RAIB
Rail Accident Investigation Branch

Rail Accident Report

Accident at Leatherhead
29 August 2007

Department for Transport

Report 19/2008
October 2008

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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Introduction

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

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

3 Access was freely given by Network Rail and South West Trains to their staff, data and records in connection with the investigation.

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

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

5 All mileages in this report are measured in miles and *chains* from the zero point at London (Waterloo) station.

Summary of the Report

Key facts about the accident

6 At 09:55 hrs on 29 August 2007 a member of railway staff, engaged in routine track inspection work, was struck by a passenger train near Leatherhead station, Surrey, and seriously injured.

7 The injured person was given first-aid by colleagues, treated on site by paramedics and later removed to hospital by air ambulance.

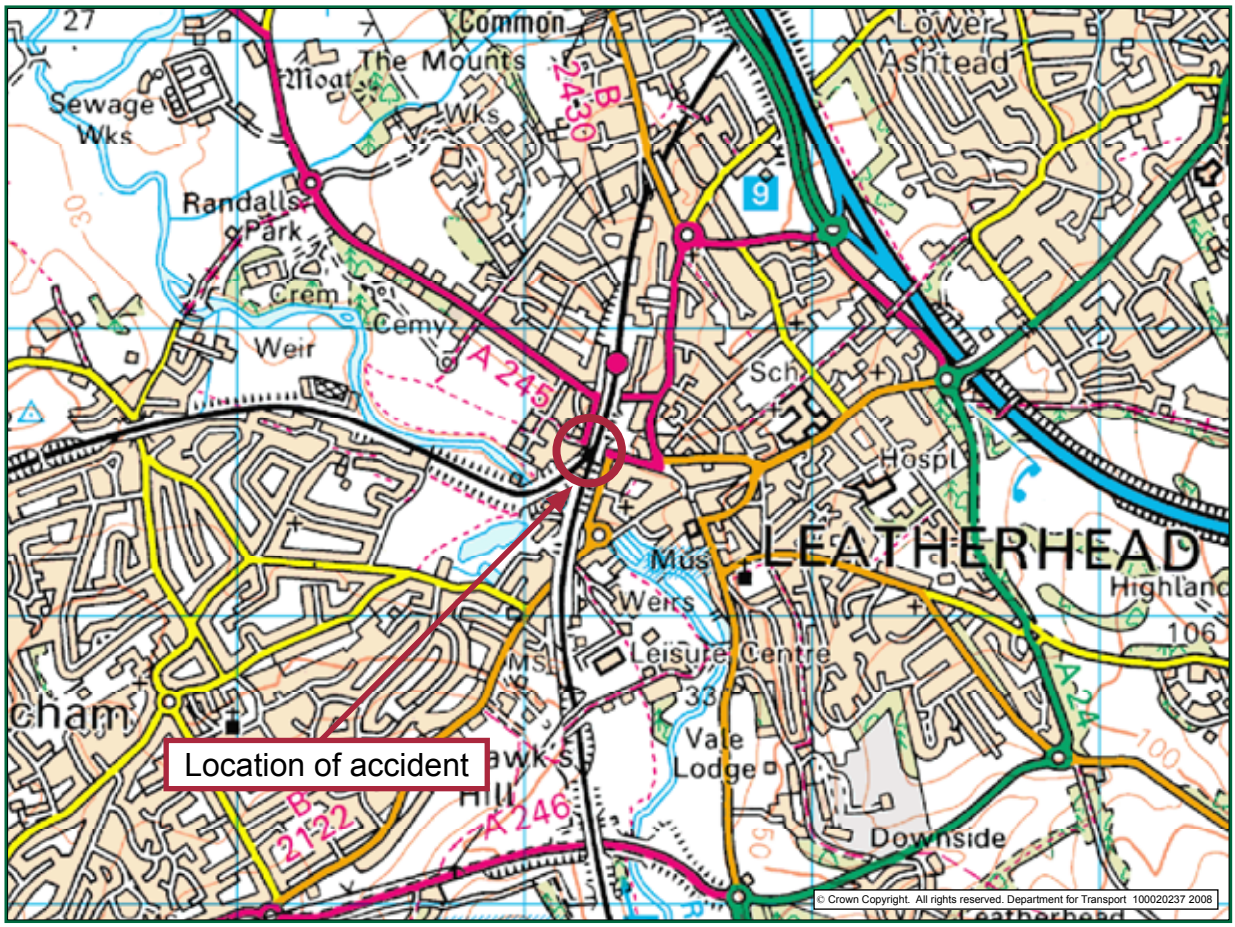


Figure 1: Extract from Ordnance Survey map showing location of accident

Immediate cause, causal and contributory factors, underlying causes

8 The immediate cause of the accident was that the *patrolman* remained in the space between the *up* and *down* Bookham lines as trains approached on both those lines.

9 A causal factor in the accident was that *red zone* working was not prohibited at Leatherhead Junction despite the inadequate sighting times available with the number of *lookouts* available to a patrolling gang.

10 The following factors were considered to be contributory:

a. the gang did not always stop work when first warned of the approach of down trains;

b. the *Controller of Site Safety*(COSS) did not confirm that all the members of the gang had moved to a place of safety;

c. the COSS had not been given sufficient guidance on the placing of lookouts for track workers; and

d. management had not identified deficiencies in the method of working used by the patrolling gang.

11 The underlying cause was that patrolling inspection of *switch & crossing* (S&C) was being carried out while trains were running, and the railway industry has not succeeded in minimising the exposure of track workers to the risks arising from this practice.

Additional observations

12 The separation of inspection of *plain line* and S&C would have benefits for the quality of inspection and the safety of the workforce. This is discussed at paragraphs 114 to 118.

Recommendations

13 Recommendations can be found in paragraph 120. They relate to the following areas:

- the prohibition of red zone working at Leatherhead junction;
- the review of arrangements for S&C inspection, to protect staff from train movements;
- the review of arrangements for protecting patrolling staff from train movements;
- the arrangements for the assessment and monitoring of staff whose duties include setting up safe systems of work on or near the line;
- the implementation of mechanised inspection techniques for plain line; and
- the standards and procedures for the inspection of S&C on routes where plain line inspection is mechanised.

The Accident

Summary of the accident

14 At 09:55 hrs on Wednesday 29 August 2007 a track patrolman was struck and seriously injured by a train at Leatherhead junction, about 50 m south of Leatherhead station, Surrey. A second train, travelling in the opposite direction, arrived at the scene of the accident very shortly afterwards and stopped soon after passing the spot where the patrolman was lying.

The parties involved

15 The track and signalling are owned, operated and maintained by Network Rail. The patrolman was part of a gang of track workers, all employed by Network Rail and based at the track maintenance depot at Wimbledon, south-west London.

16 Both the trains were operated by South West Trains (SWT) and crewed by SWT employees.

Location

17 The accident occurred at Leatherhead junction, about 50m south of Leatherhead station, at a point where the double track line from London (Waterloo and Victoria) to Horsham via Dorking (the Portsmouth lines) is running approximately north and south. At the junction the lines are on an embankment immediately north of the bridge over Station Road.

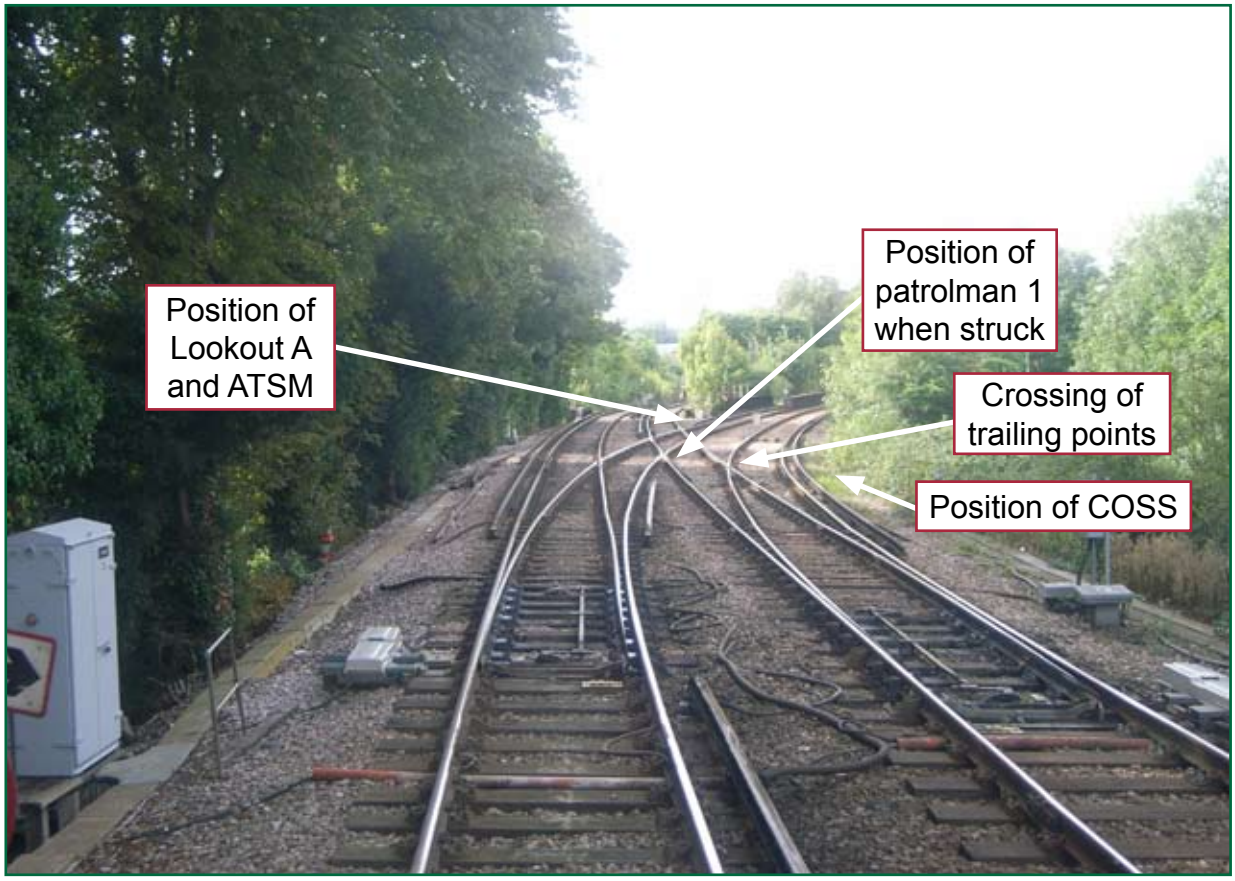


Figure 2: The site of the accident, from the front of a train going towards the Down Bookham line

18 At Leatherhead junction the double track line to Guildford via Bookham (the Bookham lines) diverges from the Portsmouth lines to the right (west) via a conventional *double junction* consisting of two sets of *points* and a fixed *diamond*. The radius of the curve on the Bookham lines is approximately 300 m.

19 Some 300 m beyond the junction both the Portsmouth and Bookham lines cross the river Mole on viaducts. There is dense tree cover on the embankments between the station and the river Mole, which restricts sighting distances around the curve on the Bookham lines.

20 All the lines in the area are electrified on the 750 volts direct current system, with power supplied to the trains through low-level conductor rails at the side of the track (the third rail). Signalling is by the *track circuit block* system, with three and four aspect colour light signals controlled from Wimbledon Area Signalling Centre.

