Rail Accident Investigation Branch

Rail Accident Report

Derailment of a freight train near Moor Street station, Birmingham
25 March 2008

Department for Transport

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March 2009

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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Contents

Preface

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.

Definitions

3 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.

4 All references to left and right are made relative to the direction of travel of the derailed train.

5 All mileages are measured from a datum at London Paddington, via Didcot.

The Accident

Summary of the accident

6 At 06:37 hrs on 25 March 2008 train 6M15 became derailed on *plain line* on the *up* and *down* goods line on the approach to Moor Street South junction (Figure 1). The train, the 01:46 hrs Aldwarke to Handsworth, consisted of a class 66 locomotive and 30 empty SSA four-wheel box wagons, and was travelling at 15 mph (24 km/h) at the time of the derailment.

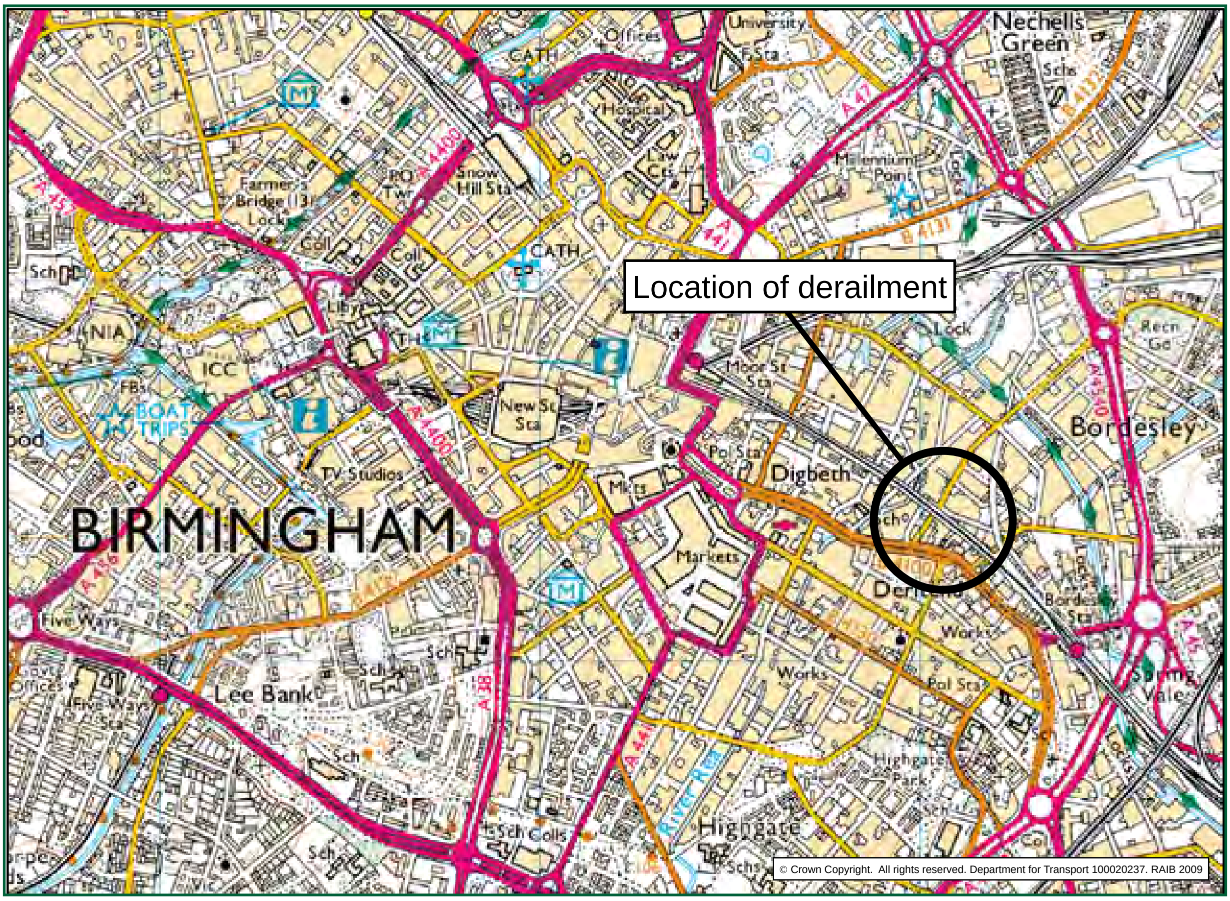

Figure 1: Location of the derailment

7 Following the initial derailment the train travelled a further 90 metres before being brought to a stand following an automatic brake application. At this point, the locomotive and leading wagons were standing on the down Snow Hill line; the wagons at the rear of the train remained on the up and down goods line. A diagram of the track layout is shown in Figure 2.

