



Rail Accident Investigation Branch

# Rail Accident Report



## Fatal accident near David Lane tram stop 15 August 2016

Report 06/2017  
April 2017

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.

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## Preface

The purpose of a Rail Accident Investigation Branch (RAIB) investigation is to improve railway safety by preventing future railway accidents or by mitigating their consequences. It is not the purpose of such an investigation to establish blame or liability. Accordingly, it is inappropriate that RAIB reports should be used to assign fault or blame, or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

The RAIB's findings are based on its own evaluation of the evidence that was available at the time of the investigation and are intended to explain what happened, and why, in a fair and unbiased manner.

Where the RAIB has described a factor as being linked to cause and the term is unqualified, this means that the RAIB has satisfied itself that the evidence supports both the presence of the factor and its direct relevance to the causation of the accident. However, where the RAIB is less confident about the existence of a factor, or its role in the causation of the accident, the RAIB will qualify its findings by use of the words 'probable' or 'possible', as appropriate. Where there is more than one potential explanation the RAIB may describe one factor as being 'more' or 'less' likely than the other.

In some cases factors are described as 'underlying'. Such factors are also relevant to the causation of the accident but are associated with the underlying management arrangements or organisational issues (such as working culture). Where necessary, the words 'probable' or 'possible' can also be used to qualify 'underlying factor'.

Use of the word 'probable' means that, although it is considered highly likely that the factor applied, some small element of uncertainty remains. Use of the word 'possible' means that, although there is some evidence that supports this factor, there remains a more significant degree of uncertainty.

An 'observation' is a safety issue discovered as part of the investigation that is not considered to be causal or underlying to the event being investigated, but does deserve scrutiny because of a perceived potential for safety learning.

The above terms are intended to assist readers' interpretation of the report, and to provide suitable explanations where uncertainty remains. The report should therefore be interpreted as the view of the RAIB, expressed with the sole purpose of improving railway safety.

The RAIB's investigation (including its scope, methods, conclusions and recommendations) is independent of any inquest or fatal accident inquiry, and all other investigations, including those carried out by the safety authority, police or railway industry.

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# Fatal accident near David Lane tram stop, 15 August 2016

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## Summary

At 22:57 hrs on 15 August 2016, a member of the public was struck by a tram between David Lane and Basford tram stops on the Nottingham Express Transit system. The person sustained fatal injuries.

The tramway between these two tram stops is not normally accessible to the general public. However, the member of the public had entered the tramway after alighting from a tram at David Lane tram stop. A tram driver had reported seeing the member of the public on this section of the tramway nine minutes before he was struck.

The supervisors in the Nottingham Express Transit control room implemented arrangements to warn tram drivers approaching the area between the tram stops. However, after a while, a supervisor formed the opinion that the member of the public had left this area of the tramway and stopped warning drivers between David Lane and Basford tram stops. This meant that the driver of the tram involved was not advised to reduce the tram's speed or exercise caution in this section.

The member of the public was by that time lying motionless along the track. The driver passed through the section at normal speed and could not see the person in time to stop the tram before striking him.

The misunderstanding happened because the supervisor thought he understood from a reporting call handled by another supervisor that the member of the public had reached Basford tram stop. The audio reception of the call was poor and the basic principles of safety critical communication were not followed during the call. Furthermore, there was no effective exchange of information between the supervisors and the misunderstanding was not detected and challenged by others in the control room.

In light of the actions already taken by Nottingham Trams Limited since the accident, the RAIB has made only one recommendation which relates to its on-going culture change programme. In addition, the RAIB has raised two learning points: one relating to using the full beam setting on trams and the other on the importance of effective safety critical communications.

# Introduction

## Key definitions

- 1 Metric units are used in this report.
- 2 The report contains abbreviations and technical terms (shown in *italics* the first time they appear in the report). These are explained in appendices A and B. Sources of evidence used in the investigation are listed in appendix C.

## The accident

### Summary of the accident

- 3 At 22:57 hrs on Monday 15 August 2016, a member of the public was struck by tram 225 in an *off-street* section of the Nottingham Express Transit (NET) system. The member of the public sustained fatal injuries during the accident. He had previously alighted from tram 218 at David Lane tram stop.
- 4 At the time of the collision, tram 225 was travelling northbound between Basford and David Lane tram stops at a speed of approximately 48 km/h. Figures 1 and 2 show the location of the accident in relation to the tram stops.

