Rail Accident Investigation Branch

Rail Accident Report

Derailment at Phipps Bridge, Croydon Tramlink
21 October 2005

Department for Transport

Report 04/2006
March 2006

This investigation was carried out in accordance with:

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

Any enquiries about this publication should be sent to:

RAIB
The Wharf
Stores Road
Derby
DE21 4BA

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

This report is published by the Rail Accident Investigation Branch, Department for Transport.

Derailment at Phipps Bridge, Croydon Tramlink 21 October 2005

Contents

Introduction

1 The sole purpose of an investigation by the Rail Accident Investigation Branch is to prevent future accidents and incidents and improve railway safety.

2 The Rail Accident Investigation Branch does not establish blame or liability, or carry out prosecutions.

3 This report contains the RAIB investigation into the derailment at Phipps Bridge on Croydon Tramlink, 21 October 2005

4 The investigation was established to discover the cause of the derailment and consider the potential contribution of the infrastructure, *rolling stock*, operational methods, management, organisation and any other relevant factors that may have contributed to it.

5 Appendices at the rear of this report contain Glossaries explaining the following:

- Abbreviations and acronyms are explained in the Glossary at Appendix A; and
- certain technical terms (shown in *italics* within the body of this report) are explained in the Glossary at Appendix B).

Summary

Key facts about the incident

6 Tram number 2530, a 3-section articulated unit, travelling eastbound on the *single line* between Wimbledon and Croydon with approximately 45 passengers on board, became derailed as it passed over *facing points* PBR02G at the single to double line junction on the approach to Phipps Bridge tram stop near Merton, Surrey, at 10.38 hrs on Friday 21 October. As the tram approached the *points*, they were set, incorrectly, for the right-hand route. As the front of the tram passed over, the points sprang back to the left-hand route and the leading bogie of the tram *split* the points and became derailed. The rear portion of the tram took the left hand route. The tram came to rest about 37m beyond the points (see diagram, Figure 6). There were no injuries, and the passengers were evacuated to the adjacent tram stop by the driver and other staff. Recovery of the tram began at 14.00 hrs and re-railing was completed by 18.25 hrs. Following repairs to minor track damage, normal services were reinstated at 21.10 hrs on the same day.