External circumstances

21 The weather at the time of the accident was fine and sunny. Visibility was good.

The trains

22 Each of the trains involved in this accident was formed of two class 455 four-car *electric multiple units* (EMUs). The 09:09 hrs Waterloo – Guildford (2D17) consisted of 455917 and 455727, and the 09:28 hrs Guildford –Waterloo (2D24) consisted of 455739 and 455707.

Events preceding the accident

23 The section of line between Leatherhead and Effingham Junction (known as the Bookham line) is normally visually inspected by a patrol on foot every Wednesday, in alternate directions each week. On 29 August the direction of the patrol was to be from Leatherhead towards Effingham Junction.

24 The patrolling gang of five track workers assembled at Wimbledon depot at 08:30 hrs. They left the depot a little later than normal, because they were to be accompanied by one of the *assistant track section managers* (ATSM) for the Wimbledon section. This day had been designated a 'safety day' in Network Rail's Wessex area, and a manager was required to accompany each gang to assess their compliance with the rules and standards governing safety on the track.

25 The ATSM and the gang travelled by road to Leatherhead, arriving about 09:30 hrs. The leading trackman who was in charge of the gang took the role of COSS. In the car park at Leatherhead station the COSS briefed the gang about the work to be done. Previous patrols had moved south from the station, but the COSS had been issued with new *patrolling diagrams* which indicated that the patrol should now start with an inspection of the *crossover* at the London end of Leatherhead station, and continue with inspection of the junction to the south of the station and then inspect the plain line as far as Effingham Junction. He appointed two of the gang as lookouts (lookouts A and B), to warn of the approach of trains. The other two patrolmen (patrolmen 1 and 2) and the COSS were to do the actual inspection of the track.

26 While lookout B and patrolman 1 remained on the down platform, the COSS, with the ATSM and lookout A and patrolman 2 walked to the London end crossover. After completing inspection in this area they walked back to the station, then the ATSM, the COSS and lookout A walked south along the up platform, while patrolman 2 rejoined his colleagues on the down platform.

27 After inspecting the track between the platforms (from a *position of safety* on the platform), the COSS delivered a short briefing about the next part of the work by calling across from one platform to the other, and the gang then moved south in two groups. Lookout B on the down (east) side of the line remained close to the south end of the platform, looking for trains approaching from the direction of London. Lookout A went to the *vee* of the junction, where he was joined by the ATSM. From this position he was supposed to look out for up trains approaching from the Bookham and Portsmouth directions (figure 3).

28 The COSS and patrolman 1 inspected the lines around the junction points. Patrolman 2 was tightening bolts on an *insulated block joint* in the down line close to the end of the platform.

Events during the accident

29 The 09:09 hrs train from Waterloo to Guildford (2D17) ran into Leatherhead station on time at 09:54 hrs. In accordance with the requirements of the *rule book*, lookout B, at the south end of the down platform, sounded a warning by a single blast of his horn. The gang acknowledged the warning, but as they could see that the train was stopping in the station they continued to work. The train remained stationary for 34 seconds, and then departed. Lookout B sounded a further warning as the train began to move.

30 The COSS, who had been examining fastenings on the points, acknowledged the warning and moved to a position of safety in the up *cess*. To his right, Patrolman 1 was tightening bolts on parts of the diamond crossing using a combined spanner and clip tightening tool known as a '*spuller*' (also referred to as a 'span-puller'). Patrolman 1 acknowledged the lookout's warning and was heard to shout "one on" (meaning that there was an approaching train in sight), but he remained where he had been working in the space between the up and down Bookham lines and bent down to attend to something (figure 2).

31 As 2D17 ran onto the junction, travelling at 24.8 mph (40 km/h), patrolman 1 rose from a crouching position and turned away from the train, but did not move clear of the down Bookham line. He was struck on the left shoulder by the train and knocked over. The train driver heard a loud bang and applied the emergency brake. The train stopped with its front about 87 m beyond the place where patrolman 1 had been standing. He was carried along about 5 m by the train and became trapped under the current collection equipment at the rear of the fourth carriage.

32 Evidence from the data logger fitted to the signalling system indicates that at the moment patrolman 1 was struck an up train, 2D24 (the 09:28 hrs Guildford to Waterloo), was approaching round the curve on the up Bookham line, at 25.5 mph (41 km/h) and was about 300 yards (280 m) away.

33 The COSS had been looking at 2D17 as it moved over the points and crossings of the junction. As he watched the front of the train, he saw patrolman 1 apparently standing, holding the spuller, with his back to the train, and then immediately being knocked down and rolled along the ground. The COSS realised that 2D24 was approaching, and turned and raised his hands in an "emergency stop" signal. The driver of 2D24 also made an emergency brake application and came to a stop about 15 m past patrolman 1, who was by then lying on the ground (figure 3).

Consequences of the accident

34 Patrolman 1 had received injuries to his head, back and legs. He was unconscious and was lying between the up and down Bookham lines, trapped under the current collection equipment of the train which had struck him. No-one else was injured, but the other members of the gang were severely shocked by what had happened.

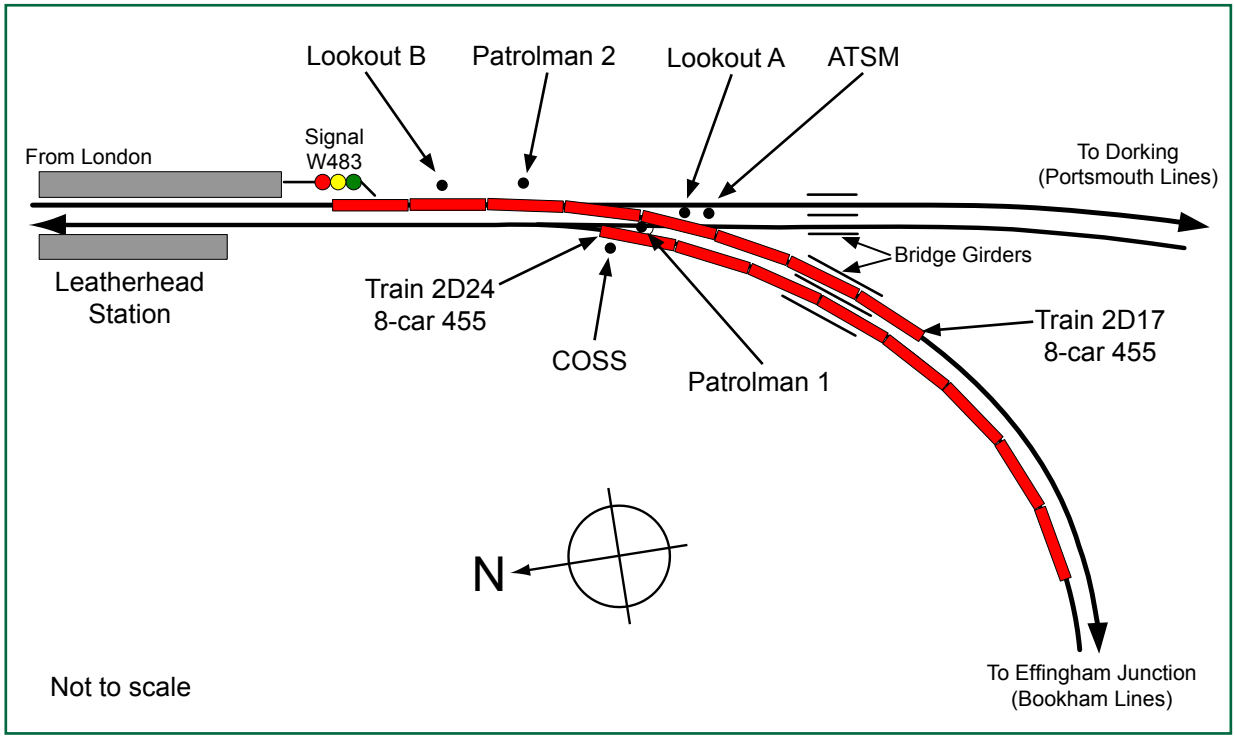


Figure 3: Diagram showing the positions of people and trains immediately after the accident

Events following the accident

35 The ATSM was standing in the vee of the junction. He saw patrolman 1 being knocked over by 2D17, which then blocked his view as it passed the spot where he was standing. He ran towards the back of the train and, since he did not have the signaller's telephone number immediately to hand, he used his mobile phone to contact the Network Rail/SWT Wessex Integrated Control Centre. He gave the control centre brief details of the incident and requested immediate medical assistance.

36 The ATSM reached the back of 2D17. He was surprised to see 2D24, which he had not previously noticed. He told the rest of the gang to remain calm, confirmed with the driver of 2D24 that the emergency services had been called, and went to assess the condition of patrolman 1, who was by then semi-conscious. He provided first aid and stabilised the injured man's condition.

37 The emergency services arrived at the site of the accident about 15 minutes afterwards. The casualty was treated at the scene and subsequently removed to hospital by air ambulance at about 11:45 hrs.

38 The passengers from both trains were detrained with assistance from railway staff by 11:30 hrs, and walked to Leatherhead station, where alternative transport was provided.

Figure 4: The scene following the accident, showing trains 2D17 (left) and 2D24. Passengers are being escorted off 2D17

The Investigation

Sources of evidence

39 The RAIB obtained detailed information about the sequence of events from:

- examination of the scene of the accident;
- interviews with the staff involved;
- the on-train data recorders (OTDR) of both the trains; and
- the data logger attached to the signalling system.

40 Other information about the management of track safety has been gathered from interviews with Network Rail managers and a review of the systems developed for the safety of staff on the track over the last fifteen years (described in Appendix E).

Key Information

Background

41 Track workers are subject to levels of risk well in excess of the average for all workers in the railway industry. A detailed analysis of the risk profile appeared in the RAIB's report into the track worker fatality at Ruscombe Junction on 29 April 2007 (number 04/2008), which was published on 28 February 2008 and is available at www.raib.gov.uk.

42 Since 1994 there have been 20 track workers struck and killed by trains, as well as accidents in which workers have been seriously injured. Twelve of the fatal accidents involved staff who were working or walking in *red zones*, and in three of these the presence of junctions nearby was a factor.

43 The rules and standards applicable to work on the track are described in Appendix D. A review of the history of the methods used to reduce the exposure of track workers to risk is in Appendix E.

The maintenance organisation

44 Following a series of derailments at Waterloo (twice) and Epsom in September and October 2006 (see RAIB reports numbers 34/2007 and 44/2007), there were a number of management changes in Network Rail's Clapham maintenance delivery unit. Extra technical support posts were created, and responsibility for the Wimbledon track section was transferred from the track maintenance engineer (TME) at Clapham to the TME at Feltham in an attempt to balance the workload.

45 This reorganisation took effect in February 2007. Some technical posts were not filled at that time, and others were being covered on a temporary basis. The Wimbledon track section manager was moved to another post later in 2007, and his replacement did not arrive in post until September, so at the time of the accident the post of section manager was being covered temporarily by the acting assistant track maintenance engineer from Feltham.

46 All the staff concerned made great efforts to keep the maintenance system running effectively, despite these changes, but the effect of them was inevitably unsettling and at times staff believed that there was a lack of management direction. The Wimbledon section had an establishment of 52 posts, and at the time of the accident 43 of these were filled. Recruitment had been concentrated at Clapham, to deal with track problems in the Waterloo area, and in the absence of a settled section manager at Wimbledon it had been more difficult to recruit to that depot. Sub-contract staff had been used to fill the gap.

