



Rail Accident Investigation Branch

Rail Accident Investigation: Interim Report 2

**Fatal accident involving the derailment of a tram
at Sandilands Junction, Croydon
9 November 2016**

Report IR1/2017
February 2017

Note: This interim report contains information obtained as part of the Rail Accident Investigation Branch's (RAIB) ongoing investigation. It supplements the first interim report published in November 2016. Some of the information contained in this report may be refined or changed as the investigation progresses.

The purpose of a RAIB investigation is to improve safety by preventing future railway and tramway 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.

Fatal accident involving the derailment of a tram at Sandilands Junction, Croydon 9 November 2016



Summary

- 1 At about 06:07 hrs on Wednesday 9 November 2016, a tram running between New Addington and Wimbledon derailed and overturned on a curve as it approached Sandilands Junction, in Croydon (figure 1). The tram travelled for a short distance on its side before stopping in the vicinity of the junction.
- 2 Seven people lost their lives in the accident and 51 people were taken to hospital, 16 of them from suffering serious injuries¹.
- 3 The Rail Accident Investigation Branch's (RAIB) analysis of the on-tram data recorder (OTDR) shows that the tram was travelling at a speed of approximately 73 km/h (46 mph) as it entered the curve, which had a maximum permitted speed of 20 km/h (13 mph).

¹ Physical injuries as defined by Railways (Accident Investigation and Reporting) Regulations 2005.



Figure 1: Google Earth image showing area where accident occurred

The RAIB's role and the context of this interim report

- 4 The RAIB is responsible for conducting independent investigations into railway and tramway accidents in the UK. The purpose of its investigations is to improve safety by establishing the causes of accidents and making recommendations to reduce the likelihood of similar occurrences in the future or to mitigate their consequences.
- 5 The RAIB is not a prosecuting body; its investigations are focused solely on safety improvement and do not apportion blame or liability. The police and the Office of Rail and Road deal with contraventions of the law. None of their statutory duties are changed by the RAIB investigation.
- 6 The RAIB's investigation is running independently of those of the British Transport Police, the Office of Rail and Road, and the industry. However, all investigating agencies, and the industry, are co-operating fully with each other.
- 7 This updated interim report builds upon the information already provided in the RAIB's earlier [interim report](#). A final report will be published on completion of the investigation. All RAIB investigation reports are available on the RAIB website.
- 8 At any stage in its investigations the RAIB may also issue urgent safety advice (see paragraph 41) and make recommendations to such persons as appropriate in the circumstances.

Background information

People

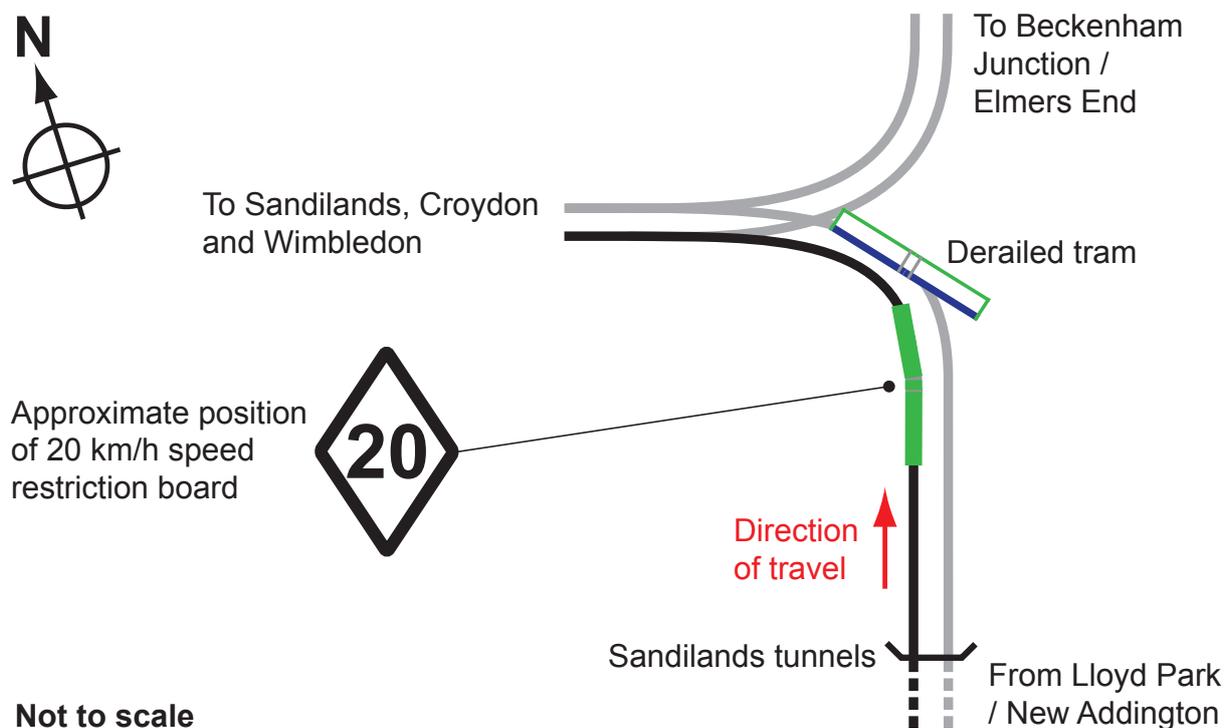
- 9 There were about seventy passengers on the tram. The driver was the only member of staff on board.