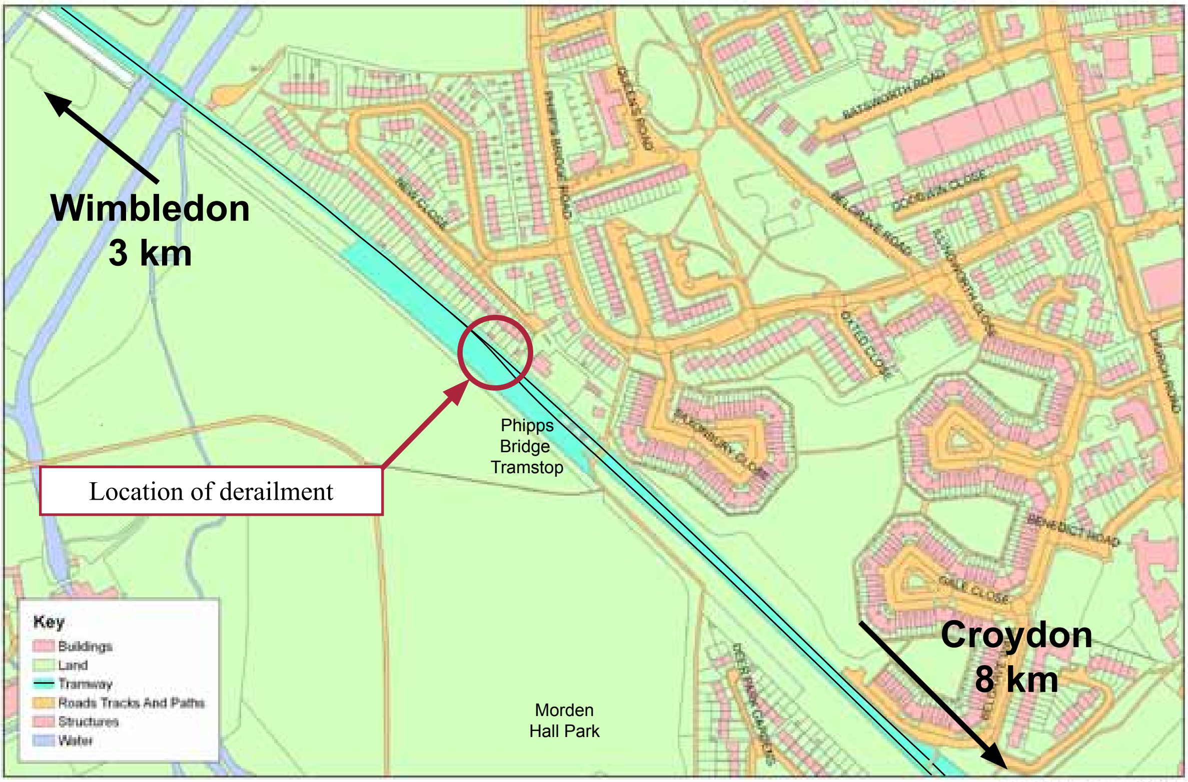

Figure 1: Extract from OS map of Phipps Bridge tramstop and surrounding area

Immediate cause

7 The accident occurred because the tram driver did not react to the display of the "points not correctly set" indication on the indicator close to points PBR02G at Phipps Bridge, and did not stop the tram before reaching the points.

Contributing factors

8 Contributing factors were:

- the failure of the points to return to *normal* after the passage of the previous tram, and the points design characteristic that allowed the points to react to the vibration of the tram passing over and spring back to the *normal* position under the tram;
- the failure of the control room staff to alert drivers on the Wimbledon line to the malfunction of the points; and
- the poor conspicuity of the points position indicator display when the points are not set correctly.

9 Four recommendations are made to improve safety following this investigation.

Investigation

Background

10 The Croydon Tramlink system, which opened in 2000, is run on behalf of Transport for London by Tramtrack Croydon Ltd (TCL), which has a 99-year concession. The system is operated under contract to TCL by Tram Operations Ltd (First Group) (TOL), and the *rolling stock* is maintained by Bombardier Transportation Ltd. Maintenance of the infrastructure is contracted by TCL to Mowlem plc.

11 The tram involved, number 2530, is one of the 24 units that make up the Tramlink fleet. It was built by Bombardier Transportation in Austria in 1998. It is a 3-section, 3-bogie articulated unit, 30.1m long, with a maximum speed of 80 km/h (50 mph). Electric power for the trams is supplied at 750 V DC through overhead wires.

12 The Wimbledon to Croydon line of the Tramlink system runs in a generally north west – south east direction throughout its 10 km length. It is double track from a short distance outside Wimbledon station for 2.13 km as far as Morden Road, where the line becomes single for 0.72 km. Double line resumes at points PBR02G, which are located some 75 m before reaching Phipps Bridge tram stop.

Figure 2 : Points position indicator - points correctly set

Figure 3: Points position indicator - points not correctly set

13 The track on the *single line* section consists of flat-bottomed rail on concrete sleepers. The points at Phipps Bridge are carried on timber *bearers*, and are fitted with a Hanning & Kahl HW 40 operating mechanism. The mechanism is not power operated, but the points are sprung to lie *normally* towards the eastbound line. There is a points position indicator (PPI) located 4m before reaching the points, at drivers' eye level on a post to the left of the line. When the points are correctly set and detected in this position, the PPI shows a pattern of white lights indicating the left-hand route (see figure 2). If the points are not correctly set, only the central white light of the PPI is lit (see figure 3).

14 The system will automatically send an alarm message to the Tramlink system control room (at Coomber Way depot) if the points are not detected as returning to the *normal* position within a short time after a westbound tram passes over them (between ten seconds and a few minutes, depending upon the level of communications traffic being handled by the fibre optic network and the control system as a whole). The use of self-restoring points which are detected but not locked in position is standard practice on tramways and low-speed railways in the UK, as it provides a reliable and economical method of operating passing loops on *single line* sections, especially in remote areas.

The accident

15 On the morning of 21 October tram 2530 was operating on the line 1 service from Wimbledon to Elmers End. There had been heavy rain earlier in the day but the weather at the time was dry. Weather conditions are not considered to have contributed to the accident.

16 At 10.32 hrs, six minutes before the derailment occurred, the Tramlink control room received an alarm message indicating that the points at Phipps Bridge had remained in an abnormal position for an excessive time (see Paragraph 14); this occurred after a westbound tram had passed over the points, and meant that they had not self-restored to *normal* at that time. There was no communication between the control room and the eastbound tram before the accident.

