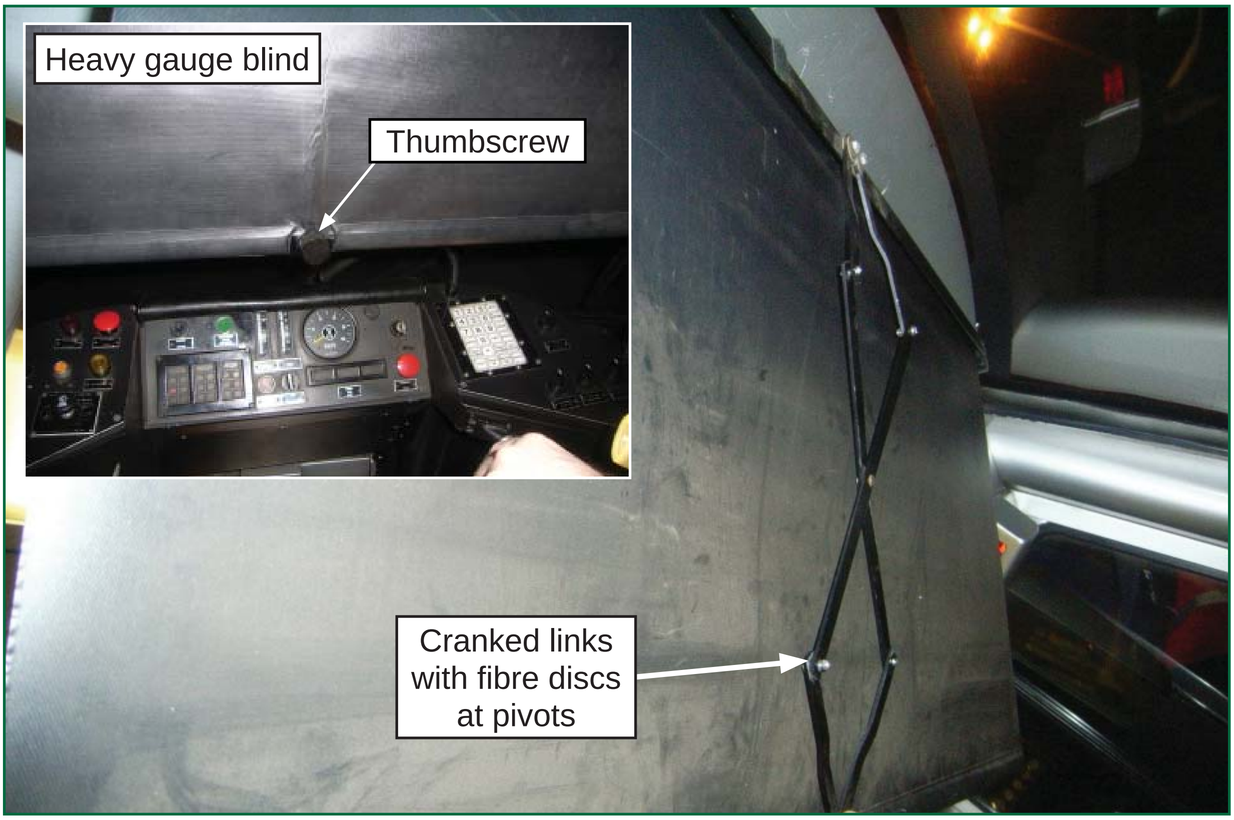


Figure 11: Sunblind mechanism - type I

62 RAIB testing found 18 sunblinds of 25 that were not fit for purpose, despite the fleet being subjected to a TMM post-accident check of sunblind mechanism performance with no faults reported.

63 The sunblinds that were not fit for purpose were either prone to involuntary retraction or not capable of operation (see Figure 13 for an example of the latter). All seven of the satisfactory sunblinds were type I, original equipment. The sunblind test results are summarised in Figure 14.