Parties involved

- 10 The tramway infrastructure is owned and managed by Transport for London through its London Trams subsidiary.
- 11 Tram Operations Ltd, a subsidiary of First Group, operates the trams.

Key features of the route and accident location

- 12 The accident occurred at Sandilands Junction on the London Trams network in Croydon; the point at which the two easterly legs of the network from Beckenham Junction/Elmers End and New Addington converge (see figure 2).
- 13 The tram involved in the accident was running between Lloyd Park and Sandilands tram stops on the route from New Addington. After the Lloyd Park tram stop, the route runs in the open for about 760 metres, and then passes through Sandilands tunnels (comprising three closely spaced tunnels with a total length of about 512 metres), before emerging into a cutting approximately 94 metres before the left-hand curve on which the accident occurred. The curve has a radius of approximately 30 metres.
- 14 The tramway runs in its own dedicated corridor in this location (it does not change from off-street to street running until after Sandilands tram stop). The alignment through the tunnels on the approach to the curve is broadly straight, and the track is on a gently falling gradient from the tunnel portal to the curve, before rising again through the junction.



Not to scale

Figure 2: Diagram of accident location

- 15 The maximum permitted speed for trams approaching the area from Lloyd Park was 80 km/h (50 mph) until the curve near to Sandilands Junction, at which point it dropped to 20 km/h (13 mph). A reflective sign denoted the commencement of the 20 km/h speed restriction; it was located close to the start of the curve and approximately 24 metres before the point of derailment.
- 16 At the time the tramway was designed and constructed, guidance on the design principles was provided by Her Majesty's Railway Inspectorate (then part of the Health and Safety Executive) in a document published in 1997, entitled 'Railway Safety Principles and Guidance Part 2 Section G – Guidance on Tramways'. Much of the guidance was based on the then recent reintroduction of trams in Manchester and Sheffield.
- 17 Trams, including those in Croydon, generally operate on 'line-of-sight' principles, with drivers being required to control their tram so it can be stopped short of a reasonably visible stationary obstruction, using the service brake. Indicators are provided at locations where conflict can occur, such as junctions and road crossings. At the time of the accident, there was no requirement for advance warning of speed restrictions (neither was there a requirement for speed control systems to be fitted to trams).

External circumstances

- 18 At the time of the accident it was dark and raining heavily.

The tram

- 19 The vehicle involved was tram 2551, one of 24 units (comprising three bogies and two cars joined by an articulation unit) that made up the initial Croydon fleet. It was built by Bombardier Transportation in Austria in 1998.
- 20 The tram was equipped with forward facing and internal closed circuit television (CCTV) cameras and an on-tram data recorder (OTDR). The OTDR records key parameters such as the vehicle speed and the driver's operation of power and brake controls.
- 21 The OTDR was functioning at the time of the accident, and the evidence obtained is being used in the RAIB's investigation. However, examination of the tram's CCTV equipment indicates that it was not recording at the time of the accident.

The accident

- 22 Tram 2551 departed from New Addington at 05:53 hrs, calling at six stops including Lloyd Park. After leaving Lloyd Park it negotiated a right-hand curve with a 20 km/h (13 mph) speed restriction at the correct speed, and then travelled at up to 80 km/h (50 mph) (in accordance with prevailing speed restrictions), as it ran towards its next stop at Sandilands.
- 23 The tram entered the curve on the approach to Sandilands Junction at a speed of approximately 73 km/h (46 mph). As it encountered the curve it derailed and turned over onto its right-hand side, coming to a stand with the front cab approximately 25 metres beyond the point of derailment, and 49 metres beyond the speed restriction sign.

Consequences

- 24 Seven people lost their lives in the accident and 51 were taken to hospital, 16 of them suffering from serious injuries.
- 25 The right-hand side of the tram, which made contact with the ground, was damaged. There was severe scraping and some tearing of the outer skin, and some windows were broken.
- 26 There was some damage to the track and lineside equipment in the vicinity of the accident.