17 Tram 2530 is fitted with a data recorder which provided information on the speed and brake applications immediately before the accident. The tram left Morden Road station at 10.37 hrs, and the driver accelerated to just below the permitted line speed of 80 km/h for the run to Phipps Bridge. As the tram approached points PBR02G, the driver braked and reduced speed to 40 km/h, the permitted speed over the points. The driver was concentrating on the speedometer and did not notice that the PPI was not indicating that the points were correctly set.

18 The tram is fitted with CCTV cameras which record the interior, and forward and back facing exterior views. The forward facing camera showed that the PPI was showing a single white light (meaning that the points were not set and detected for the left-hand, eastbound, route) as the tram approached and passed it, and the camera showed that the points appeared to be set, incorrectly, for the right-hand, westbound, route.

19 The leading bogie of the tram became derailed at the points. The left-hand wheels, facing the direction of travel, passed between the *switch blade* and *stock rail*. The right-hand wheels then dropped into the *four foot*. The tram then slid as its traction motors and other underbody equipment rode on the rail head over the crossing of the points until the inside of the right hand leading wheels came into contact with the rail head. The left hand wheels then rode over the right hand running rail and dropped into the *ballast*, and the tram came to a stop. The front of the tram came to rest 25m from the point of derailment, and 37m from the tips of the *switch blades* (see the photographs, figure 4 and 5). Following the accident, the driver made an emergency radio call to the control room and appropriate steps were taken to deal with the situation.

20 There were about 45 passengers on the tram. None of them was hurt and they were all evacuated to the nearby tram stop by the driver, with assistance from another member of staff who was travelling on the tram and an Incident Officer appointed by the tram operator (TOL). The emergency services were not called and did not attend.

Figure 4: The derailed tram from the front, showing distortion of the track

Figure 5: The derailed tram from the rear, showing the points position indicator and speed restriction sign

21 An emergency response team provided by London Underground Ltd was employed to re-rail the tram. This process began at 14.00 hrs and was completed by 18.25 hrs, when the tram was removed to the depot at Coomber Way, Croydon. The tram was examined by Bombardier Transportation after the accident and damage was found to an axle box and traction motor of the derailed bogie. There was no damage or disruption to the bodywork or interior of the tram.

22 The lateral forces involved in the derailment were sufficient to cause minor displacement of both tracks. These required realignment and minor repairs before the line was reopened for normal services at 21.10 hrs the same day. There was no damage to the points mechanism.

23 The tram driver involved in this accident is an employee of Tram Operations Ltd. He has more than three years experience of tram driving. He came on duty at 09.09 hrs on 21 October, took the tram over at the depot tram stop, and drove to Elmers End. On the return trip he drove through to Wimbledon, and was inbound from there when the accident occurred. In accordance with normal procedure, he was tested for drugs and alcohol following the accident, with negative results. The records relating to his training, assessment, and monitoring were examined as part of the investigation. No factors relevant to this accident were identified.

24 There has been one other derailment of a tram on spring *facing points* on this system; this was at Mitcham (westbound) in August 2002. The investigation by TCL and TOL found that this was caused by a wrongly adjusted *stretcher bar* which enabled the points to move under the tram although they had appeared to be set for the correct route. All the *stretcher bars* on the system were subsequently checked and adjusted as necessary to ensure they were correctly set up.

25 Similar designs of Hanning & Kahl points mechanism are widely used on tramway systems in the UK. A derailment in similar circumstances occurred on the NET (Nottingham Express Transit) system during test running in 2003. The points on the NET system were modified following this incident with rollers instead of solid inserts (see para. 26 below), but instances of sticking points failing to return to *normal* still occur occasionally.

26 All the junctions on the Tramlink system have experienced points failing to return to *normal*. Often, and particularly on the street running sections, this is caused by objects (such as stones or other litter) which lodge, or are placed, between the *switch blades* and *stock rails*, but in the case of points PBR02G at Phipps Bridge it has not been possible for the maintenance contractor and *infrastructure manager* to positively identify the reason for this problem. The points in the Tramlink system were originally fitted with phosphor bronze slide plates which incorporated graphite inserts to reduce friction between the blades and the slide plates. Following poor reliability when the system was first opened, experiments with spring roller bearings were undertaken. The present design of roller bearings was fitted to all the points from June 2003, in the same way as the points in the Nottingham system. This has reduced the number of failures on the Tramlink system generally by 62%, but points PBR02G have not followed this trend and continue to be reported for sticking more often than any other points on the system: an average of 21 occasions each year compared with a system-wide average (excluding PBR02G) of 10.