The patrolling arrangements

47 Network Rail standard NR/SP/TRK/001 'Inspection and Maintenance of Permanent Way', issued in October 2005, requires that 'patrolling diagrams shall be created to monitor and ensure all lines are inspected in accordance with the requirements of [the standard] and to the correct frequency'. The Maintenance Procedure NR/PRC/MTC/TK0075, issued in February 2006, introduced the principle that the patrol diagram should be an aid to the patrolling staff. In 2006 Network Rail identified that there was a conflict of purpose between these documents which had given rise to misunderstandings as to the content and use of patrol diagrams. In addition, various different forms of patrol diagram (which were supposed to provide uniform, detailed descriptions of the work to be done in each patrol) were in use throughout the south east territory, many of which were not adequate for their intended purpose. A manager attached to the territory HQ was requested to create diagrams in a standard format. After he had gathered the necessary information, he realised that in many cases the actual patrols did not match the information recorded in Network Rail's computer system for managing maintenance work, known as Ellipse. The scope of the project was therefore enlarged to incorporate a review of the maintenance scheduled tasks shown in Ellipse, with the aim of matching these and the patrol diagrams to the actual patrols that were being undertaken.

48 This was a large project, and it had not been completed at the time the accident occurred. Although the standard NR/SP/TRK/001 specified that a patrol diagram was required, it did not define the content and format of the diagram. The manager who was given the project devised his own format, and drew the diagrams up based on a list of patrols obtained from the depots.

49 The diagrams for Wimbledon were originally issued to the TSM for review in mid-2006. Following the reorganisation of February 2007 (paragraphs 44 to 46), the new TME decided to review the patrols, and the diagrams were revised and sent back to the TME in April 2007 for a further review.

50 The manager who had created them did not know how each depot intended to use the diagrams once they were handed over, or who would be responsible for issuing and updating them. He had created the original diagram covering Leatherhead Junction, but subsequent changes to patrols at Wimbledon depot had led the depot to produce a different diagram covering the area. This had not been finalised at the time of the accident, but a draft version (not marked as such) had been issued to the patrol gang.

51 The patrolling diagrams created for the Leatherhead – Effingham patrol were issued to the COSS, although they had not been checked or agreed by the section manager and track maintenance engineer. These diagrams described, in both written and diagrammatic form, the work to be done on the patrol.

52 There were inconsistencies between the written and diagrammatic information. The wording on the diagram of the Leatherhead – Effingham patrol said:

> 'The patroller commences the patrol at Leatherhead Junction and walks on the Down Dorking line to patrol limit at 17m 68c looking in detail at the 855 S&C. The patrol the crosses over to the Up Dorking line and includes a detailed inspection of 855 and Leatherhead Junction S&C and then continues on the Up Bookham to the patrol limit at 21m 10c'.

53 The points referred to as 855 S&C form a crossover between the up and down Portsmouth lines (incorrectly referred to on the patrolling diagram as Dorking lines) at the London end of Leatherhead station. The actual diagram suggests, contrary to the words quoted above, that the patrol should walk on the up line from Leatherhead junction to the London end patrol limit at 17 miles 68 chains. This would involve walking facing away from oncoming traffic.

54 There is no access to the line at Leatherhead Junction, so in practice the patrol began on the platform at Leatherhead station.

55 The COSS had four people available to him on 29 August. He was accustomed to patrolling the Leatherhead – Effingham length with gangs of about this size, and it was his normal practice, in accordance with the Rule Book, to appoint two lookouts and use the other gang members, supplemented by himself, to carry out the inspection. The gang members had worked together before, and it was their custom to shout acknowledgements of warnings of approaching trains to each other, as well as raising an arm as required by the rules to acknowledge to the driver of the approaching train that they were aware of the presence of the train and had heard the warning horn.

56 There were three Record of Site Safety Arrangements and Briefing forms (RT9909) supplied to the COSS for this patrol as part of the pack of information covering the day's work, as well as the patrolling diagrams described above. The general arrangements for the patrol (18 miles 12 chains to 22 miles 10 chains) were covered by one form, and the other forms detailed specific arrangements for crossing the Mole Viaduct (18 miles 25 chains to 18 miles 40 chains) and passing through Bookham Tunnel (20 miles 30 chains to 20 miles 36 chains).

57 The pack also contained a 'Task Risk Control Sheet' (GA20B) describing the hazards and control measures associated with working adjacent to DC electrified rails, and two copies of the 'Line Blockage Form' (RT3181).

58 The COSS had made the same entries for the calculation of warning time and required sighting distances on each of the RT9909 forms, and the other members of the gang had signed all three forms. The required sighting distance the COSS had entered on the forms was 740 yards (670 m). This was based on a line speed of 75 mph and a warning time of 20 seconds, consisting of 5 seconds to stop work and down tools, 5 seconds to reach a place of safety, and the 10 seconds minimum time in a place of safety before the train arrived. In fact, the greatest sighting distance actually required during the patrol would have been 700 yards (630 m), on the section of line between the Mole Viaduct and Bookham where line speed is 70 mph.

59 Before the gang began the inspection of Leatherhead junction, the COSS positioned his lookouts as described in paragraph 27, one just off the south end of the station platform and the other in the vee of the junction. The lookout in the vee of the junction (lookout A) had approximately 300 yards (270 m) sighting distance down the Portsmouth line, providing he stood on the sleeper ends. Lookout A had only 120 yards (110 m) sighting down the Bookham line because of the curvature of the line (figure 5: the lookout shown in the picture is standing in a position where an adequate view is obtainable - see paragraph 84).

60 The line speed on the Leatherhead – Effingham section varies between 30 and 70 mph. At Leatherhead junction, line speed is 30 mph for trains to and from the Bookham direction and 60 mph to and from the Portsmouth direction. The distances and times available to lookouts A and B are summarised in Table 1.

Line	Sighting distance needed	Actual sighting distance	Actual warning time
Up Portsmouth	600 yds	300 yds	10 seconds
Down Portsmouth	600 yds	400 yds	14 seconds
Up Bookham	300 yds	120 yds	8 seconds

Table 1: Sighting distances and warning times

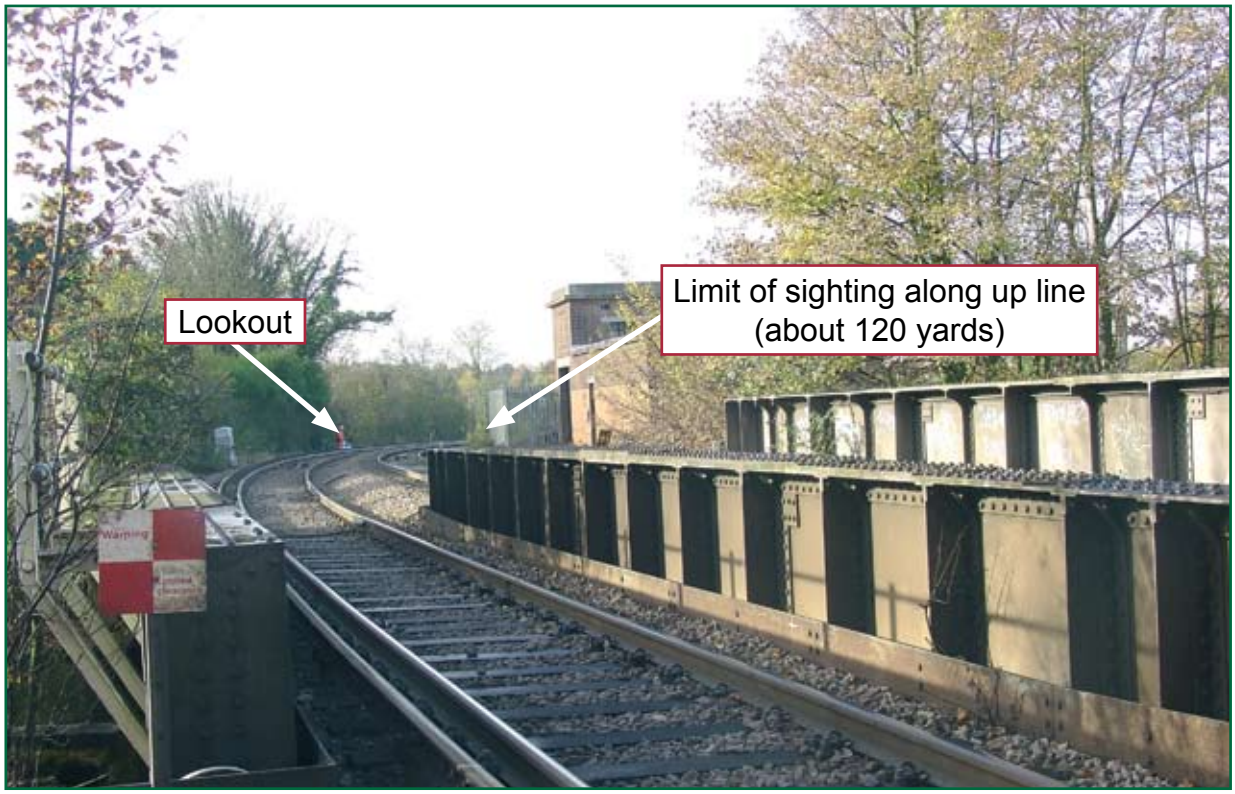


Figure 5: View along the Bookham lines from the position where Lookout A was standing in the vee of the junction

Staff competence

61 The COSS had been working on the railway for two years. He had qualified as a COSS about a year before the accident, and was promoted to Leading Trackman in August 2007. He had been transferred into the patrol gang four months before the accident, having previously worked as a COSS with welding gangs, mainly at night.

62 Patrolman 1, who was injured in the accident, was 35 years old. He had been working on the railway for five years, the whole time as a track worker in the Wimbledon area. He was appropriately qualified for track maintenance work, and was also certified as a lookout, but was not formally qualified for patrolling duties.

63 Lookout A had 3½ years experience of railway work. He was qualified as a lookout, and had acted regularly in that capacity.

64 Lookout B had worked on the railways for 2½ years. He had been passed competent as lookout six months before, but shortly after that he had been in an accident, not related to his work, and been off work for five months. Because of this he had only worked as a lookout on one occasion before 29 August 2007.

65 The ATSM had been confirmed in his post only since June 2007, although he had been covering the job for 16 months before that. He had joined the railway in 2003, and was qualified in a number of competencies, including lookout and COSS.

Previous patrols

66 On Wednesday 1 August the Clapham maintenance delivery unit manager and the acting track section manager accompanied the regular patrol over the Bookham lines. The purpose of this visit was for the managers to fulfil their laid-down role of ensuring the quality, safety and consistency of maintenance activities by regular personal observation. The same COSS as on 29 August was in charge of the gang. On this occasion the managers were impressed by the way in which the COSS generally carried out his duties, but were concerned about the method of working when the patrol (which was walking in the up direction, towards Leatherhead) came to the Mole viaduct.

67 This viaduct is 73 yds (66 m) long, on a sharp curve, and there is limited clearance between the track and the parapet walls. Although there are refuges, the managers felt that there could be insufficient warning time for the patrol members to reach them, and asked the COSS to contact the signal box and make arrangements to allow the patrol to cross safely. At that time the area was not listed in the hazard directory as requiring special care, and the COSS had previously made informal arrangements with the signaller for protection when crossing it. Following this incident the viaduct was added to the list of areas where red zone working is prohibited.