8 The 15th and 16th wagons were completely derailed to the left and turned onto their sides. The 14th and 17th wagons were partially derailed. All four of the derailed wagons had run derailed through 677 *points*. The 14th wagon ran with its *trailing* wheels derailed through 678B *facing points*.

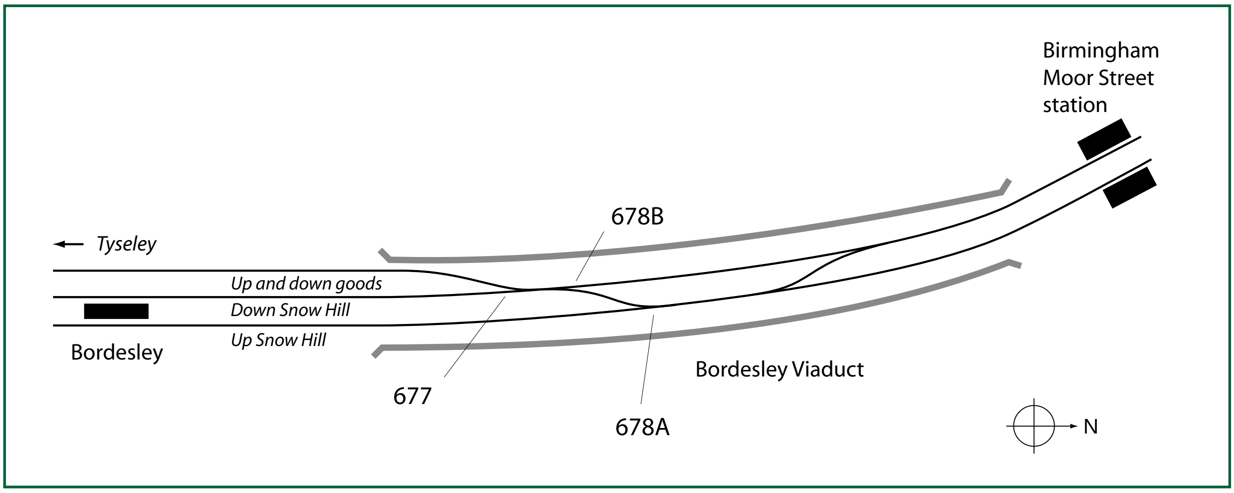

Figure 2: The track layout at Moor Street South junction

9 There was significant damage to 677 points and some damage to 678B points, the operating equipment and *sleepers, baseplates* and *timbers* along the route of derailed running. A section of the adjacent viaduct *parapet* was demolished.

10 The 16th wagon suffered significant damage to its leading left-hand suspension assembly; the three other derailed wagons suffered less severe damage.

11 Rail traffic was initially stopped on all lines. The up Snow Hill line was released for *single line working* at 07:57 hrs. Repairs to the points equipment and track components were completed and normal operations recommenced on the down Snow Hill line and up Snow Hill line at 01:55 hrs on 26 March 2008.

Figure 3: The incident site of the derailed wagons

The parties involved

12 The derailed wagons were owned and maintained by English Welsh & Scottish Railway Ltd, who also operated the train and employed the driver. Since the accident, English, Welsh & Scottish Railway Ltd have changed their trading name to DB Schenker Rail (UK) Ltd; however, with the exception of Recommendation 4 relating to future actions, the former name is used throughout the report.

13 The infrastructure is owned and maintained by Network Rail.

14 English Welsh & Scottish Railway and Network Rail freely co-operated with the investigation.

Location

15 Moor Street South junction is located 1.7 km south of Birmingham Snow Hill station on the route known as the Didcot and Chester line (Figure 1). All tracks at this location are carried on a 20 metre high brick viaduct, and the bi-directional up and down goods line converges with the down Snow Hill line using this junction. A *crossover* permits moves between the up Snow Hill line and down Snow Hill line, and hence the up and down Goods line.