27 All running line points on the system are examined every four weeks by maintenance staff, and adjusted and lubricated as necessary. If the points are reported to persistently fail to function (i.e. remain in an abnormal position) more than three times in an hour the control room must alert maintenance staff to attend and deal with the fault. The points at Phipps Bridge were reported as sticking persistently on 23 September 2005. On examination by the maintenance contractor, no fault was found with the mechanism and it was oiled as a precaution. Routine maintenance was carried out on the points on 14 October, seven days before the accident. The points stuck again on 20 October, once only, and were reset by a tram driver using the point lever which is carried on all trams. The derailment occurred the following day. The points, which were undamaged, were tested following the accident and found to function normally.

Analysis

28 The evidence of the control room alarms and the CCTV on the tram shows that at about 10:32hrs, when the previous westbound tram passed over them in the *trailing direction*, the points at Phipps Bridge failed to self-restore to *normal* and remained stuck, lying for the right-hand, westbound, route. The PPI therefore showed a single white light to the driver of tram 2530 as it approached eastbound. The driver did not react to this warning until the tram was about to pass the PPI, and by the time he applied the emergency brake the tram was passing over the points. The shock of the tram passing over caused the points to spring back to their *normal* position, lying for the *normal* route, where they were found after the accident. Consequently the leading bogie was derailed, and the centre and trailing bogies of the tram were diverted to the left. The tram stopped 37m after reaching the points. It is notable that although this derailment occurred at almost the maximum speed permitted for trams passing over spring-operated points, there were no injuries to passengers or crew and relatively little damage to the tram and the track.

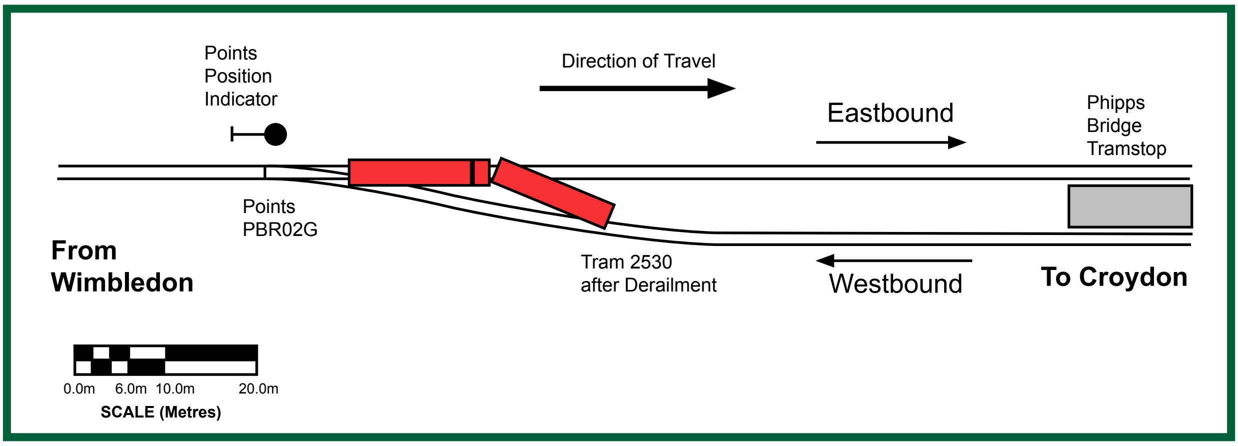

Figure 6: Site plan of the derailment

29 The tram driver had encountered indications of incorrectly set points before but in his experience this was extremely infrequent compared to the number of times the PPI showed that points were correctly set. The driver was concentrating on the tram speedometer while reducing the speed of the tram for the speed restriction over the points. The PPI becomes visible from a distance of about 200 m, and the investigation into this accident confirmed that the pattern of lights forming the "points set" indication (see figure 2) is not easily distinguishable from a single light at this range; only as the tram comes within about 100 m of the PPI does the form of the indication become clear. The single white light shown by the PPI is less conspicuous than the "points set" indication, and does not stand out as an indication requiring a response from the driver in the same way that a horizontal bar or red light would do.