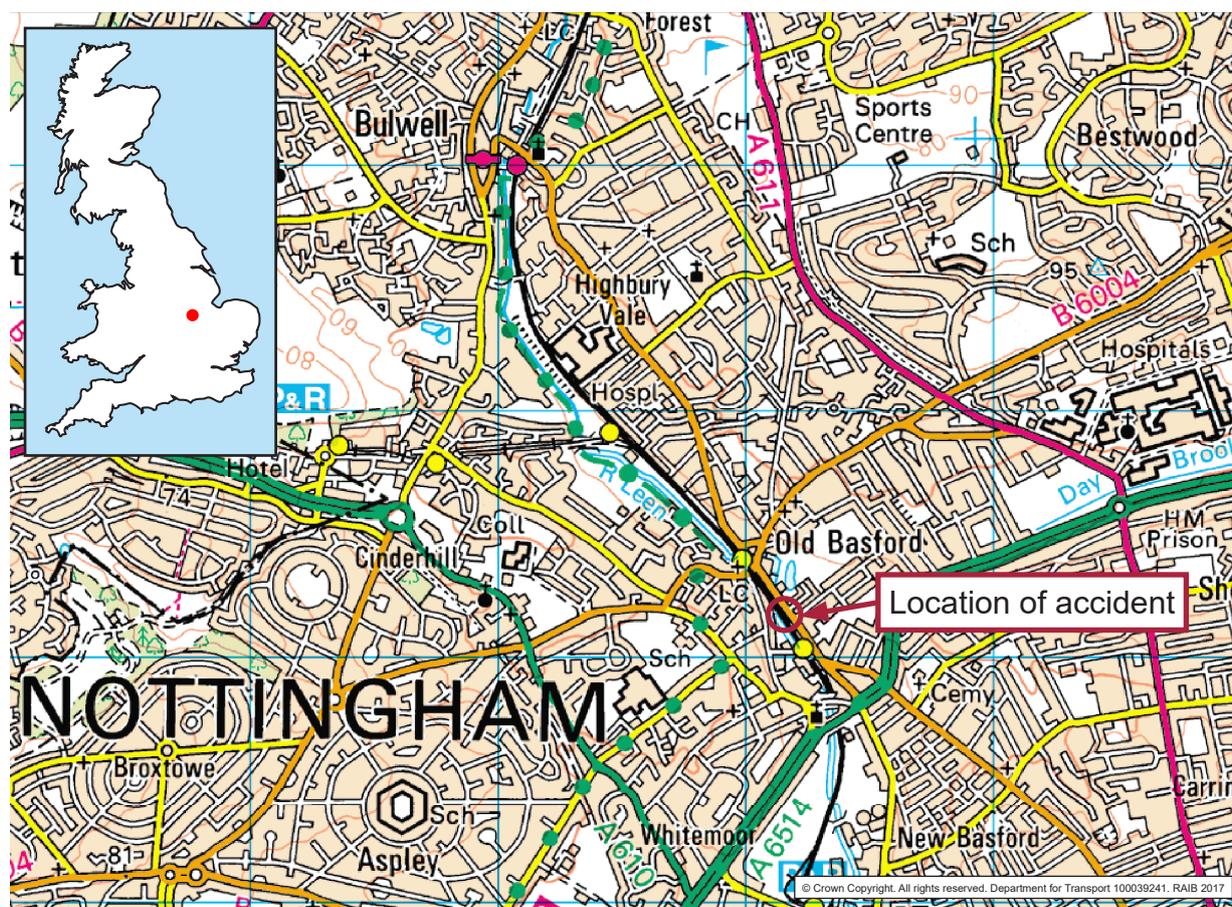


Figure 1: Extract from Ordnance Survey map showing location of accident

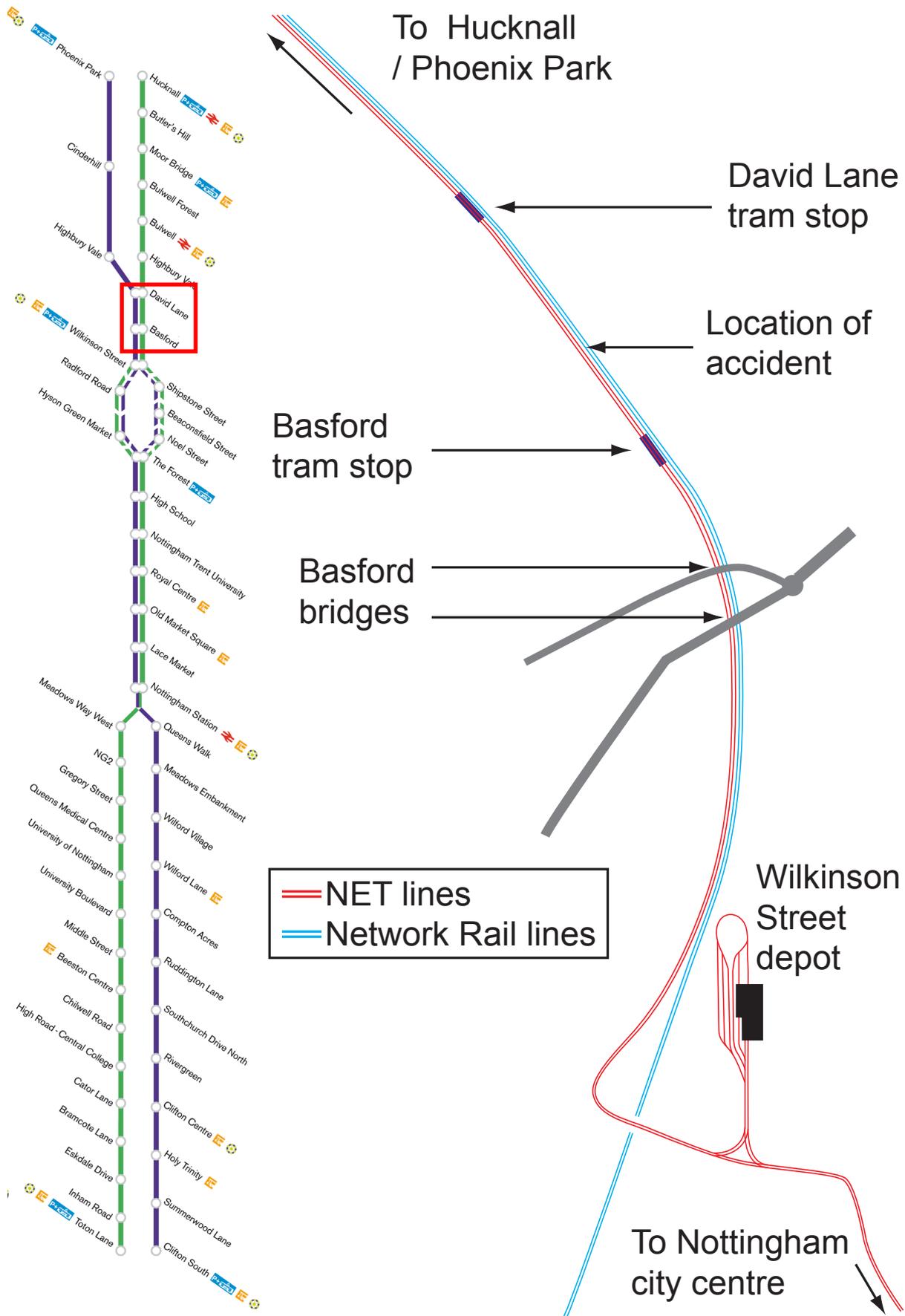


Figure 2: Nottingham Express Transit tram network (image courtesy of Nottingham Trams Limited)

## Context

### Location

- 5 Nottingham Express Transit (NET) is a tramway system in Nottingham which started operation in March 2004. A second phase, which more than doubled the size of the network to its current length of 32 kilometres, opened in August 2015 (figure 2 shows the extended network). Basford and David Lane tram stops, which were part of the original network, are the first stops immediately north of Wilkinson Street, where the tram maintenance depot is located. Between the tram stops, the tram lines are part of an off-street section that runs parallel to the railway lines operated by Network Rail and are separated from them by a continuous fence (figure 3). The speed limit between the tram stops is 70 km/h.