16 The initial *point of derailment* (POD) was identified as being on plain line 24 metres before the *crossing* of 677 points on the up and down goods line at approximately 128 miles 32 *chains*.

17 The *linespeed* to the south of 677 points is 60 mph (96 km/h) on the up Snow Hill and down Snow Hill lines and to the north is 30 mph (48 km/h). The linespeed on the up and down goods line and through 677 points is 15 mph (24 km/h). The linespeed through 678 *facing crossover* is 30 mph (48 km/h).

External circumstances

18 The weather on 25 March 2008 was dry and clear and did not contribute to the accident.

The train

19 The train was formed of class 66 locomotive, 66093, and 30 empty SSA scrap carrying wagons. SSA wagons were constructed by reusing chassis from redundant hopper wagons, and attaching purpose-built box bodies. Approximately 80 such wagons are currently in service. SSA wagons operate in *block trains* delivering scrap materials from collection points to steel terminals and returning empty. A typical SSA wagon is shown in Figure 4.

20 The nominal *tare* weight of an SSA wagon is 15.0 or 15.5 tonnes; there are some minor construction variations. The suspension is a *pedestal* system using multiple coil springs and friction damping. The arrangement is shown in Figure 5.

Figure 4: An SSA wagon

Figure 5: SSA pedestal suspension as fitted to wagon 470152

The Infrastructure

21 Trains travelling northwards on the Didcot and Chester line approach Moor Street South junction on the level and through a left-hand curve.

22 All points are *113A full depth vertical design* and are operated by *clamplock* point mechanisms. The layout has been in place for several years and there have been no recent alterations to it.

23 In the vicinity of the point of derailment, the rail is flat bottomed 113A section and rail fastenings are a mixture of *pandrol clips* attached to *pan 11* baseplates and *elastic spikes* with BR1 baseplates on softwood timber sleepers. Figure 6 shows the track in the vicinity of the point of derailment.

Figure 6: Track at the point of derailment

24 The signalling is *track circuit block* with *four aspect colour-light signals*. The signalling played no part in this accident.

Events preceding the accident

25 Train 6M15 was a scheduled service from Aldwarke near Sheffield to Handsworth in north Birmingham and was travelling northwards after *running-round* at Tyseley yard.

26 The driver who brought the train from Aldwarke was replaced by a new driver at Tyseley, as laid down by the roster, shortly before the accident.

Events during the accident

27 Prior to the derailment, train 6M15 had been stationary at signal SY185, 365 metres before 677 points, for three and a half minutes. At 06:36 hrs the signal cleared to allow 6M15 to proceed along the up and down goods line and through 677 points onto the down Snow Hill line.

28 The train accelerated to a maximum speed of 15 mph (24 km/h), the permitted linespeed. After 156 metres the driver shut off power and allowed the train to coast.

29 Following consideration of the final positions of vehicles and rails, the damage sustained by vehicles and track and observation of other markings, the following sequence was considered to be the probable course of events.

30 Twenty four metres before the crossing of 677 points the left leading wheel of the 16th wagon, 470152, climbed onto the head of the left-hand rail. The wheel flange rode along the rail head for 3 metres before dropping outside the rail. Shortly afterwards the corresponding right leading wheel dropped inside the right-hand rail. Damage marks as a consequence of the derailment are shown in Figure 7.

31 The wagon ran a short distance with its leading *wheelset* derailed until reaching 677 points. These points were trailing in the direction of travel and were set to allow the train access to the down Snow Hill line. The leading right-hand wheel struck the left-hand *closure rail* within 677 points and was deflected further to the left, crossing the left-hand *stock rail*. Its corresponding left-hand wheel was deflected across and outside of the left-hand *ballast shoulder* (Figure 9).

32 The deflection of the leading end caused the whole wagon to *yaw* to the left; this derailed the trailing wheelset. These trailing wheels were also deflected further to the left at the closure rail of 677 points.

33 The trailing end of the 15th wagon, 470153, was drawn to the left by 470152. When 470152 was deflected by the closure rail of 677 points the rear of 470153 derailed.