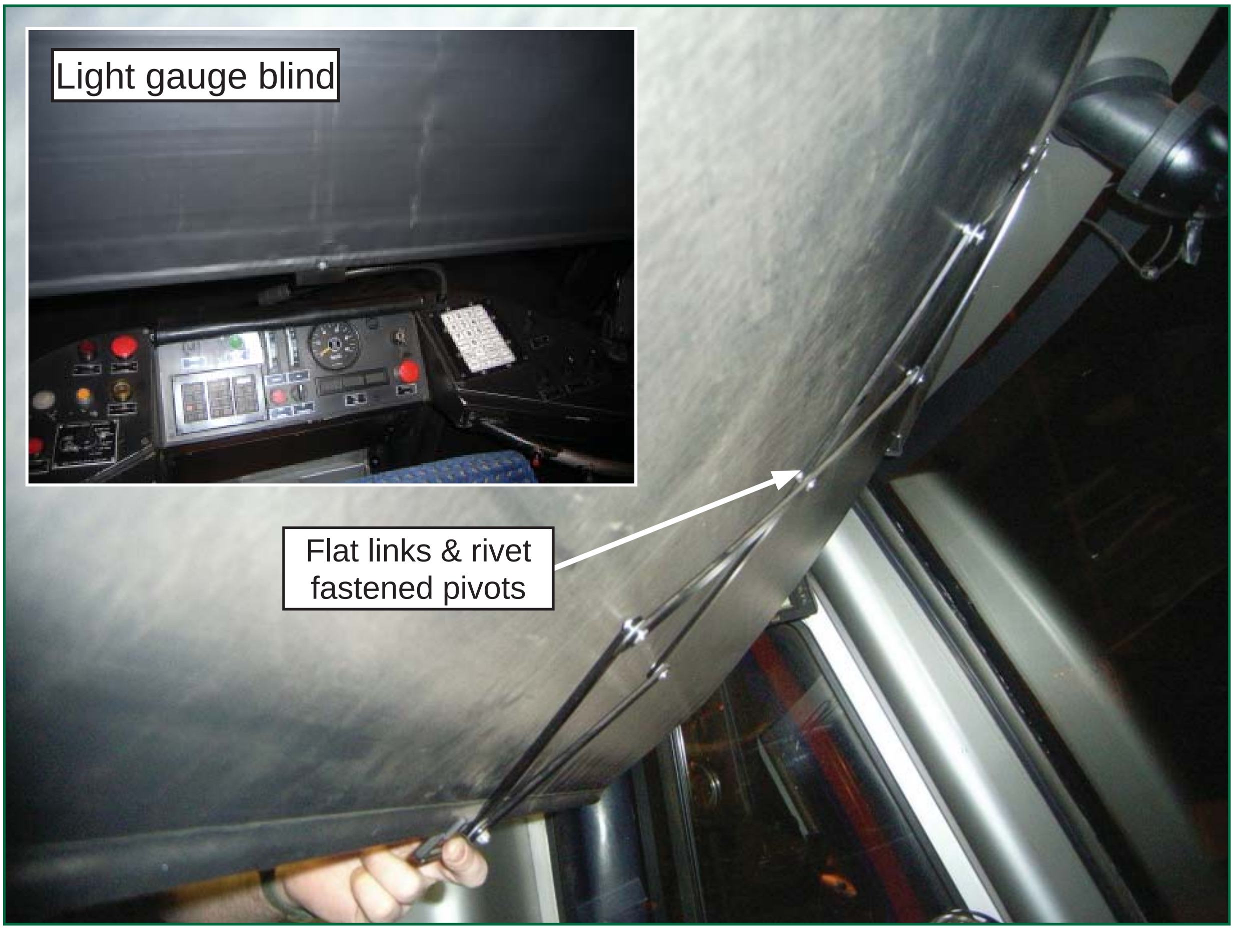


Figure 12: Sunblind mechanism - type II

Figure 13: Sunblind mechanism - type I - not capable of operation

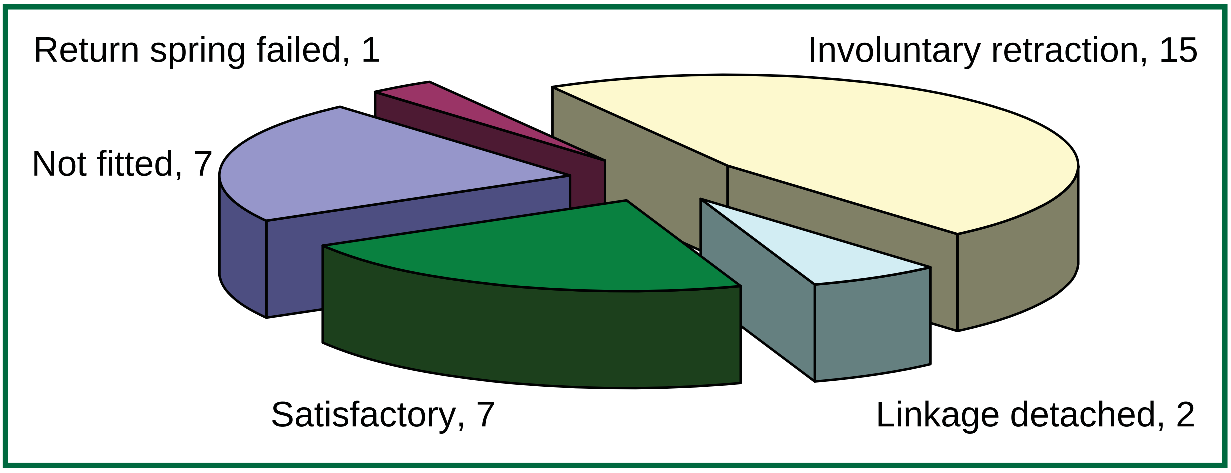


Figure 14: Sunblind test results

64 When the driver attempted to deploy tram 10's type II sunblind, a 'wedge' made from ticket roll paper fell from the mechanism. The wedge had been used by an earlier driver to prevent the sunblind from involuntary retraction, a commonplace event according to TMM staff and supported by test results.

65 The driver released the TBC and attempted to reinsert the wedge into the mechanism with the sunblind at the required position, and stated that this activity took approximately three seconds.

66 A contributory factor was that tram 10's driver became occupied with adjusting a sunblind that would not remain in position.

Tram 09 did not display hazard warning lights to warn other trams of the obstruction

67 The driver of a TMM tram operating on-street should obey the Highway Code[3]. Paragraph 96 of the Code requires a driver to display a vehicle's hazard warning lights when '…[the] vehicle is stationary, to warn that it is temporarily obstructing traffic…'. Paragraph 248 of the Code requires a driver to '…warn other traffic by using [the] hazard warning lights if [the] vehicle is causing an obstruction…'. The Highway Code does not apply to trams operating off-street.

68 TMM's arrangements for tram failure and recovery[4] do not require the use of hazard warning lights while a tram is causing an obstruction when operating off-street.

69 Drivers are shown how to operate a tram's hazard warning lights during training. TMM's ongoing assessment of driver competence takes the form of a checklist and includes a tick box for a driver's '…correct use of indicators/hazard warning lights…'. As the assessments are conducted during routine tram operation, it is unlikely that hazard warning lights are required; therefore their correct use will be assessed rarely.