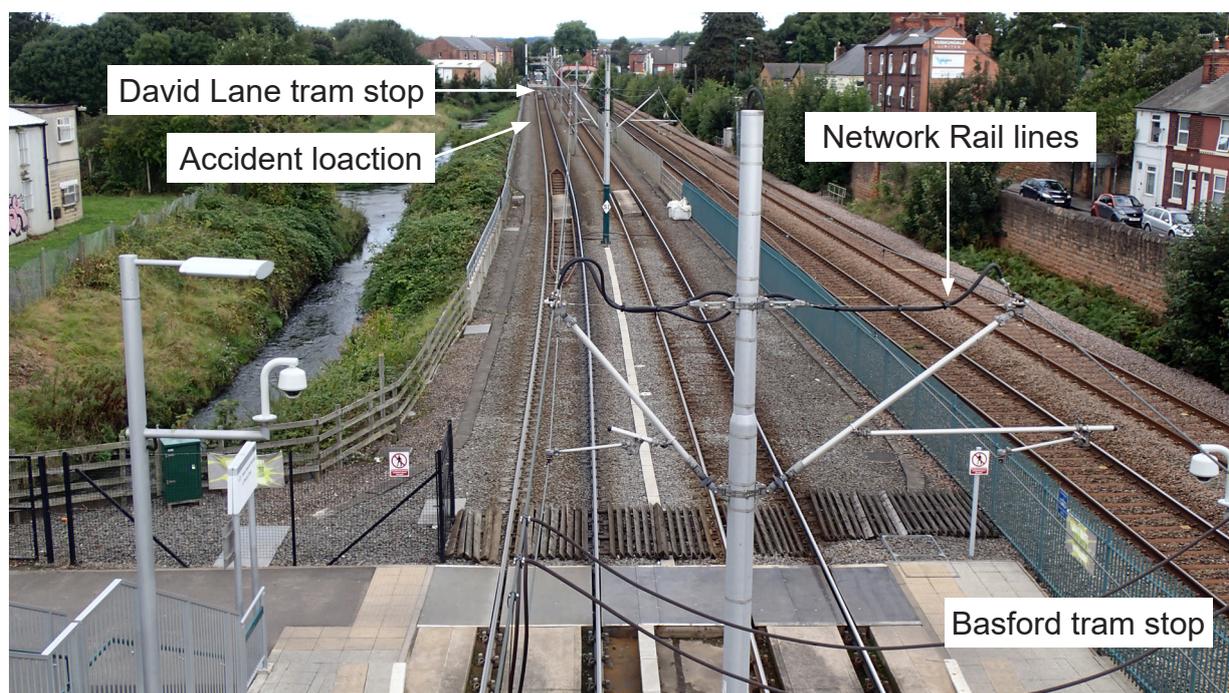


Figure 3: Track layout

### Organisations involved

- 6 Nottingham Trams Ltd (NTL) operates and maintains the NET system and employs the drivers and supervisors involved in this accident. Alstom maintains the trams at the depot in Wilkinson Street.
- 7 NTL and Alstom freely co-operated with the investigation.

### Tram involved

- 8 The tram involved, number 225, was manufactured and supplied by Alstom as part of the network extension (figure 4). It is a derivative of Alstom's Citadis brand. Tram 225 entered service in summer 2015.



Figure 4: Tram 225

### Control room

- 9 The tram maintenance depot at Wilkinson Street is also the location of the control room for the tram network. The control room is manned at all times by three service delivery supervisors (SDS) and a service delivery manager (SDM). At the time of the accident, their role was to interface with drivers, manage network operation and respond to any service disruption. Figure 5 shows the layout of the control room and the location of the three SDSs. The SDM sat in a separate office behind the control room.
- 10 Each SDS has a microphone and speakers mounted on their desk to allow them to communicate with the drivers using a *TETRA* radio system<sup>1</sup>. Each SDS also has a set of monitors on their desk presenting information from the various management systems used on the NET network (eg Supervisory Control And Data Acquisition – SCADA and Automatic Vehicle Location System - AVLS). There are two methods for the drivers of trams to communicate with the control room from the cab: a press-to-talk pedal and microphone or a wired handset. NTL's operating rules state that calls using the handset can only be made when stationary.

<sup>1</sup> The TETRA radio system technology is widely used by all emergency services in the UK.



Figure 5: Control room office

### Staff involved

- 11 The driver of tram 225 had been working as a driver for NTL for 11 years. He was last passed as competent to drive trams in January 2015; his next reassessment was due in January 2017.
- 12 The team of SDS in the control room had been working together for three years. They had all been passed as competent by NTL to work as an SDS in the control room:
  - a. SDS1 had been working for NTL for 10 years. He had been a SDS for 4 years.
  - b. SDS2 had been working for NTL for 10 years and had been a SDS for 3 years.
  - c. SDS3 was the most experienced of the SDSs, having been in the control room for 11 years.

### The member of the public

- 13 The member of the public was a 51 year-old local man who lived approximately two miles to the north-east of David Lane tram stop. Earlier that evening, he had been in Nottingham city centre.

### External circumstances

- 14 It was dark at the time of the accident, with a limited amount of ambient light being provided by the street lamps on the street that runs parallel to the Network Rail lines.
- 15 It was a dry, mild night with a temperature of 13°C as recorded at a nearby weather station in Basford at the time of the accident.

## The sequence of events

### Events preceding the accident

- 16 At 21:30 hrs on Monday 15 August 2016, SDS2 started a shift in the control room. After a brief handover, SDS2 started managing the return of the trams to the depot which takes place at around this time every night. At approximately 22:00 hrs<sup>2</sup>, SDS3 joined SDS2 in the control room and received his handover from the SDS he was replacing. He then started working, mainly checking his emails as he was returning from annual leave.
- 17 At 22:25 hrs, the member of the public boarded tram 218 at Old Market Square tram stop in the centre of Nottingham heading northbound towards Hucknall. The CCTV footage of this tram showed that he sat down towards the middle of the tram shortly after departure.
- 18 At 22:42:45 hrs, the member of the public alighted from tram 218 at David Lane tram stop. At 22:44:37 hrs, he entered the tramway next to the footbridge that goes over the Network Rail lines, having negotiated the anti-pedestrian guards fitted at this location (figure 6 shows the path he followed). He appeared to be heading back towards Basford tram stop by walking along the tramway.

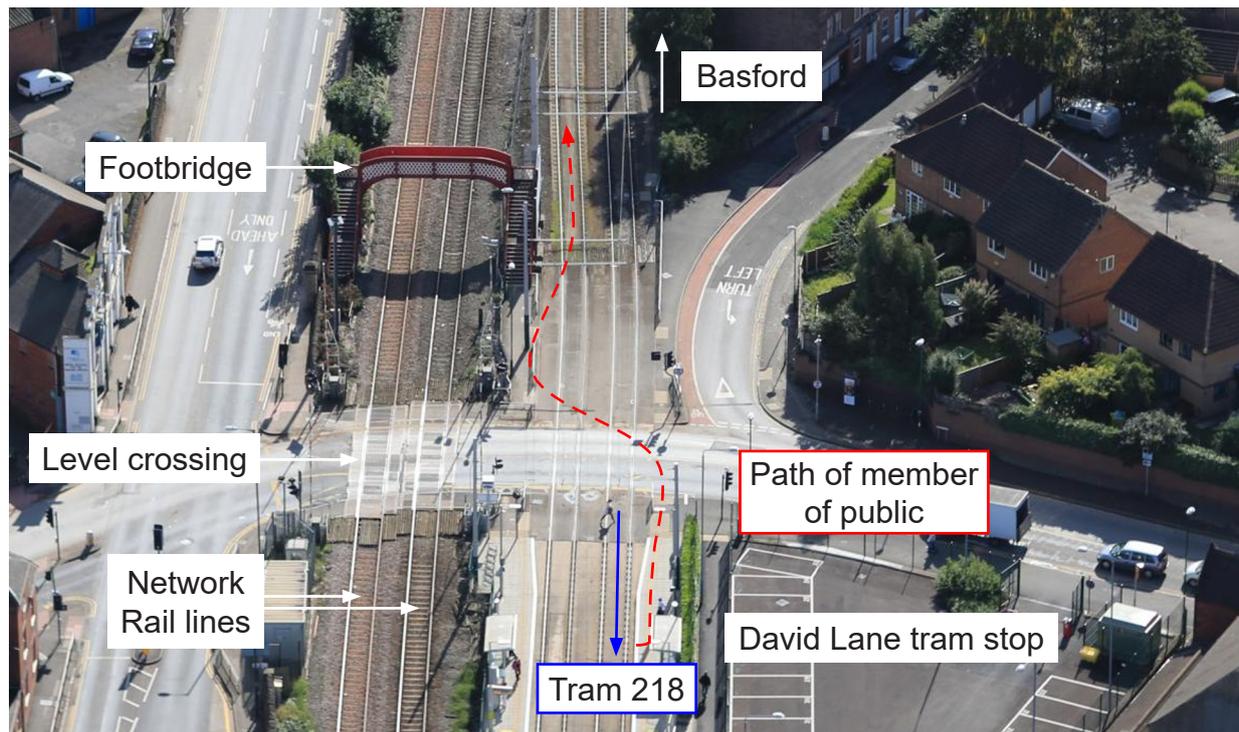


Figure 6: Location overview (courtesy of Network Rail)

<sup>2</sup> The staggered shift start time is planned to enable a consistency in managing the service during handovers.