Investigation progress

- 27 The RAIB was notified via its telephone incident line at 06:42 hrs, and deployed five inspectors and two support staff to the site of the accident. The first three inspectors arrived on site at 10:02 hrs. The RAIB completed work on site at 09:20 hrs on 12 November 2016.
- 28 The RAIB has since:
 - moved the tram to a secure location, and constructed a covered enclosure in which the tram can be safely and securely examined;
 - observed the visibility of the junction and associated signage from the driving cab of a tram travelling over the same route at a similar time of day;
 - commenced the examination and testing of the tram (in conjunction with other investigative bodies);
 - analysed the tram's OTDR;
 - analysed detailed surveys, photographs and video footage of the track and other infrastructure in the area of the accident;
 - gathered evidence from the tramway owner and operator;
 - gathered evidence from witnesses;
 - arranged for a specialist consultant to assist in the understanding of how people's injuries were incurred; and
 - started gathering information about other UK and European tram operators.

Findings to date

Infrastructure

- 29 The RAIB undertook a survey of the track in the vicinity of the derailment and has reviewed the findings. No evidence has been found of any track defects, or obstructions on the track, that could have contributed to the derailment.
- 30 A single 20 km/h (13 mph) speed restriction sign measuring 607 mm by 405 mm was located at the start of the curve (see figure 3).

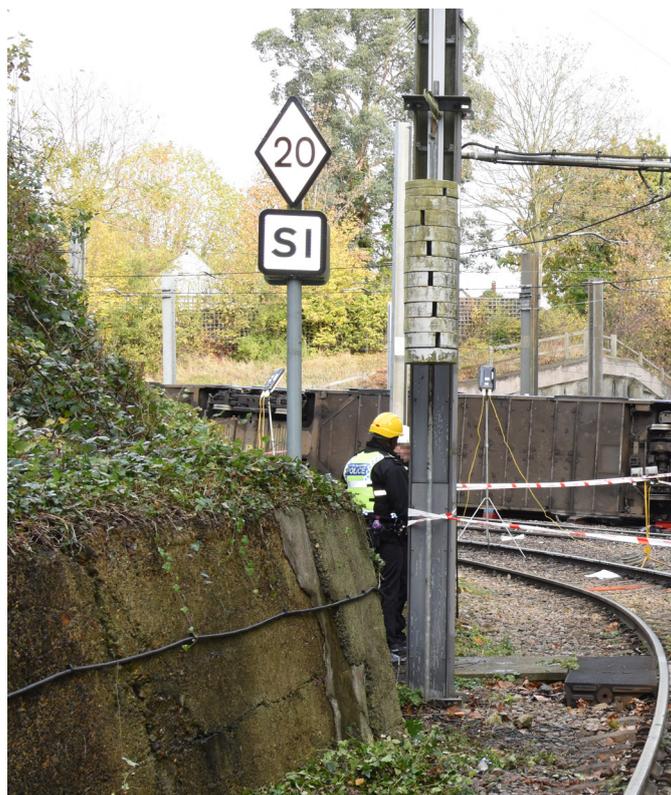


Figure 3: Speed restriction sign. The legend 'SI' under the speed figure indicates the location of a section isolator, an insulated joint in the overhead electrical power line

- 31 A tram approaching the Sandilands Junction area from Lloyd Park at 80 km/h (50 mph) would need to brake at its full service rate of 1.3 m/s² approximately 180 metres before the speed restriction sign, in order to be travelling at 20 km/h (13 mph) when the sign was reached.
- 32 RAIB observations and measurements indicate that tram drivers approaching Sandilands Junction from the direction of the tunnel during the hours of darkness, in clear conditions, can sight the curve and read the speed restriction sign from around 90 metres with headlights on main beam, and from around 60 metres with dipped beam.
- 33 The point at which the curve can be sighted and the sign becomes readable in clear conditions is therefore about 90 - 120 metres beyond the point at which a full service brake application must start in order to reduce speed from 80 km/h to 20 km/h (full service brake deceleration is around half emergency brake deceleration²). At the time of the accident the readability of the speed restriction sign is likely to have been adversely affected by heavy rain.
- 34 There was no sign to indicate to drivers where they should begin to apply the brake for the Sandilands curve; they were expected to know this from their knowledge of the route.

² Application of the tram's hazard (or emergency) brake, which employs magnetic track brakes (devices used to supplement the wheels' braking to achieve more rapid deceleration), would generally need to start 80 to 90 metres before the sign to achieve the same speed reduction, ie around the point that the sign becomes readable in clear conditions.

The tram and its operation

- 35 Detailed examination of the tram is ongoing. However, the RAIB's investigation to date has not indicated any malfunction of the tram's braking system.
- 36 Analysis of the tram's OTDR indicates that the service brake was not applied until around 2½ seconds before the tram reached the 20 km/h speed restriction sign. The tram's speed had reduced from 78 km/h (49 mph) to 73 km/h (46 mph) by the time the tram passed the sign. The hazard brake was not used.
- 37 The late application of the brakes, and the absence of emergency braking, suggests that the driver had lost awareness that he was approaching the tight, left-hand curve. The RAIB is continuing to investigate the factors that may have caused this to occur.