70 Had tram 09 used its hazard warning lights to indicate an obstruction on the tramway ahead, tram 10's driver may have realised more quickly that tram 09 was stationary and applied the hazard brake earlier. Applying the hazard brake a second earlier at 63 km/h and 62 metres distant would have avoided collision by approximately 11 metres.

[3] The Highway Code. The Driving Standards Agency. Published 2004.

[4] TMM Procedure OPS-005 Tram Operation: Failure and Recovery Arrangements. May 2002.

71 RAIB report 11/2006 - Collision at New Addington on Croydon Tramlink – stated the importance of using hazard warning lights whenever a potentially hazardous situation occurs. Recommendation 5 stated that ‘training and routine assessments should include practice in [their] immediate use [whenever a hazardous situation occurs]’.

72 A contributory factor was that the TMM procedure for tram failure did not require a tram to display hazard warning lights while causing an obstruction.

Observations

Driver ‘conditioned’ not to expect a tram ahead

73 The causal factors of the collision - the driver did not modify their driving technique when dazzled and was too late to brake safely because of the time taken to adjust the sunblind – may be the behaviour of a driver not expecting to encounter another tram between stops.

74 While TMM drivers travel the route several times each shift, encountering another tram ahead is an uncommon occurrence with an interval between trams of eight minutes on double track infrastructure. It may be that this driver, and possibly other drivers, become ‘conditioned’ not to expect another tram ahead between stops; they may therefore be less alert than necessary for off-street, line of sight tram operation. (Recommendation 3).

Driver’s use of a hand-held mobile phone while driving

75 Although TMM installed the cab mobile phone in a desk mounted cradle with a speaker for hands-free use, they did not discourage its hand-held use by retention of the phone to the cradle. See Figure 9.