### Events during the accident

- 19 The next tram through the area between the tram stops was tram 206 heading northbound from Basford to David Lane tram stop (figure 7). Soon after departing from Basford tram stop, the driver identified that there was a person on the adjacent line ahead of his tram. He proceeded cautiously at a reduced speed and passed the member of the public. At 22:48:18 hrs, the driver of tram 206 called the control room<sup>3</sup> and spoke to SDS3 to report encountering a person walking southbound on the southbound track a 'couple of hundred metres' from David Lane tram stop.



Figure 7: Passage of tram 206 at 22:48 hrs

- 20 At 22:48:45 hrs and while the conversation between the driver of tram 206 and SDS3 was still taking place, SDS2 placed a call to the next tram through the area, which was tram 228 (heading southbound). Having overheard the report from the driver of tram 206, SDS2 instructed the driver of tram 228 to exercise caution through the area between David Lane and Basford tram stops. Tram 228 was on its approach to David Lane tram stop at the time of the call.
- 21 At 22:49:34 hrs, tram 228 stopped at David Lane tram stop (figure 8). At 22:49:49 hrs, tram 228 departed from David Lane tram stop at low speed. The CCTV footage from that tram shows that the member of the public was still walking southbound but that he was now in the area between the two tramway lines (an area known as the *six-foot*). Tram 228 approached the member of the public from behind at walking pace.

<sup>3</sup> Drivers are allowed to call the control room on the move provided that they use the cab microphone and press-to-talk pedal. They are not allowed to use the radio handset in their cab unless the tram is stationary.

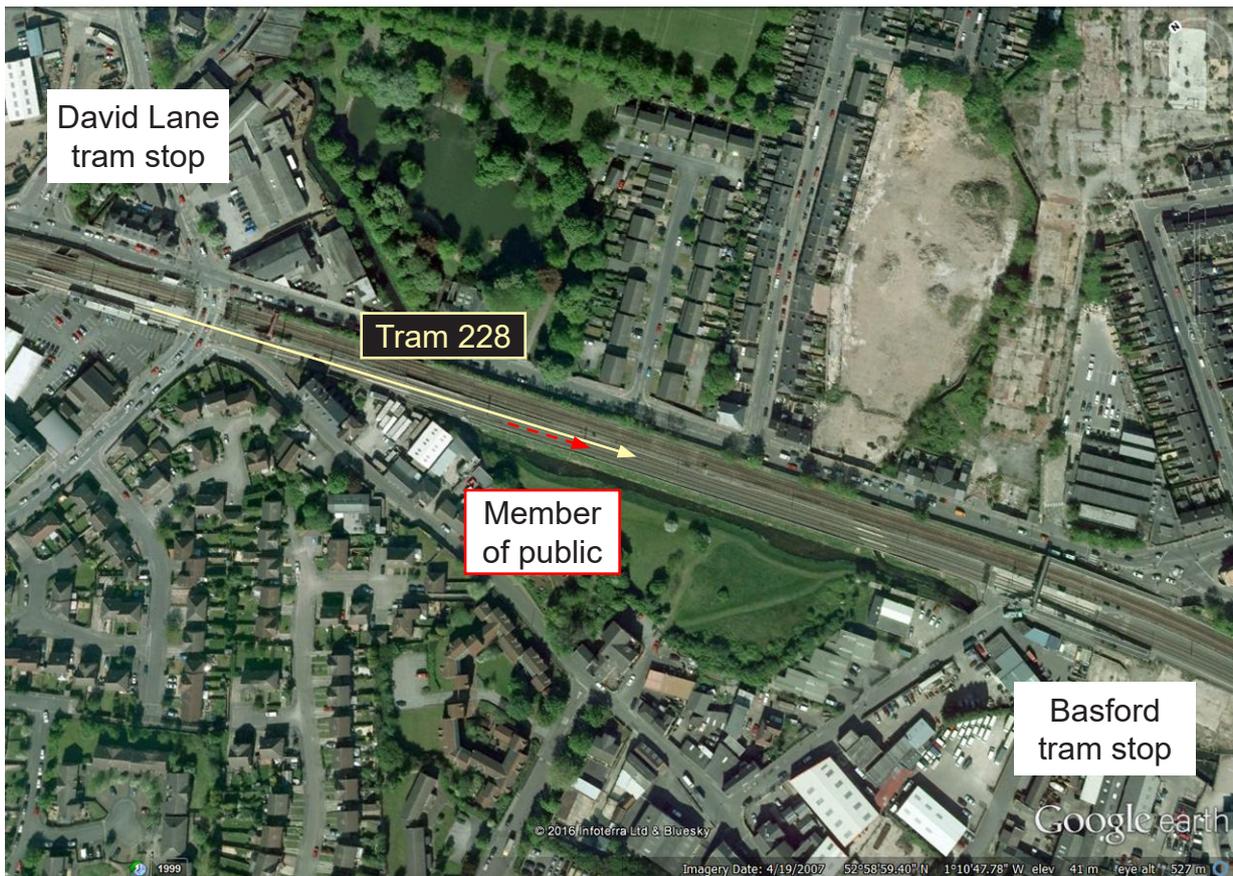


Figure 8: Passage of tram 228 between 22:49 hrs and 22:51 hrs

- 22 At 22:50:51 hrs, the member of the public reached one of the overhead power line stanchions located in the six-foot and held onto it. As he was now standing still, the driver of tram 228 decided that it was safe to pass, still driving at walking pace. Tram 228 is fitted with rearward facing cameras which look along the sides of the tram (they are used by drivers at the tram stops to confirm that it is safe to close the doors). The footage from one of these cameras shows that the member of the public left the stanchion shortly after the front of tram 228 passed him and started walking alongside tram 228. At 22:51:18 hrs, the rear of tram 228 passed the member of the public who then disappeared from the footage into darkness.
- 23 At 22:51:31 hrs and while still on the move towards Basford tram stop, the driver of tram 228 called the control room to report on the situation. The call was handled by SDS2. Witness evidence indicates that the quality of the audio reception of this call in the control room was poor. At 22:52:14 hrs and shortly after the end of the call between the driver of tram 228 and SDS2, SDS3 placed a call to the next tram travelling northbound. This was tram 225 which was stationary at Wilkinson Street tram stop.
- 24 The driver of tram 225 had signed on duty at 14:41 hrs and was on his first day back at work after two weeks holiday. He had just completed his second personal break, having rested at Wilkinson Street depot for just under an hour. He received the call from SDS3 just after entering the cab.