68 The COSS had carried out the Effingham – Leatherhead patrol on several other occasions before 29 August, without incident, but the day of the accident was the first time that he had done the patrol from Leatherhead towards Effingham.

Analysis

Identification of the immediate cause

69 Patrolman 1 was not in a position of safety when both trains approached the place where he was working. He was warned of the approach of the down train (2D17), and responded to that warning, but was struck by the train.

70 The other members of the gang both saw and heard patrolman 1 acknowledge the warning that train 2D17 was leaving the station. He raised one arm and shouted that he was aware of the train. It is possible that he moved to the cess and then, for reasons unknown, went back onto the track to the place where he was struck. This is unlikely because the short timescale involved (less than 20 seconds between the train beginning to move and the accident) means that he would have had to move back across the full width of one track very rapidly, an action which would almost certainly have attracted the attention of one of the other members of the gang. None of them noticed any such movement. The COSS, however, believed that he had seen patrolman 1 move away from where he had been working, and so did not look at him again.

71 Patrolman 1 was unable to remember anything about the accident itself. This is not an unusual consequence of the sort of trauma that he suffered. It is possible that he believed that train 2D17 was going towards Dorking, and that he would therefore be safe where he was, in the *four-foot* of the up Portsmouth line at its diamond crossing with the down Bookham line (figure 2).

72 This, however, would have been contrary to the rules and not typical of his conscientious approach to safety, which he was particularly known for in the depot. He was also in a good position to see which way the junction points were set, and to note the 'Guildford via Epsom' destination displayed on the front of the train, although he was probably facing away from the train while he was working on the S&C.

73 It is more likely that he was intending to move to the up cess, where the COSS was standing, but lingered on the track to finish tightening a bolt. It is possible that he may have momentarily been confused about which rails he was working on, and been under the impression that he was in the four-foot of the up Bookham line working on the crossing of the *trailing* points, whereas he was actually in the four-foot of the up Portsmouth line, working on the crossing at the north end of the fixed diamond (figure 2). He then stood up with the intention of moving clear, and while checking for the approach of up trains was struck from behind by train 2D17.

74 Patrolman 1 was looking in the direction of the up train, 2D24, when he was struck. It is not clear why he was looking in this direction, but it is possible that he may have become aware of the approach of this train from the sound of its wheel flanges squealing on the sharp curve, or from the noise of its collector shoes 'ringing' along the conductor rails. However, at the moment he was hit the train was about 300 m away, and it had not come into his view before he was knocked over. Calculations based on the signalling data and the speed of the trains (paragraph 32) indicate that the accident occurred about sixteen seconds before train 2D24 would have been visible to patrolman 1.

75 The immediate cause of the accident was that patrolman 1 remained in the space between the up and down Bookham lines as trains approached on both those lines.

Identification of causal and contributory factors

Driving of the train

76 The driver of train 2D17 became aware of the gang working south of Leatherhead as the train ran into the station. Station duties were carried out normally, and the train was stationary for 34 seconds. The Rule Book requires the driver to sound the horn to give a warning to people working on the track, and the driver believed that she had sounded the horn on leaving the station. The class 455 trains operated by SWT do not record the use of the horn on the OTDR, so it is not possible to confirm whether or not the driver sounded it on this occasion, but members of the gang could not recall hearing the train's horn. However, they recall hearing the horn blown by the lookout on the down side as the train moved off.

77 The train reached a speed of 24.8 mph as it crossed the junction. The driver was aware of two people to the right of the line the train was travelling on. One of them (the COSS) was looking directly at the train, and the driver believed that the other was aware of the train's approach and was standing up and moving clear. As the train moved closer to the junction these two people were hidden from the driver's view by the front of the train.

78 If the train's horn had been sounded as it approached the junction, patrolman 1 might have realised that he was in danger, and moved clear. However, he had been seen (and heard) to acknowledge the lookout's warning, and as less than 20 seconds elapsed between the train beginning to move and the accident, it seems unlikely that sounding the train horn again would have made any difference to what happened.

79 The driving and operation of the train was not causal or contributory to the accident.

Safe systems of work

Planning the work and providing information

80 The patrol took place in red zone conditions, with lookouts and no assistance from warning systems (see Appendix D, paragraph D17). This was normal practice for patrolling in the Wimbledon section, and there does not appear to have been any formal consideration of the possibility of doing it any other way. In the adjacent Clapham Junction section (which is part of the same maintenance area) there are special arrangements for patrolling in *green zones* because of the intense traffic and lack of places of safety on the multiple track sections on the approaches to Waterloo station. There were no such obvious difficulties around Leatherhead, and the 'traditional' approach to patrolling was continued without question, even following the introduction of the RIMINI system (Appendix E).

81 The actual production of the COSS packs, including the details of the safe system of work, was delegated by the Section Manager to the *works schedulers* at Wimbledon, as he was entitled to do under Network Rail procedure NR/PRC/MTC/PL0094 'Planning and documenting the safe system of work arrangements'. The works schedulers did not routinely review existing safe systems of work, unless a COSS highlighted a problem with them. If a system of work seemed to be satisfactory, it was likely to be re-used indefinitely and only reviewed if circumstances changed.

82 Evidence indicates that the gang, and the COSS in particular, considered that the system of work which they had been issued with (which they referred to as a plan, and which had been produced by the planning process) had been properly prepared, and that if they followed the plan and worked as they had done before at this location, they would be safe. It was not part of the culture of the depot to question existing arrangements or the way in which jobs such as patrolling were carried out. Two lookouts had traditionally been allocated to this patrol, and the possible need for more lookouts at certain locations was not identified or considered by the planning process or by the COSS.

83 The COSS had told the lookouts where to stand. He had not appreciated the extremely limited sighting available on the curve of the Bookham lines, which would have reduced the warning time for an up train from that direction to about ten seconds (paragraph 60, table 1). The ATSM, who was accompanying the gang to check on the safe working arrangements, did not query the position of the lookouts.

84 If a lookout had been positioned far enough round the curve to see approaching trains on the up Bookham line when they were still a safe distance way, he would have been unable to also see approaching trains on the up Portsmouth line. An additional lookout would have been required for this duty. To ensure proper warning of trains approaching on the down line, a further lookout on the London side of the station would have been needed. This would have enabled the lookout closest to the junction to act as site lookout and relay the warnings given by the other three to the gang. Therefore a safe system of work at this location would have required four lookouts, positioned as shown in figure 6. Four lookouts were being used when the photograph, figure 5, was taken, and one of them can be seen in figure 5 standing in a position from which there is adequate sighting along the Bookham lines.

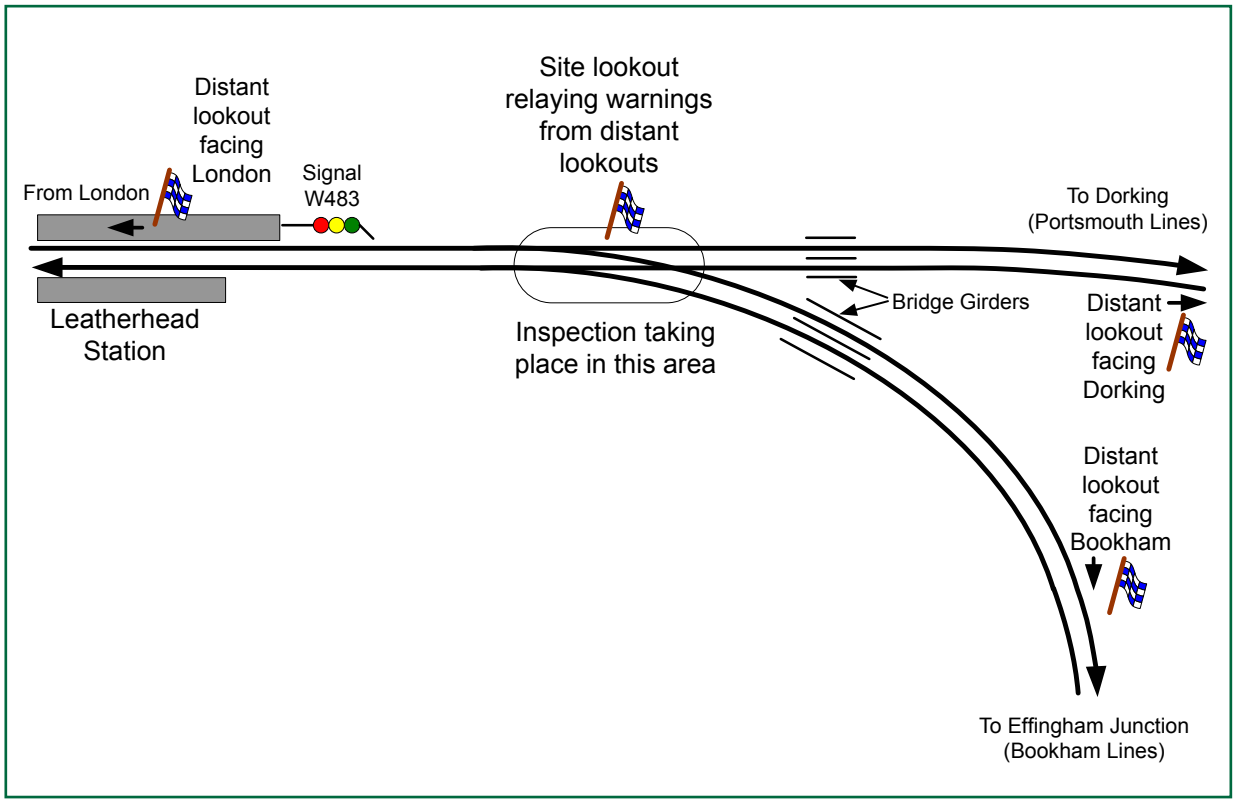


Figure 6: Positioning of lookouts for giving adequate warning of trains approaching Leatherhead junction

85 There were insufficient resources available to the COSS to enable him to use four lookouts and still conduct an effective inspection of the junction. The lack of sufficient lookouts to obtain adequate sighting in all directions was not a causal factor in the accident but placed the members of the gang at risk.

86 The COSS had been issued with a pack containing the three RT9909 forms and two patrolling diagrams for the day's inspection, amounting to 14 sheets of paper. The pack contained a lot of information, but it was not in a form in which it could be easily assimilated or understood by track workers on site.

87 The RT9909 forms had some information about specific risks (Bookham tunnel, the restricted clearance at the Mole viaduct) but this was not complete. If all the specific risks associated with this patrol, including the curvature of the line and restricted sighting around Leatherhead junction, had been identified clearly at the start, the COSS might have been alerted to take a different approach to setting up safe systems of work in these areas.

88 The copious paperwork that was provided gave the impression that all risks had been considered. This was not the case, and the combined effect of the provision of pre-planned systems of work, together with the absence of important information, tended to create a false sense of security for the COSS. This was not a contributory factor in the accident, but increased the risks that the gang were exposed to. A similar situation was identified in the RAIB's report on an incident near Manor Park on 19 March 2006 (report number 26/2007) in which a gang narrowly avoided being struck by a train. The RAIB recommended that the contractor involved should revise its RIMINI plan design to highlight key information and remove superfluous information, but this recommendation did not apply to Network Rail.