76 TMM did not formalise and enforce hands-free use of cab mobile phones while driving by procedure or assessment. On occasion cab mobile phones were used hand-held while driving because it was not possible to conduct clear, hands-free communications.

77 At 11:45 hrs the control centre called tram 10’s mobile phone as the tram slowed for the Hawthorns tram stop. The driver took the phone from the cab desk cradle with the right hand, accepted the call and held the phone to the right ear.

78 The call duration from the control centre to tram 10 was 24 seconds. The driver placed the phone back into its cradle and did not make further use of it or any other hand-held device until after the collision.

79 The driver’s use of a mobile phone while driving was neither a causal nor a contributory factor as the call took place five minutes before the collision.

Reduced line of sight due to vegetation

80 ORR guidance on tramways paragraph 207 states that ‘a tram [under line of sight control] should be able to stop before a reasonably visible stationary obstruction ahead…from the intended speed of operation, by using the service brake’.

81 Relevant considerations must be made when assessing line of sight operation, including: the available sighting distance; the speed of operation; and the braking performance of the tram, taking into account the gradient, the tram brake equipment response time and the expected driver reaction time.

82 The required line of sight at the collision location is the service braking distance plus the response time - the distance travelled during the time taken for driver perception, mental reaction, physical action and brake system activity. The response time was estimated to be 2.5 seconds.

83 At 70 km/h, a TMM tram's service braking distance is 182 metres plus 39 metres for a response time of 2.5 seconds. Therefore the required line of sight at the collision location is 221 metres.

84 The line of sight available from Soho to tram 09 was restricted to 195 metres by the right hand curvature of the tramway and vegetation at Musgrave Road underbridge. This is less than 221 metres and therefore not compliant with the requirements of ORR guidance.

85 This observation is neither a causal nor a contributory factor. The driving technique should have been to slow to a speed that would allow the tram to be braked to a halt and avoid any obstruction the driver sighted in the prevailing conditions.

Tram structural performance

86 ORR guidance paragraph 281 (b) states that '[a tram's] underframe and body, including any articulation joint, should be designed to mitigate against the effects of a collision with another tram…in a way which minimises injury to passengers [and] staff'.

87 During design the tram was the subject of computer-modelled crash simulation and analysis. The simulation considered the collision of two trams with full payloads, one travelling at 25 km/h, the other stationary and braked.

88 The computer simulation assumed a symmetrical collision of structurally equal trams and predicted permanent deformation to (i) the cabs' bumper assemblies and (ii) the cabs' structures, including floor and waist rail fabrications.

89 The accident was not a symmetrical collision of structurally equal trams; differences existed in tram vertical height due to differences in payload, suspension setup, deceleration forces and track gradient. The result of this non-symmetrical collision was that:
(i) tram 10's cab structure was undamaged; (ii) tram 09's bumper assembly was deformed vertically down and not longitudinally as predicted by the simulation; (iii) tram 09 sustained permanent deformation to its cab floor and waist rail fabrications although a driver's survival space was maintained; (iv) trams 09 and 10 sustained damage to their windscreens and glass reinforced plastic cab exteriors.

90 Structural damage was confined to the trams' cabs only. Neither tram 10 nor tram 09 sustained damage to any other structural element, including the passenger saloon and the articulation joints. The trams' collision damage compared favourably with the damage predicted by the computer simulation.

91 Tram structural performance did not influence the severity of the consequences of the collision.

Communications

92 Tram 10's driver had not seen tram 09 ahead at any time in its journey, even when the time interval between trams reduced to one minute.

93 Tram 10 was approaching the Hawthorns when the control centre contacted its driver to advise that tram 09 may be causing an obstruction at Winson Green due to a technical fault, despite it being located near the Handsworth tram stop.

94 Tram 10's driver arrived at Winson Green and Soho tram stops without encountering tram 09 and so presumed it had resumed normal operation. The control centre did not advise tram 10's driver that separation from tram 09 had reduced to one minute. The control centre was later unable, through lack of time, to advise that tram 09 was causing an obstruction beyond Soho tram stop.

95 Although the time interval between trams was significantly reduced, the non-communication of this information to tram 10 is neither a causal nor a contributory factor. The driving technique should have been to slow to a speed that would allow the tram to be braked to a halt and avoid any obstruction the driver sighted in the prevailing conditions.