- 25 During that call, SDS3 advised the driver of tram 225 to exercise caution between Basford bridges and Basford tram stop and to drive no faster than 10km/h under the bridges (figure 2 shows the location of the Basford bridges between Wilkinson Street and Basford tram stops). At 22:53:02 hrs, tram 225 departed Wilkinson Street tram stop, heading cautiously towards the Basford bridges.
- 26 At 22:55:35 hrs, SDS2 placed a call to the next tram travelling southbound. This was tram 204 which was on its way to David Lane tram stop. During that call, SDS2 asked the driver of tram 204 to call back from Basford tram stop. At 22:55:52 hrs, tram 204 arrived at David Lane tram stop.
- 27 At 22:56:02 hrs, SDS3 placed a call to the driver of tram 225 to get an update. The driver of tram 225, which had passed the Basford bridges at the time but was still approaching Basford tram stop, reported seeing nothing near the bridges. SDS3 thanked the driver for the update and terminated the call. Tram 225 arrived at Basford at 22:56:38 hrs.
- 28 At 22:56:09 hrs, tram 204 left David Lane tram stop heading towards Basford at normal speed (figure 9). Tram 204 reached Basford tram stop at 22:57:00 hrs, just as tram 225 was about to depart. As instructed, the driver of tram 204 placed a call with the control room at 22:57:10 hrs during which he was asked by SDS3 to exercise caution between Basford and Wilkinson Street.



Figure 9: Passage of tram 204 at 22:56 hrs

- 29 At 22:57:02 hrs, tram 225 left Basford tram stop (figure 10). The tram accelerated and reached a speed of approximately 50 km/h about 130 metres away from Basford tram stop at which point the driver stopped accelerating.
- 30 Approximately 180 metres from Basford tram stop, the on-tram data recorder (OTDR) shows that the driver started to apply the service brake. This was in response to the driver detecting that there was something in between the rails on the track used by his tram (an area known as the *four-foot*). The driver was unaware that this was the member of the public who was now lying in the four-foot of the northbound track close to the position where he was last seen on the footage from tram 228.



Figure 10: Passage of tram 225 at 22:57 hrs

- 31 At 22:57:25 hrs, one second after applying the service brake, tram 225 struck the member of the public at a speed of 48 km/h. One second later, the OTDR shows that the driver applied the emergency brake and the tram came to a stop 42 metres from the point of collision.

### Events following the accident

- 32 At 22:57:51 hrs, the driver of tram 225, which was now stationary, placed an emergency call to the control room to report the accident. During this call with SDS2, he agreed to go outside and investigate whether his tram had hit a person or an object. He put on his high-visibility vest and took a torch, left the tram and walked in the cress back towards the point of collision.

- 33 Upon reaching the back of the tram, he discovered the member of the public lying immediately behind it. The driver returned to his cab believing the member of the public to be dead. There he reported back to SDS2 in the control room who reassured him that help was on its way.
- 34 At 23:09 hrs and under the instruction from the control room, the driver of tram 225 started detraining the passengers, having instructed them to walk in the cess towards David Lane tram stop. All passengers except one with restricted mobility had detrained by 23:12 hrs.
- 35 At 23:14 hrs, the first ambulance crew together with a member of staff from NTL arrived at the tram having walked from David Lane tram stop.

## Key facts and analysis

### Background information

- 36 The section of tramway tracks between David Lane and Basford tram stops is an off-street section of the NET network. Off-street sections are not intended to be accessed by members of the public. However, NTL's experience is that it is not unusual for a tram driver to encounter someone in these sections. Evidence gathered since the accident shows that on average, there are three reports a day of one or more members of the public being encountered in any one of the off-street sections on the network.
- 37 NTL did not have a formal process instructing drivers to report persons being encountered in an off-street section of the NET network; they were only instructed to report trespassers on Network Rail's infrastructure. However, drivers would routinely report such occurrences to the control room. The control room worked to a procedure containing instructions on the actions to take in the event of observing or getting reports of an incident (including vandalism and trespass) and applied this procedure to reports from drivers of a person being encountered in the off-street sections of the tramway. The control room would warn drivers of other trams approaching the area and expect that the person would leave the area of his/her own accord. Only if it was considered that the person might be an obvious danger to trams or trying to harm themselves, would the control room contact the police and/or send someone to site.
- 38 NTL discourages people from accessing the off-street sections of its network with the fitment of anti-pedestrian guards at the interfaces between the off-street sections and the rest of the network. Warning signs are also provided at locations where the tram infrastructure interfaces directly with an off-street section (eg at both ends of Basford tram stop which is located within an off-street section). Where the highway crosses an off-street section (eg the level crossing immediately south of David Lane tram stop), no such sign is provided. This is to be consistent with mainline railway practices where reliance is solely placed on anti-pedestrian guards where the highway crosses the railway.
- 39 The RAIB could not establish the reason why the member of the public decided to access the tramway at this location as it was not on his direct route home. However, it is evident that he was intent on doing so and that the anti-pedestrian guards did not dissuade him. Post-mortem results showed a high level of alcohol in his blood which may have impaired his judgement.

### Identification of the immediate cause

- 40 The tram driver could not bring his tram to a stop in time to prevent the collision with a member of the public who was lying on the track.**
- 41 The forward facing CCTV footage from tram 225 shows that at the time of the accident the member of the public was lying immobile on the track, in the four-foot. The RAIB has not been able to determine whether he was conscious or awake at the time. He was lying parallel to the rails with his feet facing towards Basford tram stop.

- 42 OTDR data from tram 225 shows that the driver reacted to detecting the presence of something on the track ahead of his tram, by applying the brakes. However, he could not bring his tram to a stop in time to prevent the collision. Detailed analysis of the OTDR and testing on site using tram 225, shows that the brakes were applied about 1.5 to 2 seconds after the presence of something on the track was first reliably detectable by the driver. A review by the RAIB of research shows that this reaction time is consistent with those for most car drivers responding to an unexpected event requiring an immediate brake application.
- 43 The brakes of tram 225 were tested post-accident and demonstrated to provide deceleration rates both in full service brake and emergency brake as defined in the Office of Rail and Road's (ORR) guidance on tramway operations (about  $1.3 \text{ m/s}^2$  in full service brake and at least  $2.5 \text{ m/s}^2$  in emergency brake). OTDR downloads from other trams travelling over this section before the accident indicate that it was usual for trams to be travelling at this speed.
- 44 The headlights of tram 225 were tested post-accident using the MOT test requirements for public service vehicles and found to be within the range in terms of vertical alignment (ie angled down between 1.25% and 4% for headlights higher than 850 mm above ground level). The headlight on the left-hand side in the direction of travel was pointing too far left but the RAIB considers that this is unlikely to have played a part in the accident as the right-hand side headlight was correctly aligned. Soiling of the internal parts of the headlights was also found on tram 225. In both cases the amount of light falling on an object would have been slightly reduced, which may mean that an object would be detectable from a shorter distance. Because a dark object is only detectable when light falls on a sufficient area, and taking into account the shape of the light beam, it is considered unlikely that the reduction in distance would have been significant in this accident.