The patrolling diagrams

89 The information on the patrolling diagrams which were given to the COSS is described in paragraphs 47 to 53. Some of the information was inaccurate, and the way it was presented was inconsistent, contradictory and confusing. The names of the TME and the former Wimbledon TSM were on them, against a box certifying that the diagrams were accurate and compliant with the requirements of NR/SP/TRK/001, but the diagrams had not been signed off by those managers and were still regarded (by the acting TSM) as 'work in progress'.

90 The patrolling diagrams were not integrated with the safe system of work documents (the RT9909 forms) produced by the 'RIMINI' system. The diagrams added additional work (the inspection of the 855 S&C at Leatherhead) to the patrol, which was not included in the RT9909 forms. This was not a contributory factor in the accident, but exposed the gang to greater risk.

Alternative methods of protection

91 The alternative protection methods which should have been considered for the work at Leatherhead because of the deficient sighting times were:

1. Green zone working;
2. Red zone working with train- or lookout-operated warning system.

92 The green zone guide produced by Network Rail showed that the train service is such that, on weekdays, it is only possible to create a green zone (using module T12 of the Rule Book) lasting 20 minutes during the day after 06:00 hrs. Since the accident, this method has been used for inspection of the junction, but it was not considered beforehand.

93 Red zone working using a warning system would have been technically feasible, but it would still have relied on the staff moving clear when the warning was given, and so might not have prevented this accident. Setting-up and using temporary systems is complex and time-consuming in junction areas, and for this reason it is done very rarely, especially in situations where junctions are inspected as part of a long patrol of plain line.

Prohibition of red zone working

94 The patrol had been carried out in the same way for a very long time. The sighting difficulties at the junction had never been identified, probably because all passenger trains call at Leatherhead station, and therefore travel through the area of the junction at low speed. If the absence of adequate sighting had been appreciated and, as a result, red zone working was prohibited at this location, the accident would not have occurred; the lack of red zone prohibition at Leatherhead junction was a causal factor in the accident. The investigation also identified that other, similar, junctions exist within the Wimbledon area and elsewhere where the sighting is insufficient to permit safe red rone working, but it had been taking place.

The staff involved

Competence of staff

95 All the staff involved in this incident were appropriately qualified and certificated for the work they were doing (except for patrolman 1, who was not formally qualified for patrolling duties). However, the COSS had only two years railway experience (less than any of the rest of the group), and one year's experience as COSS. He was well thought of by his supervisors and had recently been promoted to Leading Trackman. His training to act as COSS in red zones had mainly involved watching more experienced staff, and he accepted the working practices that he had been shown. These included the positioning of the lookouts at Leatherhead junction, but the consequent lack of warning time was not picked up by managers who accompanied the patrol, either on 1 August or on the day of the accident. Network Rail's lack of knowledge of the way in which the COSS was working, and the lack of guidance for him on correct positioning of lookouts was a contributory factor in the accident.

96 The average experience of leading trackmen at Wimbledon was two to three years, somewhat lower than the neighbouring depots. The managers believed that in some cases the rapid promotion of individuals had led to difficulty in ensuring the relevant competence was maintained. However, managers considered that recent changes in line management arrangements, introduced by Network Rail for managing junior staff, had been useful in giving section managers a good knowledge of the competence of their staff.

Methods of working used by the gang

97 The 'RIMINI' system gives a COSS a firm steer towards the method of working selected by the work planner. It is rare for a COSS to challenge a RT9909 form that specifies that the work will be carried out red zone. During the patrol on 1 August, managers accompanying the gang challenged the arrangements for safety when inspecting the Mole viaduct, and these were subsequently amended. They did not similarly challenge the arrangements for inspecting Leatherhead junction, and neither the COSS nor the ATSM accompanying the gang on 29 August recognised that the system of work they were using was not safe, and that they did not have sufficient resources to put a safe system of work in place.

98 This lack of experienced, effective oversight of day-to-day operations, and consequently not identifying deficiencies in the working methods used by the gang, was a contributory factor in the accident.

Response of the gang to approach of trains

99 The rule book, Module T6, section 5.2(c), required the members of the gang to move to a position of safety when the down train was first warned to them as it entered the station: they did not do this. It had become custom and practice in some circumstances (such as when a train was evidently stopping at a station) not to move clear until a definite risk was perceived. It is not possible to say that the fact that they did not move clear on 29 August was a causal factor in the accident, but it contributed to the likelihood that an accident would occur.

Group cohesion

100 Only two of the members of the gang, the COSS and patrolman 2 (who was not injured), were regular members of the Wimbledon patrolling team. The others were part of the day production team, who normally work on routine maintenance and rectification of minor track faults. Although the gang had all worked together before, they did not regularly work as a team.

101 Because they did not work together regularly, the members of the gang were not fully aware of each others competencies and abilities: the COSS, for instance, was unaware that the person he appointed as lookout on the down side (lookout B) had only completed one previous turn of duty as a lookout.

102 This lack of cohesion may have influenced the way in which the COSS checked that each member of the gang was clear of the line when a warning was sounded. He had moved to a place of safety, and believed that he had seen patrolman 1 do the same. However, he did not look around to confirm that this was the case. This was a contributory factor to the accident.

Managers accompanying work gangs

103 Only four weeks before the same COSS had had his working methods challenged at the Mole viaduct. Following this, changes to the safe system of work had been fed into the 'RIMINI' planning system. This may have created a belief among the members of the gang that the way in which the patrol was now being carried out had been endorsed by authority. This may have been strengthened by the fact that the ATSM was accompanying the gang on 29 August, and before the accident he had appeared to endorse the method of work that the COSS had set up.

Identification of underlying causes

104 The accident would not have occurred if the members of the patrol gang had been able to do their work in a green zone, ie when trains were not running on the lines they were inspecting. The need for regular visual inspection of the track, and the difficulty of obtaining safe access to the track for this and for other maintenance work, combined to expose track workers to the risk of being struck by moving trains.

105 The history of the attempts that have been made to reduce the exposure of track workers to risk is described in Appendix E. Despite these, patrolling on foot is still carried out at least weekly on the great majority of Network Rail's infrastructure. The risks of this, in terms of the safety of workers and the effectiveness of the inspection itself, are that either the patroller will concentrate on their own safety at the expense of looking closely at the track, or they will be at risk from approaching trains, particularly in locations where sighting is restricted, while they are focused on identifying and rectifying track faults.

106 At Leatherhead, and elsewhere in the Wimbledon area (paragraph 94), basic visual inspection of S&C was done in red zone conditions. There is also a need to carry out more detailed inspections of S&C, usually every four weeks, and this is done by specialist asset inspection staff. The RAIB has found no evidence of previous attempts to obtain green zones for inspection of the S&C at Leatherhead, or generally in the Wimbledon area. The changes made at Leatherhead after the accident, and the systems used at Clapham Junction (paragraph 80), indicate that it was practicable to obtain green zones in which to examine S&C in the area.

107 The absence of effective action to end the practice of inspecting S&C while trains are running was the underlying cause of the accident.

Response of others

108 The ATSM responded rapidly and very competently after the accident, and the first aid that he gave, and the way that he organised the remaining members of the team to assist, was important to the recovery of the injured person.

Conclusions

Immediate cause

109 The immediate cause of the accident was that the patrolman remained in the space between the up and down Bookham lines as trains approached on both those lines (paragraph 75).

Causal factor

110 A causal factor in the accident was that red zone working was not prohibited at Leatherhead Junction despite the inadequate sighting times available with the number of lookouts available to a patrolling gang (paragraph 94, **Recommendation 1**).

Contributory factors

111 The following factors were considered to be contributory:

a. the gang did not always stop work when first warned of the approach of down trains (paragraph 99);

b. the COSS did not confirm that all the members of the gang had moved to a place of safety (paragraph 102);

c. the COSS had not been given sufficient correct guidance on the placing of lookouts for track workers (paragraph 95, **Recommendation 4**); and

d. management had not identified deficiencies in the method of working used by the patrolling gang (paragraph 98, **Recommendation 3**).

Underlying cause

112 The underlying cause was that patrolling inspection of S&C was being carried out while trains were running, and the railway industry has not succeeded in minimising the exposure of track workers to the risks arising from this practice (paragraph 106, **Recommendation 2**).

Additional observations

113 The following observations are made as a result of the investigation:

<u>The need for change to inspection methods</u>

114 The way in which the arrangements for protecting track workers have developed historically, and recent technical developments in track inspection, are described in Appendix E. Since 2005 there have been several incidents (described in Appendix F) which, taken together, point to the desirability of separating plain line and S&C inspection, both to minimise the risk to staff from moving trains and to improve the quality of S&C inspection, so that there is a lower risk of train accidents caused by defective track. The high incidence rate of fatal injuries to track workers (paragraph E2) indicates that action to improve safety for these people is urgently required.

115 At present, Network Rail's standards still require all inspection of S&C to be done on foot, and for all plain line to be inspected on foot at least once every four weeks. At Leatherhead, the use of a combined plain line and S&C patrol was largely driven by the needs of the plain line inspection. The resources available and the tools carried by the gang were appropriate to plain line and restricted the extent of the detailed inspection that could be carried out on the S&C. There was no attempt to take a possession (under module T12 of the rule book) to provide a green zone for S&C inspection (Appendix D).

116 There are new train-borne methods available for the inspection and measurement of plain line track (Appendix E). If one of these was being used to cover basic inspections of plain line, it would have allowed the S&C inspection to be more carefully planned.

117 The RAIB's investigation of the derailment of an express passenger train at Grayrigg, Cumbria, on 23 February 2007 (Report 20/2008), found that the absence of proper technical checks on the condition of the points involved was one of the causal factors in the derailment. Separate inspection of S&C would enable staff to bring more appropriate equipment to site and to carry out the inspection more effectively. In addition, at present patrolling staff have to be competent to inspect both plain line and S&C. If these functions were to be separated, a cadre of S&C inspectors could be developed with appropriate specialist skills. Recommendation 19 of the RAIB's report on the Grayrigg derailment addresses similar areas to those covered by Recommendation 2 of this report.

118 The mechanisation of plain line inspection would remove patrol staff from a large proportion of their exposure to risk. The separation of plain line and S&C inspection would enable alternative arrangements to be put in place for S&C to be inspected in non-traffic hours or under the protection of fixed warning systems (**Recommendations 5 and 6**).

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

119 Network Rail have prohibited red zone working in the junction area at Leatherhead. Inspection is now carried out under T12 arrangements (described in Appendix E), without disruption to the train service.

Recommendations

120 The following safety recommendations are made[1]:

Recommendations to address causal and contributory factors

1 Network Rail should prohibit red zone working at Leatherhead Junction (paragraphs 110, 119) (reported by Network Rail as already complete).

2 Network Rail should review the inspection arrangements for S&C throughout its network, especially at junctions where sighting is restricted by curvature or train speeds are high, so that the staff carrying out the inspection are adequately protected, considering for example:

- S&C inspection in non traffic hours, or other green zone arrangements;
- provision of suitable lighting to enable inspection in green zone in darkness; and
- train operated warning systems.

(paragraph 112, Appendix F).

3 Network Rail should review the arrangements for protection of patrolling staff and others whose work involves moving along the line, throughout its network so that adequate warning time to move to a position of safety is always available (paragraph 111d, Appendix F)).

4 Network Rail should review its arrangements for the assessment and monitoring of staff who have to set up safe systems of work, so that there is regular confirmation that they are making appropriate arrangements, particularly for work which moves along the line (paragraph 111c, Appendix F).