30 Although most of the features of the signals and indicators are the same on the on-street and off-street sections of the Tramlink system, there is one significant difference. On-street signals conform to the requirements for road traffic signals (currently the Traffic Signals and General Directions Regulations 2002), which require a horizontal white bar to be displayed to indicate "stop". However, the PPIs, which indicate points both on and off street, display a single white light to indicate "points not correctly set". On the on-street sections, an additional stop/proceed signal is displayed if the PPI is associated with a road junction where trams may be required to stop. Off-street, the PPI is used on its own. If the "not correctly set" indication is displayed an approaching tram must stop; this has the same significance for the tram driver as a "stop" indication at an on-street traffic signal. More modern tramways use a white bar for this indication off-street, which is both more conspicuous, and consistent with the on-street display.

31 Human factors research indicates that an "abnormal" indication should be easily distinguished from a "normal" indication, and be at least as conspicuous. Conspicuity can be improved by increasing the number of lights in the display and arranging them in a distinct pattern (recommendation 1).

32 The control room staff did not respond immediately to the alarm generated by the malfunction of the points. There are many alarms generated by the system; the exact number is not known by the operator but is believed to be in excess of a hundred. Because the tram system operates on line of sight, few of these alarms are categorised as safety related. The alarms reach their controller in the form of a red or yellow message in a two-line banner at the base of their display screen. Yellow alarms relate to low-risk or commercial matters, such as ticket vending machines requiring replenishment, whilst red alarms relate to operational matters, including intermittent low levels of radio signals, which are not directly safety-critical. The alarm disappears from the controller's screen after another two alarm-generating events have occurred.

33 Alarms at the "red" level, which include points which have remained incorrectly set, are accompanied by an audible signal, which must be acknowledged by the controller. Controllers were encouraged, where possible, to alert tram drivers on the affected section of line to the failure of points. This is normally done by radio and there is no requirement for trams to be stopped. If the fault occurs more than three times in an hour (in practice, if three consecutive trams produce the same problem) the controller is required to contact the maintenance contractor and have the points inspected, although TCL maintain their points on a four-weekly frequency (see Paragraph 27). Other similar systems using such points have them examined every two weeks, and react to faults as soon as possible, depending on the location and the resources available. At Croydon, the practice of not requesting maintenance action unless there have been more than three failures in an hour was instituted because of the problem of "nuisance" failures, which still occur in significant numbers. TCL has found that these are a source of considerable wastage of technician's time, as almost inevitably by the time they had been called out, often at unsocial hours, the "fault" would have cured itself and nothing could be found to either explain it or warrant attention. The period of one hour was set on the basis of experience, on the basis that three failures within that time could be taken as reasonable indication of a genuine fault. TCL believe that some sets of points, including those at Phipps Bridge, benefit from re-lubrication following heavy rain, and this is done when practicable, to improve the reliability of the system.

34 The controller did not contact the driver of tram 2530 before the derailment occurred. TCL's investigation of the system screen dump identified that the alarm relating to the points at Phipps Bridge would have been visible on the controller's screen for 41 seconds before being displaced by other messages. At the time the controller was dealing with an incident at East Croydon in which a signal had failed to give a proceed indication to a tram. This required manual intervention by the controller, occupying his full attention. The next message he received was from the driver of the derailed tram at Phipps Bridge. The number of alarms being received, the absence of a formal requirement to contact trams, and the lack of any system for giving priority to safety-related alarms appear to be factors in this failure to respond (recommendation 4).

35 The number of alarms received is variable depending on the level of traffic on the tramway, the time of day and any degraded operating conditions that may exist. For example, on 19 October, there were 26 "red" and "yellow" alarms received between 11.00hrs and 13.00hrs, while the following day the half-hour period from 09.34hrs to 10.03hrs produced 20 alarms. In the eight minutes immediately before the accident on 21 October, there were 14 alarms (12 red, 2 yellow). The alarms appear on the control screen in sequence and are not sorted into any order of priority.

36 As with many control rooms, workload and levels of activity vary greatly during a shift. The staff have to deal with enquiries made through the public help points at each tram stop, and during periods of disruption this can generate a significant workload. At other times, RAIB's observation of the control room in operation shows that radio traffic can distract staff from close attention to the small area of their screens in which alarm messages appear. Alarms for the entire system appear on all screens, rather than being limited to the area each controller is supervising. Tramtrack Croydon Ltd and Tram Operations Ltd are currently working with the suppliers of the software to review the system with a view to reducing and classifying by risk the number of alarms (recommendation 3).