### Identification of causal factors

- 45 The accident occurred due to a combination of the following causal factors:
- a. it was difficult for the driver of tram 225 to detect the presence of the member of the public on the track (paragraph 46); and
  - b. the driver of tram 225 had not been asked to reduce the tram's speed or to exercise caution between Basford and David Lane tram stops (paragraph 50).

Each of these factors is now considered in turn.

### Detecting the presence of the member of the public

#### **46 It was difficult for the driver of tram 225 to detect the presence of the member of the public on the track.**

47 In accordance with the training provided by NTL to its drivers, trams are driven using the line-of-sight principle on the entire NET system. The Railway Safety Publication on tramways<sup>4</sup> published by the ORR defines the line-of-sight principle as follows:

‘A tram should be able to stop before a reasonably visible stationary obstruction ahead from the intended speed of operation, using the service brake.’

48 The CCTV evidence shows that the member of the public was wearing dark clothing at the time of the accident. As he was lying parallel to the rails in the four-foot, he was displaying the smallest discernible cross-sectional area to the tram driver. In the RAIB’s view, he cannot be considered to represent a reasonably visible obstruction. As such the driver of tram 225 would not have been expected to be able to detect his presence on the track in time to bring his tram to a stop.

49 With the help of NTL, the RAIB conducted a series of tests at the accident site using tram 225 to determine whether the driver would have been able to stop short of reasonably visible obstructions. These tests used three different sizes of obstructions representing a standing, crouching and lying person, and various colours based on their contrast ratio with a dark background. On the basis of these tests, the RAIB concluded that the driver was travelling at a speed that would have allowed him to stop short of reasonably visible stationary obstructions. Therefore the driver of tram 225 was driving in accordance with the line-of-sight principle.

### Response to the reports of a member of public on the track

#### **50 The driver of tram 225 had not been asked to reduce the speed of the tram or to exercise caution between Basford and David Lane tram stops.**

51 Tram drivers receive instructions for dealing with out-of-course events from the SDSs in the control room. All conversations between drivers and SDSs can be heard in the control room (as a result of the desk loudspeakers) and are recorded. This allowed SDSs to work together on the same incident by acting on these conversations; a practice that had been in place since the commencement of operation in 2004.

52 On the night, the driver of tram 206 identified that there was someone on the track and reported this to SDS3. On receipt of the report from the tram driver, the SDSs followed the process for dealing with reports of trespass (paragraph 37) and SDS2 immediately started warning the driver of the next tram due through the area (tram 228).

53 At this stage, the member of the public was still walking towards Basford. The control room had no understanding of his intentions, but one option was that he intended to leave the tramway at Basford tram stop.

<sup>4</sup> Railway Safety Publication – Guidance on tramways – November 2006.

- 54 Tram 228 passed the area at extreme caution and reported back to the control room. However, the reception of this audio communication in the control room was poor, and witness evidence indicates that it was difficult for the SDSs to understand what had been said by the driver of tram 228.
- 55 Witness evidence indicates that SDS2, who took the reporting call from tram 228, thought that the member of the public was still between David Lane and Basford tram stops by the end of the call. However, witness evidence also indicates that SDS3 thought he heard the driver of tram 228 report that the member of the public had reached Basford tram stop. SDS3 did not know whether the member of the public would leave the network at Basford tram stop or continue to walk along the track. He was aware that the area around the Basford bridges is very dark and with *limited clearance*. He also knew that tram 225 was about to leave Wilkinson Street and head towards Basford. Therefore, he decided to immediately warn the driver of tram 225 to be cautious between Basford bridges and Basford tram stop.
- 56 Witness evidence indicates that SDS2 overheard SDS3's call to the driver of tram 225 and that SDS2 focused on the speed limit instruction from SDS3 to the driver of tram 225 (10 km/h), instead of the location SDS3 gave (which differed from SDS2's understanding). Nevertheless, SDS2 called southbound tram 204 three minutes later and asked the driver to call back from Basford tram stop so that he could be cautioned between Basford and Wilkinson Street. This call confirmed to SDS3 that SDS2 also thought that the member of the public had reached Basford tram stop.
- 57 Having being cautioned between Wilkinson Street and Basford, the driver of tram 225 drove at less than 10 km/h under the Basford bridges. He reported seeing nothing when contacted for an update by SDS3. This led SDS3 to believe that the member of the public had left the tramway at Basford tram stop and he did not caution driver of tram 225 between Basford and David Lane tram stops.
- 58 This causal factor arose due to a combination of the following:
- SDS3 misunderstood the reporting call from the driver of tram 228 to SDS2 (paragraph 59);
  - SDS3 acted on an overheard call (paragraph 63); and
  - SDS3's misunderstanding was not detected and challenged by anyone in the control room (paragraph 65).

Each of these is now considered in turn.

### SDS3 misunderstanding

#### **59 SDS3 misunderstood the reporting call from the driver of tram 228 to SDS2.**

- 60 Witness evidence indicates that during the reporting call from the driver of tram 228 to SDS2, the location of the member of the public between the tram stops was not mentioned. The only indication provided during the call about the location was that he was 'in between both tracks' (ie in the six-foot). Having overheard the call, SDS3 thought he had heard the word 'Basford' and took it to mean that the member of the public had reached Basford tram stop, which was not the case.

- 61 This misunderstanding occurred because of poor safety critical communications between SDS2 and the driver of tram 228. SDS2 did not take the lead in the conversation, did not ask important questions such as the location of the member of the public, and did not repeat back the message received<sup>5</sup>. Had this taken place it may have reduced the likelihood of SDS3 misunderstanding the message.
- 62 SDS3's understanding was also compromised because the quality of the audio reception of the reporting call in the control room was poor. The TETRA radio system was introduced on the NET network during summer 2014 as part of the extension. The quality of the radio reception was assessed at the time by the company providing the system and was found to be acceptable between Basford and David Lane tram stops. Since then the quality of calls received in the control room has been found to be variable without any specific emerging trend (eg from a specific location). The quality of calls received by drivers in the cab of the trams appears to be good. Since its introduction and in response to comments from the SDSs, NTL has implemented some changes (eg different speakers on the SDS' desks) but without any noticeable improvements. As part of its contract delivery, the supplier of the radio system carried out an audit in July 2016 where the SDSs and SDMs provided negative feedback on the system. Since the testing and commissioning of the radio system in summer 2015, NTL has been working with its supplier to determine the cause of the technical problems (paragraph 95d).