Recommendations to address other matters observed during the investigation

5 Network Rail should review the implementation of mechanised inspection techniques for plain line, on routes laid with continuous welded rail with the objective of ending the practice of foot patrolling under traffic (paragraph 118).

continued

[1] Duty holders, identified in the recommendations, have a general and ongoing obligation to comply with health and safety legislation and need to take these recommendations 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, these recommendations are addressed to The Office of Rail Regulation (Her Majesty's Railway Inspectorate) to enable them to carry out their 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 167 to 171) can be found on RAIB's web site at www.raib.gov.uk.

6 Network Rail should revise the standards and procedures for the inspection of S&C on the routes referred to in Recommendation 5, so that:

- S&C inspections are carried out by specialist staff who are appropriately trained; and
- S&C inspection takes place in green zone conditions.

(paragraph 118).

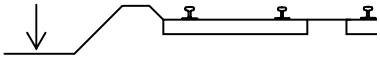
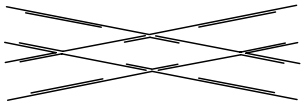
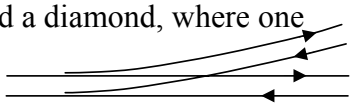
Appendices

Appendix A - Glossary of abbreviations and acronyms

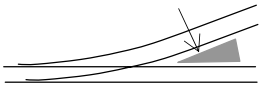
ATSM	Assistant Track Section Manager
ATWS	Automatic Track Warning System
COSS	Controller Of Site Safety
GZTS	Green Zones: Thinking Strategically
HMRI	Her Majesty's Railway Inspectorate
HSC	Health and Safety Commission
LOWS	Lookout Operated Warning System
OTDR	On Train Data Recorder
RIAC	Railway Industry Advisory Committee
RIMINI	Risk minimisation
S&C	Switch and Crossing
SSOW	Safe System Of Work
SWT	South West Trains
TOWS	Train Operated Warning System

Appendix B - Glossary of terms

All definitions marked with an asterisk, thus (*), have been taken from Ellis' British Railway Engineering Encyclopaedia © Iain Ellis. www.iainellis.com

Assistant track section manager	An assistant to the manager responsible for the maintenance of a section of track, typically about twenty route miles.
Automatic track warning system	A temporary staff warning system similar in principle to the Train Operated Warning System (TOWS) but erected only for the duration of a specific worksite.*
Cess	The part of the track bed outside the ballast shoulder that is deliberately maintained lower than the bottom of the sleepers to aid drainage.* 
Chain	A unit of length, being 66 feet or 22 yards (approximately 20117mm). There are 80 chains in one mile.*
Controller of site safety	A safety critical qualification demonstrating the holder's competency to arrange a Safe System of Work, i.e. protecting staff working on the line from approaching trains.*
Crossing	An assembly that permits the passage of wheel flanges across other rails where tracks intersect.* 
Crossover	Two sets of points connected to permit movements between parallel tracks.* 
Diamond	A switch and crossing unit that consists of two common crossings and two obtuse crossings, allowing two tracks to cross each other on the flat.* 
Double junction	A junction comprising two sets of points and a diamond, where one two track railway connects with another.* 
Down	Track or platform normally used by trains travelling away from London or towards the highest mileage.*
Electric Multiple Unit	A train consisting of one or more vehicles (semi-permanently coupled together) with a driving cab at both ends, whose motive power is electricity supplied externally from overhead line equipment or conductor rails.*
Facing	Switches positioned so that the routes for trains passing over them diverge in the normal direction of travel.
Four-foot	The area between the two running rails of the track.
Green zone	A site of work on the track in which there are no train movements.
Insulated block joint	A rail joint in which one rail is electrically insulated from the abutting Rail for signalling or electrification purposes, normally utilising insulated fishplates.*

Lookout	A competent person whose duties are to watch for and to give an appropriate warning of approaching trains by means of whistle, horn or warning siren.*
Lookout operated warning system	The generic term for any system that warns staff of the approach of trains but is triggered by a lookout. An example is PeeWee.*
Patrolling diagram	A document which provides, in both textual and visual form, the details of the section of line to be inspected by a patrol gang. It includes instructions on where the patrol gang should walk and the positions from which tracks should be inspected.
Patrolman	A member of railway staff engaged in pedestrian visual inspection of the track (and superficial inspection of other lineside items).*
Pee Wee	A system which uses a remotely controlled siren to allow one lookout to give up to 1½ miles' warning of approaching trains, probably named from Portable Electronic Warning Equipment.*
Plain line	Track without switches and crossings.*
Points	Assembly of switches and crossings designed to divert trains from one line to another.
Position of safety	A place far enough from the track to allow a person to safely avoid being struck by passing trains. On Network Rail infrastructure this is 1.2 m (4 feet) at speeds up to and including 100 mph, 2 m (6 feet 6 inches) at speeds up to 125 mph, and 2.75 m (9 feet) at speeds over 125 mph.*
Railway Group Standard	A document mandating the technical or operating standards required of a particular system, process or procedure to ensure that it interfaces correctly with other systems, process and procedures. Railway Group Standards are produced, maintained and controlled by the Rail Safety and Standards Board (RSSB).*
Red zone	A site of work which is not protected from train movements.
Rule Book	Railway Group Standard GE/RT8000, a comprehensive set of rules for safe working on the railway, grouped into 51 modules, each covering activities which railway staff carry out.
Spuller	Combined spanner and pulling tool for Pandrol rail clips, used by patrolmen.
Switch and crossing	Track consisting of switches and crossings forming connections between lines.
Track circuit block	A signalling system where the line is proved clear to the overlap beyond the next signal using track circuits or axle counters.*
Trailing	Switches positioned so that the routes for trains passing over them converge in the normal direction of travel.

Train operated warning system	A permanently installed warning system for track workers in which an audible warning is triggered automatically on the approach of a train by links to the signalling system. The warning time is usually pre-set to a minimum of 45 seconds.
Up	Track or platform normally used by trains travelling towards London or away from the highest mileage.*
Vee	The space between the main line and diverging route immediately adjacent to a junction.* 
Works scheduler	A person responsible for planning work activities at the local level.*

Appendix C - Key standards current at the time

Rule Book module T6	Walking as a group and working on or near the line
Rule Book module T7	Safe systems of work when walking or working on or near the line
NR/SP/OHS/019	Safety of people working on or near the line
NR/PRC/MTC/TK0075	Management of permanent way inspections
NR/PRC/MTC/PL0094	Planning and documenting the safe system of work arrangements
NR/SP/TRK/001	Inspection and Maintenance of Permanent Way
NR/L2/TRK/053	Inspection and repair to reduce the risk of derailment at switches

Appendix D - Rules, Standards and Procedures

D1 The Rule Book (*Railway Group Standard* GE/RT/8000) describes two systems for carrying out work on or near the line. These are:

- green zone: a site of work in which there are no train movements.
- red zone: a site of work which is not protected from train movements.

D2 It is Network Rail's policy (paragraph E10) that work should take place in a green zone whenever this is reasonably practicable. However, to create a green zone for work on the track it is necessary to stop trains approaching the site of work. This is disruptive to the running of the railway network, and can normally only be done at night, or at specific weekends that have been identified a long period in advance.

D3 Staff perceive it as difficult to arrange for regular maintenance work, such as patrolling inspection, to be done in a green zone, especially as Network Rail standard NR/SP/TRK/001 'Inspection and Maintenance of Permanent Way' requires that this work is done in daylight, unless the Territory track engineer has decided that, for reasons related to restrictions on access, that it may be done in darkness in specific locations.

D4 If it is not practicable to establish a green zone, it is sometimes permissible for work to be carried out in a red zone. This is standard practice for patrolling inspections on lines where train speeds are low enough for it to be possible for workers to be given sufficient warning of an approaching train to enable them to reach a position of safety at least ten seconds before it arrives.

D5 The Rule Book defines the arrangements that must be made for working in a red zone in modules T6 and T7. The provisions relevant to the work being done at Leatherhead on 29 August are summarised in the following paragraphs.

D6 Module T6, section 3.6 sets out the briefing arrangements for staff. The COSS will tell staff about the hazards at the work site. The staff receiving the briefing are required to sign the 'COSS Arrangements and Briefing Form' (RT9909), to confirm their understanding of the system of work that will apply. Section 3.6 also requires staff to move to a position of safety in the event that there is any doubt about the safety of the system of work.

D7 Module T7, section 9.7 stipulates that the COSS must decide where to position the lookouts. Section 9.3 requires the COSS to calculate the warning time required, and make arrangements for warning to be given, taking the following points into consideration:

Time – the minimum time needed to stop work, down tools and reach a position of safety at least 10 seconds before a train arrives at the site of work.

Speed – the speed of approaching trains including any temporary or emergency speed restrictions imposed for the work.

Distance – the distance needed for the equipment to detect, or for the lookout to clearly see an approaching train.

A method for calculating warning time, supported by a table of sighting distances, is provided in Module 7 to help the COSS work out the distance needed.

D8 Module T6, section 5.1, deals with the methods of warning to be given by the lookout, and section 5.2 lays down what staff must do when warning of an approaching train is given:

- acknowledge the warning by raising an arm above the head;
- immediately move to a position of safety; and
- stay in the position of safety until the COSS tells them it is safe to start work again.

D9 Module T6, section 7, covers the responsibilities of the lookout. Section 7.6.c says:

> 'You must give a warning by:
>
> - sounding your horn or whistle; and
> - by shouting if necessary.
>
> If anyone you are warning does not acknowledge your warning by raising one arm and does not move to a position of safety, you must give a series of short sharp blasts (which means an urgent warning) on the horn, or whistle until everyone has moved to a position of safety.'

D10 Section 7.10 of module T6 requires the lookout to give a warning to the group if for any reason they are unable to perform their duties in a safe manner. Once every person in the group has gone to a position of safety the lookout should then explain to the COSS what the concern is.

D11 Module T7 section 1 describes the responsibility of the COSS to make suitable arrangements for a safe system of work on the line. The object of a safe system of work is to ensure that staff working on the track or walking as a group 'are not put in danger from any passing train or movement'.

D12 This module requires that whenever possible, the safe system of work must be planned in advance and provided to the COSS. Section 3.1 of module T7 requires the COSS to make sure that the planned safe system of work is adequate. The Rule Book does not explain how the COSS is to do this, or who is to plan the work, but Network Rail provides some guidance (see paragraph D21).

Planning safe systems of work

D13 The way in which work on or near the line is to be planned is described in Network Rail specification NR/SP/OHS/019 'Safety of people working on or near the line'. In the first instance (section 4) this document requires that, where a risk assessment has identified a need for people to go on or near the line, 'consideration shall be given to alternative means of carrying out the work which will remove this need'.

D14 Network Rail Standard Maintenance Procedure NR/PRC/MTC/PL0094 'Planning and documenting the safe system of work arrangements' makes the section manager or maintenance engineer responsible for the initial determination of how the work will be done, and whether it is to be done within a possession, or in red zone arrangements.

D15 The section manager or maintenance engineer is required to decide upon the safe system of work arrangement based on the nature of the work and the guidance provided in NR/SP/OHS/019. It is possible for the safe system of work to be proposed by a Works Scheduler, provided they are suitably qualified, but this is subject to acceptance by the section manager or maintenance engineer.