Causes of injuries to passengers

- 38 The RAIB's initial examination of the tram indicates that its body structure and interior fittings remained largely intact, apart from the right-hand side windows and doors. The injuries to passengers were not therefore caused by loss of survival space as a result of deformation of the tram body, although impact with interior fittings is a possible cause of some injuries.
- 39 Some windows on the right-hand side were broken and dislodged from the tram body. The windows in the body-side of the tram were made from 6 mm toughened glass, and the windows in the doors were made of 4 mm toughened glass. All the windows were fitted with an anti-vandal film on their internal faces. Initial indications are that a number of passengers with fatal or serious injuries had been ejected, or partially ejected, from the tram through broken windows, both in the body-side and the doors. Of the seven passengers who died: one was found inside the tram; two were found partially inside the tram; three were found underneath the tram; and another was found on the track close to the tram. Work to understand the detailed sequence of events, and the means by which passengers received their injuries, is ongoing.

Previous incidents

- 40 The RAIB is aware of allegations that trams have gone round the curve at Sandilands at a higher speed than the 20 km/h limit on some previous occasions, and that such an event was reported as having occurred on 31 October 2016. The investigation is looking at this incident, whether Tram Operations Limited were notified at the time, and how they handled the report. It will also try to establish whether any of the same factors may have applied to the accident on 9 November 2016.

Urgent Safety Advice

41 In the light of this accident, the RAIB issued the following urgent safety advice to Tram Operations Ltd and London Trams on 14 November 2016:

‘The factors that led to the over-speeding are still under investigation. Until these factors are better understood, and before the junction re-opens to passenger operation, the RAIB advises London Trams and Tram Operations Ltd to jointly take measures to reduce the risk of trams approaching Sandilands Junction from the direction of New Addington at an excessive speed. Options for consideration should include the imposition of a further speed restriction before the start of the existing 20 km/h speed restriction around the curve and/or additional operational signs.’

42 The RAIB has been informed that London Trams introduced additional speed restrictions on the approach to Sandilands junction and at other locations in response to this advice. Following this, passenger services on the tramway through the junction resumed on 18 November 2016. London Trams has since installed chevron warning signs on the curve and on other similarly tight bends.

43 The ORR has reported that in response to the RAIB’s urgent safety advice, it asked other UK tram operators to introduce intermediate stepped speed restrictions in situations on the approach to curves where the required reduction in speed was greater than 30 km/h. All tram operators to whom the advice was relevant have responded, and such additional restrictions were added on Blackpool Tramway, Edinburgh Tramway, Midland Metro and Nottingham Express Tramway. ORR has also asked tram operators to provide them with evidence of management processes to monitor over-speeding. The ORR is in discussions with UKTram (the UK tram operators’ trade body) regarding the use of a range of innovations to reduce the risk of over-speeding.

RAIB’s future action in the investigation

44 The RAIB is working in conjunction with other agencies to maintain contact with the families of those who lost their lives and those who were injured in the accident. The RAIB has also contacted passengers who were on-board the tram when the accident occurred, but who were not injured.

45 The RAIB’s ongoing investigation continues to include consideration of:

- the sequence of events before and during the accident;
- events following the accident, including the emergency response and how passengers evacuated from the tram;
- the way in which the tram was being driven and any influencing factors, including the signage and other information presented to the driver;
- the design, configuration and condition of the infrastructure on this section of the route, including signage;
- the tram’s behaviour during the derailment and how people sustained their injuries including:
 - assessment of the way the tram overturned and its effect on passengers; and
 - understanding the behaviour of the tram windows.

- any previous over-speeding incidents on Croydon tramway; and
- any relevant underlying management and regulatory factors including:
 - the management of the competence and fitness of staff;
 - the risk management arrangements, including hazard identification and risk assessment throughout the life of the system;
 - the accident and incident reporting regime, and investigation of previous events; and
 - the monitoring and review of safety on the Croydon tramway (including the activities of Tram Operations Ltd, First Group, London Trams and Transport for London).

46 In addition to these areas, the RAIB is also looking into:

- the standards and design guidance used in the construction and maintenance of the Croydon tramway infrastructure, including their source and development;
- the standards applicable to the tram's windows;
- the standards and design guidance used on tramways elsewhere in Europe (eg the German BOStrab standard) relating in particular to off-street running; and
- the differences between standards applied to trams and those applied to buses and trains.

47 The RAIB's investigation report will include recommendations to reduce the likelihood and/or consequence of similar events occurring in the future.

Rail Accident Investigation Branch

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