34 Damage was sustained to the left leading suspension and wheel bearing of 470152 while running derailed (Figure 8). The suspension eventually failed with the springs coming adrift. The lower suspension and bearing of the left leading corner were ploughed into the ballast causing the wagon to yaw and diverge further to the left. The 15th and 16th wagons both overturned to their left-hand sides dragging the trailing end of the 14th and leading end of the 17th into derailment. During this time the *brake pipe* separated and the train brake was applied automatically.

35 After the locomotive had passed through 677 points and onto the down Snow Hill line the driver felt a series of jerks and, before he could take further action, the train brake automatically applied. Looking back he observed a cloud of dust and saw the derailed vehicles. The train came to a stand at 06:37 hrs. Figure 9 shows the path of the 16th wagon and the final locations of the derailed vehicles.

Figure 7: Damage marks (photograph courtesy of West Midlands Police)

Figure 8: Damage to the left leading suspension of wagon 470152

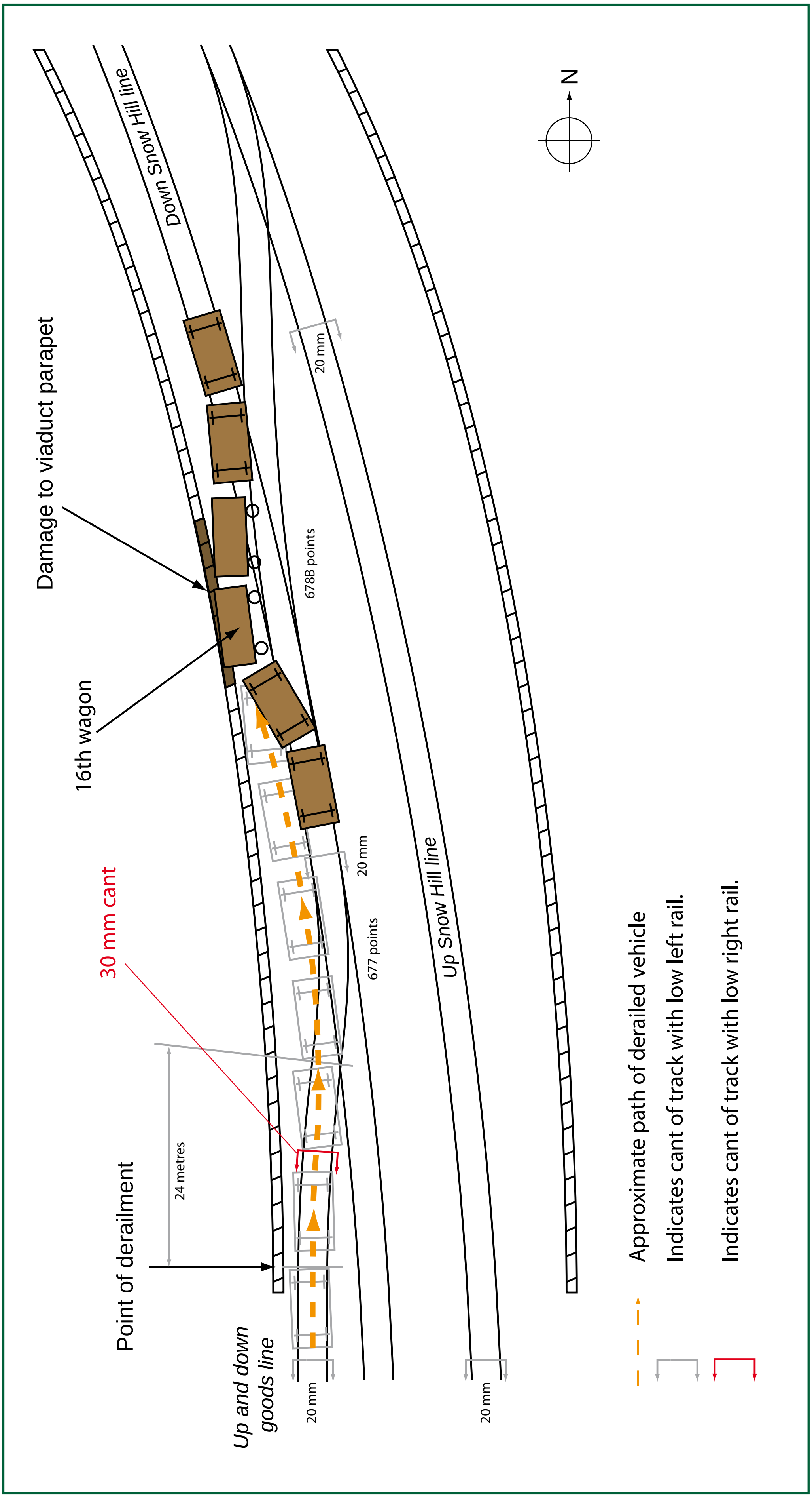

Figure 9: Diagram of derailment sequence

36 Just as the train stopped the upper trailing edge of the body of the 16th wagon, 470152, now lying and travelling on its left side, struck and displaced a 10 metre section of the brick parapet of the viaduct, which fell approximately 20 metres onto private ground below, severely damaging a parked car (Figure 10).

Figure 10: Fallen debris and damage to the parked car (image courtesy of West Midlands Police)

Consequences of the accident

37 There were no injuries as a result of the accident.

38 Four wagons were damaged:

- the 15th wagon, 470153, received minor damage as a result of a short distance of derailed running and overturning;
- the 14th and 17th vehicles, 470054 and 470129, sustained minor damage as a result of their partial derailment in the final stage of the accident; and
- the 16th wagon, 470152, had significant damage to the left leading suspension, wheel and bearing and damage to other elements of its *running gear*.

39 The train travelled a total of 90 metres after the initial derailment. From the point of derailment on the up and down goods line to the final position of the derailed vehicles on the down Snow Hill line there was significant infrastructure damage. This included damage to baseplates and sleepers in plain line and stock rails, *switch rails*, timbers and *stretcher bars* in the points, including severe deformation of the left-hand point blades of 677 and 678B points. The passage of derailed wheels severed a number of control and track circuit cables.

40 An unoccupied parked car was severely damaged by falling brickwork. The accident had potential for a more serious outcome, had there been any persons below the parapet.