D16 NR/SP/OHS/019 says that, having confirmed that it is necessary for people to go on or near the line, the work planner must use a defined process to arrive at the appropriate safe system of work (SSOW) for the activity. This involves consideration of the opportunities for carrying out the work when the line is closed to traffic.

D17 The work planner should take into account the risk minimisation hierarchy set out in the Rule Book and in NR/SP/OHS/019, which is:

1. Safeguarded green zone
2. Fenced green zone
3. Separated green zone
4. red zone with *automatic track warning system* (ATWS)
5. red zone with *train operated warning system* (TOWS)
6. red zone with *lookout operated warning system* (LOWS)
7. red zone with lookout using *Pee Wee*
8. red zone with lookout with no additional equipment

D18 Level 8 (red rone with lookout unassisted by other equipment) is to be regarded as the last resort. However, this is qualified by NR/PRC/MTC/PL0094, which says (at 4.4):

> 'Generally, you should not plan to use green zone arrangements or red zone level 4–7 arrangements if it would increase total man-hours to complete the work by more than 25%, including time spent track-side waiting and time spent setting up the arrangements.'

D19 Once the planning is complete, a pack of information, partly completed with details of the location, is prepared for the COSS. This is specified as consisting of the RT9909 form, supported where applicable by the 'line blockage form' (RT3181), which is used in connection with establishing protected areas in accordance with modules T2 and T12 of the Rule Book, and where appropriate by a site diagram showing the relevant running lines, signals, points and work location.

Setting up safe systems of work

D20 On site, Rule Book module T7 makes the COSS responsible for setting up a safe system of work. Section 3.1 says (referring to the COSS):

> 'Before you start to set up the planned safe system of work, you must make sure it is adequate. You may have to vary the planned arrangements in which case you must get any necessary authority before you do this.'

D21 Network Rail document NR/SP/OHS/019 says (at 4.5):

> 'If the COSS considers the safe system of work to be inadequate or cannot implement it as planned, he/she shall be required either to:
>
> - vary the arrangements as necessary to ensure that an adequate safe system of work is established *[q]* or
> - abort the work until such time as an adequate safe system of work can be established *[q]*.'

D22 Note *[q]* to this document says:

> 'Under certain circumstances, the planned safe system of work may prove to be inappropriate. Such situations could include:
>
> - The COSS is unable to implement the safe system of work (eg green zone working planned but not granted at the time of the work, ATWS planned but equipment found defective during pre-use checks, lookout planned but actual sighting conditions mean more than one intermediate lookout would be required in any one direction, or scheduled resources not available)
> - The COSS considers the safe system of work to be inadequate
> - Conditions (eg weather) change after work has started
>
> In such circumstances, the COSS should be permitted to implement an alternative safe system of work or to adjust the work or planned safe system of work. The COSS should not be permitted to implement a safe system of work that is lower in the hierarchy without specific authority from a designated manager who should have a sufficient understanding of the relevant Rules, this specification, and the arrangements for the work to make an informed decision. It should be emphasised that the COSS retains ultimate responsibility for safety on site and has the final decision as to whether a planned safe system of work is acceptable. Under no circumstances should the COSS attempt to commence or complete the work without adequate arrangements in place.'

D23 Once the COSS is satisfied that the planned safe system of work is adequate, on the basis of the information available, then the COSS should complete the COSS Briefing Form (RT9909) with details of the actual method of protection and, where lookouts are in use, the sighting distances that are required.

D24 The COSS must brief the members of the group on the arrangements, confirm that they are all appropriately qualified for their duties, and obtain their signatures on the RT9909 form to confirm that this part of the process has been carried out.

D25 Section 9.7 of module T7 specifies the requirements for using lookouts. In particular, if a combined total of more than four distant and intermediate lookouts would be required to get adequate sighting distance, the COSS must not use lookouts and must find an alternative safe system of work. The COSS is not permitted to act as a lookout while also carrying out the duties of a COSS.

Patrolling diagrams

D26 Network Rail specification NR/SP/TRK/001 requires (section 9.2.1) patrolling diagrams to be created to monitor and ensure all lines are inspected in accordance with the requirements of NR/SP/TRK/001 and to the correct frequency.

Appendix E - Exposure of track workers to risk

The risks

E1 A detailed analysis of the rate of fatal accidents to track workers appeared in the RAIB's report on the death of a welder at Ruscombe, near Reading, on 29 April 2007 (number 04/2008). There have been 20 deaths since 1994 caused by workers being struck by trains, two of which were in 2007.

E2 The Rail Safety & Standards Board (RSSB) has estimated that the average individual track worker risk (probability of fatality per year) is 1.30×10^{-4} (1 in 7,696 per year).

Exposure of track workers to risk

E3 The high risks arising from work on the track were recognised over one hundred years ago, when the Railways (Prevention of Accidents) Act 1900 empowered the Board of Trade to make rules relating to the safety of workers on the track. The resulting rule 9 of the Prevention of Accidents Rules 1902 required that:

'With the object of protecting men working singly or in gangs on or near lines of railway in use for traffic for the purposes of relaying or repairing the permanent way of such lines, the railway companies shall ... in all cases where any danger is likely to arise, provide persons or apparatus for the purpose of maintaining a lookout or for giving warning against any train or engine approaching such men so working ...'

E4 This statutory duty, the earliest example of prescriptive legislation relating to the safety of railway workers, assisted in reducing the number of track workers killed from about 350 in 1900 to about 100 in 1950. Changes in working methods, including the mechanisation of heavy maintenance and renewal, and improvements in the management of safety, contributed to a further reduction to a level where only two people were killed on the track in 1993/94, the last year in which British Railways was a unified organisation.

E5 Maintenance work on the track is one of the most dangerous occupations in the railway industry. The Health & Safety Commission's (HSC) Railway Industry Advisory Committee (RIAC) stated[2] in 1995: 'The most common single type of fatal accident to railway workers has been to be struck by a train while on the track. The risk is higher than the industry average because workers are frequently exposed to the hazard (a train) and the consequence of being struck is often fatal. The overall rate of deaths per 1000 railway workers is comparable to that for workers in more apparently hazardous industries such as mining and construction, while for those actually exposed to danger on the track it is higher still.'

[2] *Railway safety: the prevention of risk to workers on the track.* Railway Industry Advisory Committee/Health & Safety Commission, London, 1995. ISBN 0 7176 0805 0.

E6 Since 1994 there have been 20 people killed by being struck by trains while working on the track. The fatal accident rate for track workers was 13 per 100,000 workers per year in 2006, compared with an average industrial rate of 0.8 in 2006/07[3], making this one of the most dangerous industrial sectors in the UK. The number of track workers exposed to this risk is about 30,500[4], and the small number of fatal accidents each year may cause this rate to fluctuate significantly: in 2007 it fell to less than 6 per 100,000 because a single multi-fatality accident in 2004 was no longer included in the calculation of the statistic. A rate of 6 per 100,000 is typical of performance over the last ten years, and is greater than, for example, the construction industry (4 per 100,000).

Origins of the RIMINI system

E7 The potential safety risks presented by the restructuring of the railways in preparation for privatisation led to the creation of a new safety regime, based on a 'safety case' system for the control of risks to the public and staff arising from the operation of the railway.

E8 In support of this system, in 1995 RIAC issued guidance on the prevention of risk to workers on the track. This was the first document to formally establish a hierarchy of protection principles. These were:

Principle 1: So far as is reasonably practicable, work should be done when trains are not running at all.

Principle 2: Where work must be done during times when trains are running, so far as is reasonably practicable:

a. trains should be diverted onto other tracks for the duration of the work;

b. the work site should be fenced off from any track remaining open to trains; and

c. safe means of access to a separated site should be provided, separated if possible from any track in use.

Principle 3: Where it is not reasonably practicable to stop or divert trains, opportunities for access to the track should be provided between train movements where practicable. Methods of using those opportunities safely, by formal and recorded agreements, supported by suitable protective measures where practicable, should be devised and installed.

Principle 4: Where it is not reasonably practicable to separate the work from running trains, people who need to work on or near the track will need to be protected by a system that gives adequate warning of the approach of trains.

E9 This guidance also included additional principles relating to the detailed organisation of safety on the track, and advice on how these principles could be put into practice.

E10 Railtrack, at that time the infrastructure manager for the national network, responded to this guidance by, among other things, creating the concept of 'green zones' and 'red zones', which began to appear in internal documents in April 1995. These terms first appeared in the Rule Book in January 1996, and in the same year Railtrack produced line procedure RT/D/P/050 'Facilitation of Green Zone Working'. This was intended to detail a process to enable Railtrack and its contractors (who at that time carried out all maintenance work on Railtrack's network) to maximise the use of green zone working.

[3] Source: Health & Safety Executive http://www.hse.gov.uk/statistics/tables/table3.htm

[4] Source: Network Rail

E11 The procedure required all Railtrack Zones to publish information on where and when green zones were likely to be available, and the contractors to undertake work in green zones wherever and whenever reasonably practicable. Zones were also required to document locations where, due to the nature of the infrastructure (eg extensive lengths of line with limited clearance with no or inadequate refuges, restricted sighting times, or inadequate warning arrangements), red zone working was prohibited.

E12 The procedure allowed red zone working to be undertaken when a contractor's risk assessment demonstrated that it was reasonably practicable to do so. It also went further, and said that it was likely that the contractor's red zone risk assessment would be able to demonstrate that such working was reasonably practicable for 'work of a minor nature which has to be done in daylight on the grounds of safety, due to either its nature, or to poor physical conditions.'

E13 HM Railway Inspectorate (HMRI), the railway industry safety regulator, investigated progress with maximising green zone working as part of its inspection programme for 1999/2000. The report of this study[5] found that, although documentation associated with track workers protection procedures had developed, red zone working remained the norm in 'work situations associated with between trains infrastructure maintenance in traffic hours'. It was difficult to monitor the situation accurately because different methods of measuring amounts of work and methods of protection were used in different parts of the country.

E14 The lack of real progress in the use of green zone working was recognised by HMRI and the industry. The procedure RT/D/P/050 had not been effective in changing ingrained working practices, and was acknowledged to be 'inadequate to meet the industry's obligations'[6] in respect of compliance with health and safety law. A working group with representatives from Railtrack, contractors, staff and HMRI produced a fresh strategy for risk minimisation, known as 'RIMINI'. The main thrust of this strategy, apart from maximisation of green zone working, was to require all work on or near the line to be pre-planned, so that the COSS for each work group could be in possession of all the information that was required for implementing a safe system of work.

E15 'RIMINI' was published in April 2002 as Railtrack company specification RT/LS/S/019 'Protection of People Working On or Near the Line', which superseded RT/D/P/050. It introduced the RT9909 form and the role of 'work planner', and set out the hierarchy described in paragraph D17 for selecting the appropriate protection method.

E16 The 'RIMINI' document required Railtrack and contractors to maximise green zone working, particularly by taking account of maintenance requirements within timetable planning processes. However, the train operators and the agencies responsible for specifying the timetable were not among the parties responsible for preparing the document, so it is doubtful whether this could be classed as any more than an aspiration.

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[5] *HM Railway Inspectorate National Topic 1999/2000 – Topic 6: Red/Green Zone working – a report on the progress with maximisation of green zone working on Railtrack infrastructure.* HSE, London 2000. http://www.rail-reg.gov.uk/upload/pdf/trackside-safety-red_green-zone.pdf

[6] *Protection of People Working On Or Near The Line* (RT/LS/S/019), issue 1 briefing note, Railtrack, April 2002.