### *SDS3 acting on overheard call*

#### **63 SDS3 acted on an overheard call.**

- 64 SDS3 warned the driver of tram 225 on the basis of information he heard in the exchange between the driver of tram 228 and SDS2. There was no process for the recipient of the information (SDS2) to formally pass the information to SDS3 who was to warn the driver of tram 225. Furthermore, having both listened to the same call, they had formed different views as to the content of the message. However, they did not confer to discuss their respective understanding before taking actions. An exchange between the SDSs might have highlighted that they had reached a different understanding.

### *Misunderstanding not detected or challenged*

#### **65 SDS3's misunderstanding was not detected and challenged by anyone in the control room.**

- 66 SDS2 could have challenged SDS3 on the instruction given to the driver of tram 225, but did not. This is probably because SDS2's understanding of the reporting call by tram 228 was not a very confident one. If SDS2 had followed the basic principles for safety critical communications, SDS2 would have been in a better position to challenge SDS3 on his instruction to the driver of tram 225.
- 67 As well as SDS2 and SDS3, SDS1 was also in the control room at the time. He had arrived at around 22:35 hrs and had just completed his handover. Although he took no part in the management of the events, witness evidence indicates that he was listening to the calls and that he too formed the view that the member of the public had reached Basford tram stop. There was therefore no reason for him to challenge the instruction of SDS3 to the driver of tram 225.

<sup>5</sup> Repeating back the message received is a key feature of safety critical communications as it ensures that both parties have reached a common, clear and unambiguous understanding.

- 68 The SDM on duty that night was working in the office behind the control room. He was unaware of the developing events until after the accident.

## Identification of underlying factors

### Management of safety critical communications

#### 69 **NTL's senior management did not manage the risks associated with deficiencies in safety critical communications effectively.**

- 70 A review of the voice communications on the night of the accident showed that the quality of the SDSs' safety critical communications was not good. The terminology used by the SDSs during the communications was not appropriate, given the seriousness of the incident, and their manner of communication was casual. NTL's senior management has stated that it had already recognised the need to address some aspects of the control room staff behaviours and had, in June 2016, made provisional allowance in its budget for 2017 to undertake a cultural change programme<sup>6</sup>. NTL expects that this programme will have an overall beneficial effect on the safety of its operations, including in safety critical communications in the control room. However, at the time of the accident, this programme was still under development and had not been implemented.
- 71 NTL was aware of the issues associated with the quality of the audio reception in the control room (paragraph 62). All reports of poor radio audibility were recorded as faults and were investigated by the supplier under equipment warranty but without any noticeable improvements.

## Factors that were not causal to the accident

### Headlight setting

- 72 At the time of the accident, the headlights on tram 225 were in the dipped beam setting. NTL expects its drivers to follow the guidance given in the Highway Code to road users (including being aware of other road users when using the full-beam). This guidance leaves the usage of the full-beam to the discretion of the individual driver.
- 73 With the help of the police and NTL, the RAIB compared the distance at which the presence of a person dressed in dark clothing and lying in the four-foot becomes detectable in dipped and full-beam setting. This testing was undertaken at the accident site using tram 225. This demonstrated that, while enabling an earlier detection of the presence of the member of the public by approximately one second, using the full-beam setting would not have prevented the accident, as there was still insufficient time to stop the tram before a collision.

<sup>6</sup> NTL stated that all control room staff had also been re-briefed in communications as part of the introduction of the new equipment associated with the network extension; the records show this took place in 2014.

## Factors associated with the emergency response

### Detrainment

74 **The driver of tram 225 had to detain the passengers on his own, having just been involved in a fatal accident.**

75 Following the accident, the control room instructed the driver of tram 225 to detain the passengers. As he was the only member of staff on site at this stage, he had to stay with the tram and could only show them the way to David Lane tram stop. This meant that the passengers had to walk unguided in the dark over *ballast* for about 200 metres. Although this was completed without incident, it may have been safer to have waited until help had arrived to supervise the detrainment and minimise the chance of any incidents.

## Observations

### Lack of procedures

76 **NTL did not have fully documented procedures for dealing with some foreseeable elements of this accident.**

77 Despite being a regular occurrence, NTL did not have a documented procedure for drivers to follow when encountering a member of the public in the off-street sections of the NET network (paragraph 37).

78 Although NTL had a procedure covering tram detrainment for drivers, it did not have a documented procedure explaining the considerations to be made by the SDSs when deciding on the detrainment of a tram (paragraph 74).

## Summary of conclusions

### Immediate cause

79 The tram driver could not bring his tram to a stop in time to prevent the collision with a member of the public who was lying on the track (paragraph 40).

### Causal factors

80 The causal factors were:

- a. It was difficult for the driver of tram 225 to detect the presence of the member of the public on the track (paragraph 46, no recommendation).
- b. The driver of tram 225 had not been asked to reduce the tram's speed or to exercise caution between Basford and David Lane tram stops (paragraph 50). This causal factor arose due to a combination of the following:
  - i. SDS3 misunderstood the reporting call from the driver of tram 228 to SDS2 (paragraph 59, paragraphs 95 and 97; **Learning point 2**)
  - ii. SDS3 acted on an overheard call (paragraph 63; **Learning point 2**).
  - iii. SDS3's misunderstanding was not detected and challenged by anyone in the control room (paragraph 65, paragraphs 95 and 96a).

81 The RAIB considered the relevance of the headlight setting on tram 225. The RAIB found no evidence to suggest that it was a factor in the causation of the accident (paragraph 73, **Learning point 1**).

### Underlying factor

82 An underlying factor was that NTL's senior management did not manage the risks associated with deficiencies in safety critical communications effectively (paragraph 69, **Recommendation 1**).

### Factors associated with the emergency response

83 The driver of tram 225 had to detrain its passengers on his own, having just been involved in a fatal accident (paragraph 74, paragraph 94).

### Additional observations

84 Although not linked to the accident on 15 August 2016, the RAIB observes that NTL did not have fully documented procedures for dealing with some foreseeable elements of this accident (paragraph 76 and 93).

## Previous relevant recommendations

85 The following recommendations, made by the RAIB as a result of its previous investigations, are relevant to this investigation, but were not addressed to NTL.

### [Accident at Lebanon Road \(Croydon\), 13 April 2013, Recommendation 1](#)

86 Recommendation 1 of this report ([RAIB report 05/2014](#)) read as follows:

Tram Operations Ltd should revise its policy on verbal communications to:

- reinforce rules on the avoidance of communicating with drivers by mobile phone while trams are moving;
- minimise, where possible, communication by radio while trams are moving particularly for complex issues (such as the resolution of faults); and
- enhance the use of readbacks for safety-critical communications in abnormal, degraded and emergency scenarios.

87 This recommendation was addressed to Tram Operations Ltd. In March 2015, the ORR reported to the RAIB that it considered that Tram Operations Ltd had implemented this recommendation.

### [Accident at Lebanon Road \(Croydon\), 13 April 2013, Recommendation 2](#)

88 Recommendation 2 of this report ([RAIB report 05/2014](#)) read as follows:

London Tramlink should develop and implement a programme to prioritise and expedite the planned upgrade of the radio system, to achieve an improvement in signal coverage and strength across the whole network (including tunnels) and reliable operation in adverse weather conditions.