Events following the accident

41 All lines were blocked to rail traffic after the derailment. Following discussions with the RAIB the up Snow Hill line was released at 07:57 hrs and single line working was implemented, with trains passing the incident site under *caution*.

42 The RAIB obtained a copy of the output of the locomotive's *On Train Data Recorder* (OTDR).

The Investigation

Investigation process and sources of evidence

43 The RAIB investigation into this derailment included:

- a detailed examination of the site and a track survey;
- analysis of the track survey in the vicinity of the identified point of initial derailment;
- examining the wagons involved in the derailment; and
- a review of the data from the OTDR.

44 The investigation considered other evidence including:

- Network Rail procedures for the inspection and maintenance of the track;
- Network Rail records of inspection and maintenance of the track;
- interviews with staff;
- English,Welsh & Scottish Railway records of wagon maintenance; and
- English,Welsh & Scottish Railway wagon maintenance procedures.

Key Information

Track

Track geometry

45 A key measurement in monitoring track geometry to ensure the safe carriage of rail traffic is that of track *twist*. Track twists are normally expressed as a gradient (eg 1 in 200). This is derived from the difference in the *cross-level* of the track at locations 3 metres apart.

46 Network Rail company standard NR/SP/TRK/001, "Inspection and Maintenance of Permanent Way", deems a track twist more severe than 1 in 200 to be unacceptable, and it must be rectified within 14 days of detection; a twist more severe than 1 in 125 must be rectified within than 36 hours and a twist more severe than 1 in 90 requires the line to be blocked for immediate attention.

47 Track geometry is considered in two states; the natural condition when the inherent topography of the ground and components will dictate the track shape, referred to as *static* geometry, and that experienced by a train when the track is depressed by the weight of vehicles referred to as *dynamic* geometry.

48 NR/SP/TRK/001 does not identify whether the twist limits specified are to be applied to static or dynamic geometry.

49 To determine dynamic geometry from static geometry it is necessary to add measured values for the vertical deflection of the track at each sleeper position when *loaded* by a train, measured using *void meters*.

Track inspection

50 NR/SP/TRK/001 specifies the type and frequency of inspection and monitoring to be performed and also the maintenance limits which apply. NR/SP/TRK/001 includes minimum actions to be taken and the timescales for remedy of specific deficiencies. These parameters vary according to the *track category* and *track type*. At the time of this derailment, issue 2, dated October 2005, was applicable.