E17 The effect of the new document on track patrolling, as explained in Appendix A to RT/LS/S/019, was expected to be that patrolling would have to be planned, and that there would be some restrictions on the existing availability of opportunities for patrolling. This would be because red zone working was now specifically prohibited in situations where it was necessary to cross three or more lines to reach a position of safety (as well as existing locations with sub-standard sighting).

E18 Another strand of the 'RIMINI' strategy was to increase the use of automatic track warning systems (ATWS) and train operated warning systems (TOWS). Various types of ATWS have been developed and presented to the industry since the 1990s, but none has been taken up to any significant extent. They are seen as expensive and time-consuming to set up, potentially reducing the amount of time available for actually working. There were also, perhaps more significantly from the point of view of those who may have to use them, real concerns about the reliability of the automatic systems following a number of incidents shortly after the systems were introduced in which 'wrong side' failures appeared to take place.

E19 TOWS has, for many years, been incorporated in resignalling schemes in areas where it has been technically possible to do so. It is capable of giving a reliable warning of approaching trains, but its application has been limited for several reasons. When in use, it emits a continuous "confidence" tone, which can be unacceptable to people living near the line. In multiple track areas, TOWS does not identify the line on which a train is approaching, which limits its usefulness. It is designed to be switched on and off at the same place, making it difficult to use for mobile work like patrolling.

E20 The 'RIMINI' principles were introduced in 2002. From then until April 2005 there were no fatal accidents to track workers that were associated with red zone working. Since April 2005, however, there have been five accidents in which people have been killed by moving trains while working on lines open to traffic. Three of these occurred in connection with work on junctions.

E21 In August 2006 the 'RIMINI' document, now renumbered NR/SP/OHS/019 and retitled 'Safety of people working on or near the line', was re-issued with details of the documentation to be provided in the 'COSS pack', new requirements for the competence of planners, and revised guidance in various areas. Those relevant to the accident at Leatherhead included advice that the number of people involved in the work, and whether it is appropriate for the COSS to have work duties in addition to COSS duties, should be taken into account in planning the work. There is also a requirement for the COSS to be briefed on the safe system of work and for the necessary resources to be made available to the COSS.

E22 The latest revision of NR/SP/OHS/019, read with the supporting document NR/PRC/MTC/ PL0094, allows the time and effort needed to set up protection to be taken into account when determining the safe system of work (paragraph D18). It is easy to argue, in the case of locations such as Leatherhead, that the time taken to set up a green zone or warning system is more than disproportionate in terms of the work being undertaken. This sort of logic, combined with the dynamics of the day-to-day operation of the railway, results in the level of protection cascading down to the lowest level possible, red zone with lookouts.

E23 This is contrary to the basic principle of 'RIMINI', that the highest level of protection should be used wherever possible.

Green Zones: Thinking Strategically

E24 RSSB recognised in 2001 that the 'RIMINI' principles were only addressing one aspect of the reduction of risk to track workers. Accepting that the hoped-for improvements in green zone access had not materialised, there was a need to consider other methods by which the exposure of people to risk could be reduced.

E25 The 'Green Zones – Thinking Strategically' initiative was established at the end of 2001 'in order to achieve the target of zero workforce fatalities set in the Railway Group Safety Plan 2002/03.'[7]

E26 'Green Zones – Thinking Strategically' was set up as a cross-industry group. The strategy that was devised had six elements, and the potential for practical application of these was tested by pilot teams who examined three routes to identify and implement ways of meeting the objectives. These teams brought together representatives from Railtrack (and later Network Rail), maintenance and renewal contractors and the train operators to work towards better cross industry co-operation aimed at improving the safety and efficiency of track work and thereby increasing the reliability of the network.

E27 The output from 'Green Zones – Thinking Strategically', in addition to improved co-operation at local level in the pilot team areas, included 37 recommendations under six headings:

- Encouraging cross industry co-operation
- Automate inspection and mechanise maintenance
- Design a reliable and low maintenance railway with good accessibility
- Provide sufficient engineering access within the timetable
- Maximise work efficiency by improving planning of work and possessions
- Simplify Rules, Standards and methods of protection

E28 These recommendations were directed to many bodies within the railway industry, plus HMRI and 'all railway staff'. They were intended to provide a set of ideas or toolkit for improvement and so were not focussed on a particular area, and were not limited by consideration of resources. The main thrust of the strategy, and the area in which there was most scope for risk reduction, was the mechanisation of inspection.

E29 The report recommended that Network Rail should publish its strategy and timetable for mechanisation, consider the ability of contractors to provide mechanised plant when letting renewals contracts, and develop a programme for fitting inspection equipment on service trains and utilising the data which this would provide. It also recommended that RSSB and Network Rail should make the rules and standards changes required to allow for mechanised inspection.

[7] *Green Zones – Thinking Strategically* RSSB, London 2003
http://www.rssb.co.uk/pdf/GZTS/Green%20Zone%20Thinking%20Strategically%20main.pdf

Subsequent developments

E30 Network Rail produced the new specification 'Inspection and Maintenance of Permanent Way' (NR/SP/TRK/001) in August 2005. This permitted up to 75% of basic visual inspections (patrols) of plain line to be done using inspection vehicles, an option which had not been available in the previous specification (RT/CE/S/103). However, in practice this option is of very limited use, since the speed of the inspection vehicle is limited to 10 mph and it is required to be able to stop readily to enable minor defects to be attended to. Such a regime, in daylight, would be disruptive to traffic on any but the most lightly used lines.

E31 Network Rail commissioned its New Measurement Train in 2003, and has also got the Southern Measurement Train. Although its main purpose is to measure and record track geometry, this train is also equipped with cameras capable of recording the information needed for the basic visual inspection of the track. The measurement trains are far better than patrols for detecting and recording faults in plain line track geometry.

E32 The Ultrasonic Rail Flaw detecting train used by Network Rail, together with an updated strategy for rail maintenance and replacement, has addressed the issue of broken rails, and resulted in a significant reduction in the number occurring.

E33 The residual workload for patrols is mainly checking the condition of rail fastenings and joints. On sections of plain line track laid with bullhead rails, the patrol will also carry out the routine maintenance task of knocking keys back into chairs. More modern track, especially CWR, does not require such attention and inspection is the patrol's only task. New technology to record the condition of fastenings (the Cybernetix system of non-contact optical sensors) is being evaluated by Network Rail.

E34 There are only two measurement trains, and a large proportion of their time is spent on the main line routes. Work on the possible use of service trains for inspection of track is continuing, but at present Network Rail's standards require all inspection of S&C to be done on foot, and for all plain line to be inspected on foot at least once every four weeks. The patrol frequency of S&C is governed by the frequency specified for the adjacent plain line.

Appendix F - Recent Incidents – S&C inspection

Switch inspection and maintenance

F1 A passenger train was derailed at a trailing crossover near Epsom, Surrey, on 11 September 2006. The RAIB's investigation (34/2007) found that the switches were in poor condition and overdue for replacement. A misaligned rail joint at the heel of the switch had been identified at several successive inspections, but no action had been taken to correct it. Reports of switch inspections were not reaching the appropriate people, and there were insufficient resources available in the area to maintain the track to an adequate standard.

F2 In September and October 2006 there were two derailments at Waterloo station, London, caused by worn switch rails (see RAIB report 44/2007). The need for repairs had been identified, but the repair work had been poorly carried out and inadequately inspected on completion. There was inadequate access for inspection in daylight, and staff were not adequately qualified in switch inspection.

F3 On 22 February 2007 an express passenger train was derailed near Grayrigg, Cumbria, at a set of *facing* points, resulting in the death of one person and injury to 86 others (RAIB report 20/2008). The derailment was caused by the unsafe condition of the points. A combination of failures of components had not been detected by inspection, and the points had deteriorated to the extent that the switch rails were no longer restrained by fastenings. Recommendation 19 of the RAIB's report on the Grayrigg derailment addresses similar areas to those covered by Recommendation 2 of this report.

F4 On 3 September 2007 an empty passenger train was derailed on a crossover at Exhibition Centre station, Glasgow, injuring two members of staff. The RAIB investigation into this accident is continuing, but indications are that issues connected with the maintenance of the switches contributed to the derailment.

F5 Switch inspection, as defined and prescribed in Network Rail company standard NR/L2/TRK/053 'Inspection and repair to reduce the risk of derailment at switches', requires staff who are fully trained, experienced and certificated, together with adequate, pre-planned access to the S&C to enable the inspection be properly carried out. At present, patrolling staff are required to visually inspect S&C as part of their regular patrols. As shown in these incidents, this can result in important defects being missed and hazardous situations developing. Regular inspection by specialist staff would reduce the likelihood that this would occur, as well as reducing risk to patrol staff who would be able to rely on simpler and more robust protection arrangements.

Staff safety

F6 In the last three years there have been three fatal accidents in which people have been struck by trains while engaged in work on or near junctions.

F7 At Newbridge Junction, Edinburgh, on 13 April 2005, a lookout was struck and killed by a train which was diverging from the main line at the junction. It seems likely that he had not expected the train to make this move. The accident was investigated by the RSSB, observed by the RAIB (which at that time had not yet begun operations).

F8 There was a fatal accident at Trafford Park, Manchester, on 26 October 2005, when an operations manager employed by an equipment contractor was struck by a train at a junction. He was carrying out an inspection of the track layout where a warning system was due to be installed, and had not set up any safe system of work for the inspection. The accident was investigated by the RAIB (report number 16/2006).

F9 A near-miss occurred on 17 March 2007 at Tinsley Green Junction, Sussex. A welder working on repairs to a crossing jumped clear just in time to avoid being struck by a train. The work was being done while trains were running (red zone). The RAIB investigation (43/2007) found that the system of work the welder was using did not take into account the possibility of trains moving from one line to another at the junction. The Rule Book is not explicit about the correct system of work when work is being done beyond facing points.

F10 At Ruscombe Junction, near Reading, Berks, on 29 April 2007, a welder was fatally injured in very similar circumstances to those at Tinsley Green. The RAIB investigation (04/2008) found that the welder had continued to work even though it was likely that he had been warned of the approaching train.

F11 The underlying cause in all these cases was that work was being done while trains were running and in situations that created a high risk that something would go wrong, with little or no chance to escape the consequences.

F12 The accident at Leatherhead which is the subject of this report has some similarities to both the Tinsley Green and Ruscombe accidents. It occurred beyond facing points, and the alternative directions in which the train could travel may have been a factor in what happened. More significantly, work was being done on the track while trains were running.

F13 Before the accidents discussed above, the previous fatal accidents to trackside workers in which the presence of junctions was a factor both occurred in 2001. Both these accidents were investigated by HMRI. There have been no other accidents of this type since 1994.

F14 On 28 October 2001 a member of the local track maintenance staff was struck by a train on the West Crossings, a short distance from Waterloo station, London. He had been engaged in patrolling under Green Zone conditions on the south side of the multiple track formation. After completing this patrol, for reasons which remain unknown, he moved towards the north side and was struck by a train which was diverted to the right at the west crossings. It is possible that he did not expect the train to take this route.

F15 On 19 December 2001 a contractor engaged in installation of signalling equipment, who was walking on the lineside near Hitchin, Herts, was struck and killed by a passenger train. The train had crossed from the fast to the slow line immediately before striking the contractor, and the investigation concluded that he had not realised that the train had moved onto the line that he was walking next to.

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