37 The frequency with which the spring points malfunction is considered by the *infrastructure manager* (TCL) to be generally within the expected levels of reliability for this equipment. However, experience from the NET system suggests that more frequent inspection may improve reliability. The speed (40 km/h) that is permitted over the points at Phipps Bridge and the consequences of malfunction as demonstrated in this incident are factors which should be taken into account when considering the reliability of the mechanism and the adequacy of the maintenance regime (recommendation 2).

Conclusions

38 The accident occurred because the tram driver did not react to the display of the “points not correctly set” indication on the indicator close to points PBR02G at Phipps Bridge, and did not stop the tram before reaching the points.

39 Contributing factors were:

- the failure of the points to return to *normal* after the passage of the previous tram, and the points design characteristic that allowed the points to react to the vibration of the tram passing over and spring back to the *normal* position under the tram;
- the failure of the control room staff to alert drivers on the Wimbledon line to the malfunction of the points;
- the poor conspicuity of the indicator display when the points are not set correctly.

Actions already taken or in progress

40 Tram Operations Ltd (TOL) have issued a notice advising drivers that when passing through spring points in the *trailing direction* they should, where possible, monitor the PPI through the side mirror and, should it not show that detection has been obtained when the tram is clear, then the driver should inform the control room. Control should then alert the driver of the next tram due to use the points in the *facing direction*. RAIB’s view on this is that the procedure requires the tram driver to check in the rear-view mirrors at a time when their attention should be on the track ahead as the tram accelerates, and it is difficult to enforce and so may not be a reliable long-term control measure.

41 TOL have also given control room staff a formal briefing on the importance of taking action on high-level alarms related to safety on the system.

Recommendations

42 Implementation of the recommendations below is the responsibility of the organisations identified in each one. When they have considered the recommendations, the organisations should establish a priority and timescale for the necessary work, taking into account their health and safety responsibilities and the safety risk profile and safety priorities within their organisations.

1 The conspicuity of the PPI 'abnormal' indication should be assessed and improved by an appropriate means, such as display of a horizontal white bar when the points are not correctly set (para. 31).

2 As soon as practicable, the *infrastructure manager* and the maintenance contractor should review the inspection and maintenance regime for the points at Phipps Bridge to ensure that the risks associated with the use of facing spring points at speeds up to 40 km/h are being adequately controlled. Any applicable lessons from this review should be extended to the rest of the Tramlink system. (para. 37).

3 The *infrastructure manager* and operating company should jointly complete their review of the number and nature of the alarms received in the control room with a view to sorting them by risk and eliminating unnecessary information being presented to the controllers (this action is already in hand) (para. 36).

4 As soon as practicable, the operating company should review the control room procedures, taking account of the controllers' workload, with particular reference to instructions relating to points which are not correctly set, to ensure that controllers respond promptly and appropriately to each incident (para. 34)

Appendices

Glossary of abbreviations and acronyms — Appendix A

CCTV	Closed circuit television
DC	direct current
NET	Nottingham Express Transit
PPI	*points* position indicator
TCL	Tramtrack Croydon Ltd
TOL	Tram Operations Ltd
V	Volts

Glossary of terms

Appendix B

Ballast	graded stone sub-base used for drainage and support of the track.
Bearer	timber (or concrete) transverse sleeper supporting the rails in switches and crossings
Facing direction	the direction of travel through points in which two routes diverge
Facing points	*points* where two routes diverge in the direction of travel
Four foot	the area between the inner running faces of a pair of rails
Infrastructure manager	means any person who is responsible for establishing and maintaining infrastructure or a part thereof, which may also include the management of infrastructure control and safety systems, but does not include a maintainer
Normal	The position that spring-operated points are set to return to after a tram has passed over them
Points	the items of permanent way which may be aligned to one of two positions, *normal* or reverse, according to the direction of train movement required
Rolling stock	passenger and freight vehicles
Single line	a track which is normally used by trains or trams travelling in both directions
Split	a form of derailment in which the wheels pass outside both switch rails
Stock Rail	the fixed rail at each side of the *points*
Stretcher bar	a bar linking the two *switch blades* in a set of *points*
Switch blade	the moving portion of rail on each side of a set of *points*
Trailing direction	the direction of travel through *points* in which two routes converge

This report is published by the Rail Accident Investigation Branch,
Department for Transport.

Any enquiries about this publication should be sent to:

RAIB	Telephone: 01332 253300
The Wharf	Fax: 01332 253301
Stores Road	Email: enquiries@raib.gov.uk
Derby UK	Website: www.raib.gov.uk
DE21 4BA	