89 This recommendation was addressed to London Tramlink. In December 2015, the ORR reported to the RAIB that it considered that London Tramlink had implemented this recommendation.

### [Accident at West India Quay \(London\), 10 March 2009, Recommendation 5](#)

90 Recommendation 5 of this report ([RAIB report 03/2010](#)) read as follows:

Serco Docklands should establish and implement management arrangements for monitoring and reviewing the performance of controllers in order to assess the levels of compliance with current procedures and implement a system to ensure appropriate actions are taken to address any deficiencies identified.

91 This recommendation was addressed to Serco Docklands. In March 2011, the ORR reported to the RAIB that it considered that Serco Docklands had implemented this recommendation.

## Actions reported that address factors which otherwise would have resulted in a RAIB recommendation

- 92 Following the accident, Alstom laterally re-aligned the left-hand headlight on tram 225 (paragraph 44). Alstom also cleaned the internal parts of the headlights on tram 225 and implemented a maintenance task to clean the headlights on all its Citadis trams at regular intervals.
- 93 In November 2016, NTL issued a new dedicated procedure for dealing with reports of persons being found in an off-street section which details the expected actions from all staff. In addition to the existing process of warning approaching trams, it includes instructions to:
- the tram drivers to stop if they are concerned about the welfare of the person;
  - the SDSs to monitor on the CCTV both ends of the section of track where the person has been reported; and
  - the SDSs to only declare a return to normal working after two trams in either direction have confirmed the area to be clear.
- 94 In November 2016, NTL issued a specific procedure for the detrainment of trams which details a process to follow for the drivers and SDSs in the event of a need to detrain a tram.

## Other reported actions

- 95 With regards to safety critical communications, NTL has implemented the following:
- All drivers, SDSs and SDMs have been re-briefed on safety critical communications (completed in November 2016).
  - A new communication review panel has been created. It meets monthly to review and grade the quality of operational communications. Every driver and every SDS will be monitored at least once a year. In addition, the panel will review the communications after any incident or customer complaint. The procedure detailing the work of this panel was issued in December 2016.
  - In the event that the quality of the audio reception is poor in the control room, the SDSs have been briefed to instruct the drivers to call back using the handset in their cab when stationary at the next available tram stop.
  - NTL and its supplier is continuing its investigation into the TETRA radio system and the reasons for the occasional poor quality of some of the calls. The ORR has instructed NTL to complete its investigation by the end of March 2017.

- 96 As part of its culture change programme (paragraph 70), NTL has taken the following actions:
- a. Since October 2016, the desk of the on-duty SDM has been relocated to be in the control room. This is to enable the SDM to supervise and manage the work of the control room, particularly during times of disruption.
  - b. In November 2016, NTL introduced the position of driver supervisor to its operation. This is to reduce the workload of the SDSs and the SDM. The on-duty driver supervisor is now the interface with the drivers for all operational matters (eg signing-on and off, sickness, discipline, etc). The driver supervisors report to the SDM. This alteration was planned before the accident.
  - c. In December 2016, NTL commissioned an external study of culture change for its operations, including the control room.
  - d. The layout of the control room is being reconfigured to provide the new driver supervisors with an office to interface with the drivers. This will reduce the potential distraction to the SDSs. Access to the control room will also be restricted to authorised personnel. The alteration to the control room layout was planned before the accident.

## Recommendation and learning points

### Recommendation

97 The following recommendation is made<sup>7</sup>:

- 1 *The intent of this recommendation is to improve the quality of safety critical communications in the control room.*

Nottingham Trams Limited should undertake a review of its culture change programme started in 2016 to ensure that it addresses the risks associated with the quality of safety critical communications in the control room. The findings of this review should be translated into effective corrective actions where appropriate (paragraph 82).

### Learning points

98 The RAIB has identified the following key learning points<sup>8</sup>:

- 1 Drivers of trams are reminded of the importance of using the full-beam setting on their tram whenever possible in the areas of the network that have low levels of ambient light during the hours of darkness.
- 2 This investigation acts as a reminder to all people involved in tramway operation of the importance of good quality safety critical communications.

<sup>7</sup> Those identified in the recommendation have a general and ongoing obligation to comply with health and safety legislation, and need to take this recommendation into account in ensuring the safety of their employees and others.

Additionally, for the purposes of regulation 12(1) of the Railways (Accident Investigation and Reporting) Regulations 2005, this recommendation is addressed to the ORR to enable it to carry out its duties under regulation 12(2) to:

- (a) ensure that recommendations are duly considered and where appropriate acted upon; and
- (b) report back to RAIB details of any implementation measures, or the reasons why no implementation measures are being taken.

Copies of both the regulations and the accompanying guidance notes (paragraphs 200 to 203) can be found on RAIB's website [www.gov.uk/raib](http://www.gov.uk/raib).

<sup>8</sup> 'Learning points' are intended to disseminate safety learning that is not covered by a recommendation. They are included in a report when the RAIB wishes to reinforce the importance of compliance with existing safety arrangements (where the RAIB has not identified management issues that justify a recommendation) and the consequences of failing to do so. They also record good practice and actions already taken by industry bodies that may have a wider application.

## Appendices

### Appendix A - Glossary of abbreviations and acronyms

AVLS	Automatic vehicle location system
CCTV	Closed-circuit television
NET	Nottingham Express Transit
NTL	Nottingham Trams Ltd
ORR	Office of Rail and Road
OTDR	On-tram data recorder
RAIB	Rail Accident Investigation Branch
SDM	Service delivery manager
SDS	Service delivery supervisor

## Appendix B - Glossary of terms

All definitions marked with an asterisk, thus (\*), have been taken from Ellis's British Railway Engineering Encyclopaedia © Iain Ellis. [www.iainellis.com](http://www.iainellis.com).

Ballast	Crushed stone, nominally 48mm in size and of a prescribed angularity, used to support the rails and sleepers both vertically and laterally.*
Cess	The space alongside the line or lines.*
Four-foot	The area between the two running rails of a standard gauge railway.*
Limited clearance	An area where there is insufficient space to stand safely during the passage of trams on the adjacent Line.*
Off-street	The Railway Safety Publication on tramways defines off-street sections as areas where: (a) operation is by either line-of-sight or signalled, or by a combination of the two; (b) the track is wholly segregated from any highway; and (c) the alignment is wholly separate from any highway.
Six-foot	Term used for the space between two adjacent tracks, irrespective of the distance involved.*
TETRA	Terrestrial Trunked Radio is a mobile radio and two-way transmitter/receiver system. It was specifically designed for operation by the emergency services and for public safety networks.

## Appendix C - Investigation details

The RAIB used the following sources of evidence in this investigation:

- information provided by witnesses;
- information taken from the train's on-tram data recorder (OTDR);
- closed-circuit television (CCTV) recordings taken from the trams and tram stops;
- site photographs and measurements taken on site during various reconstructions;
- weather reports and observations at the site; and
- a review of previous RAIB investigations that had relevance to this accident.

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