Severity of consequences

96 A number of passengers on both trams were able to brace themselves before the collision; passengers on tram 10 as they became aware of the imminent collision from the sound of the hazard brake application and the sensation of deceleration and passengers on both trams as they observed the imminent collision.

97 The tram seats and handrails maintained their integrity and minimised the number of passengers that were thrown into objects and one another during the collision.

98 The severity of consequences was mitigated by passengers who braced themselves and by tram seats and handrails that minimised the number of passengers that were thrown into objects and one another during the collision.

Conclusions

Immediate cause

99 Tram 10 did not stop short of tram 09 which was stationary due to a technical fault (paragraph 44).

Causal factors

100 The causal factors were that:

a. tram 10’s driver did not modify their driving technique when dazzled by the low lying winter sun (paragraph 54a); and

b. tram 10’s driver was too late in applying the tram’s hazard brake (paragraph 54b).

Contributory factors

101 The contributory factors were that:

a. tram 10’s driver had reduced vision in the direction of travel while dazzled by the low lying winter sun (paragraph 57);

b. tram 10’s driver became occupied with adjusting a sunblind that would not remain in position to screen sunlight (paragraphs 62, 66 and Recommendation 1); and

c. the TMM procedure for tram failure did not require a tram to display hazard warning lights while causing an obstruction (paragraph 72 and Recommendation 2).

Actions reported as already taken or in progress relevant to this report

102 The failed radio system has been restored and is now operating between the control centre and all trams. TMM no longer routinely use mobile phones to communicate with tram drivers on operational matters.

103 TMM has issued an instruction that prohibits the use of personal mobile phones by tram crews during tram operation.

Recommendations

104 The following safety recommendations are made[5]:

Recommendations to address causal and contributory factors and observations

1 TMM should:

(i) modify the design of the tram sunblinds to ensure that, when deployed, they remain in position during tram operation;

(ii) amend the maintenance regime to ensure that sunblind mechanisms remain fit for purpose over their working lives; and

(iii) amend their procedures to ensure that fleet checks are carried out to a standard sufficient to correctly identify faults (Paragraph 101b).

2 TMM should amend their procedure for tram failure to require the use of hazard warning lights immediately a tram is causing an obstruction (Paragraph 101c).

3 TMM should conduct a risk assessment into their off-street operation to identify improvements that could be made in the identification of and response to unexpected hazards, including obstructions on the tramway (Paragraph 74).

[5] Responsibilities in respect of these recommendations are set out in the Railways (Accident Investigation and Reporting) Regulations 2005 and the accompanying guidance notes, which can be found on RAIB's web site at www.raib.gov.uk

Appendices

Glossary of abbreviations and acronyms — Appendix A

BTP	British Transport Police
D & A Policy	Drugs and Alcohol Policy
ORR	Office of Rail Regulation
TBC	Traction Brake Controller
TMM	Travel Midland Metro

Glossary of terms

Appendix B

Cess	The area to the side of the railway and immediately off the ballast shoulder that provides a safe path for walking.
Electric braking	The use of the traction motors as generators, the generated current being returned to the overhead power supply (regenerative braking) or dissipated as heat from resistors (rheostatic braking).
‘For cause’ testing	Testing to identify whether or not drugs or alcohol are present in a person where there are reasonable grounds to suspect that the fitness of that person might have contributed to the cause of an accident or incident.
Hazard brake	The application of full braking effort that produces maximum tram deceleration at the expense of passenger comfort. In certain circumstances, injuries may result from a hazard brake application.
Line of sight control	A method of operation that requires a tram to stop before a reasonably visible stationary obstruction ahead from the intended speed of operation by use of the service brake.
Magnetic braking	An electromagnetic friction brake applied to the railhead under hazard braking.
Progressive driving	Travel Midland Metro’s policy to achieve the defensive driving initiative promoted by HMRI.
Service brake	The application of normal braking effort that produces a tram deceleration that does not affect passenger comfort.
Traction brake controller	A handle to the driver’s left in a TMM tram cab. The TBC is pushed forward and pulled back to accelerate and decelerate the tram respectively. Pressure must be continuously applied to the TBC to avoid an audible warning sounding for three seconds and, two seconds later, an automatic brake application being made.

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Any enquiries about this publication should be sent to:

RAIB
The Wharf
Stores Road
Derby UK
DE21 4BA

Telephone: 01332 253300
Fax: 01332 253301
Email: enquiries@raib.gov.uk
Website: www.raib.gov.uk