Basic visual inspection

51 The fundamental mechanism for ensuring the fitness for use of a railway line is the visual track inspection. This occurs at two levels; the primary is a Basic Visual Track Inspection, sometimes referred to as patrolling, performed by a person competent and certificated by Network Rail to carry out the task. No measurements are required as part of a basic visual track inspection.

52 Among the items listed as “Features to be observed”, whilst patrolling, in NR/SP/TRK/001 are:

- dipped joints;
- vertical or lateral movement of chairs or baseplates;
- vertical and horizontal misalignments, and twist; and
- signs of ballast voiding, slurrying, or effects of inadequate drainage on ballast conditions.

53 NR/SP/TRK/001 also states “Where practicable the opportunity shall be taken to observe the track under traffic, particularly where there is any suspect condition”.

54 According to NR/SP/TRK/001, the up and down goods line basic visual track inspections should take place weekly; the inspections were compliant with this frequency at the time of the derailment. The three members of inspection staff utilised for this task during the 13 weeks prior to the derailment were experienced and certificated as competent.

55 None of the relevant weekly inspection reports contained any notes of defects for this section of the up and down goods line. It is unlikely that any of these inspections were able to observe the track under traffic, due to the infrequent and mainly night-time usage of this line.

Supervisory inspection

56 The second level of visual inspection is carried out in the form of a supervisor’s visual track inspection. This is carried out less frequently, but measurements of track twist and track gauge should be taken “…to suit the track condition”.

57 The frequency specified in NR/SP/TRK/001 for the supervisors visual track inspection at this location is 13 weekly. To improve staff utilisation, these inspections were taking place in conjunction with the Moor Street South junction eight weekly *Switches & Crossings* (S&C) inspections. The supervisor’s visual track inspections were also compliant with the requirements of NR/SP/TRK/001. The last three supervisors inspections prior to the date of the derailment were:

- 30 October 2007;
- 27 December 2007; and
- 22 February 2008.

58 All three of these inspections had been performed by one person, who was competent and approved to carry out a supervisor’s inspection.

59 Network Rail hold information on their assets and any outstanding or incomplete items of work in a system called *Ellipse*. When items which require remediation are identified, they are entered into Ellipse together with the appropriate remedial action and a timescale for the work. Timescales for action are designated using a scale from M1 for action within one month through to M24 for action within 24 months. Other designations exist where urgent attention is required.

60 Only the supervisor's inspection report for the 27 December 2007 contains any entries for the up and down goods line in the vicinity of the point of derailment at 128 miles 32 chains (704 yards). The first entry identifies a requirement to *Measured Shovel Pack* (MSP) joints between 128 miles 35 chains and 128 miles 00 chains, a total quantity of 770 yards. This work was given a priority 2, indicating that it should be completed within two months of the date of the inspection. The second entry is for vegetation control between 128 miles 35 chains and 126 miles 50 chains. No priority is identified against this.

61 At the date of the derailment there were no *workbank* items listed as outstanding, in Ellipse, in the vicinity of the point of derailment. Six small specific items of plain line lift and pack work are shown in Ellipse as completed during the period between 21 August 2007 and 20 February 2008. None of the short lengths listed for these work items included the mileage of the point of derailment.

Track recording

62 One of the inspection processes specified in NR/SP/TRK/001 is the use of the Network Rail track recording vehicles. These are programmed to run over the network to measure and record data related to infrastructure condition. Output from the vehicle recording system is provided to the infrastructure maintenance organisation in two forms, a continuous output, both graphical and tabular, of all track measured, and a schedule of all specific locations where measured parameters exceed the limits specified in NR/SP/TRK/001 for that track category (paragraph 50).

63 There are a number of track sections consisting mainly of goods lines, loops, platform lines and crossovers, where it is not practicable to use the track recording vehicles. NR/SP/TRK/001 states that a register of these lines shall be maintained by the *Track Maintenance Engineer* and approval shall be sought for alternative inspection methods.

64 The up and down goods line is a section of line which is not recorded using the Network Rail track recording vehicles. There was no history of derailments on this section of track and the line speed was 15 mph (24 km/h). Using engineering judgement and consideration of risk and available resources, the Network Rail West Midlands and Chilterns Area Track Engineer had approved the monitoring of the up and down goods line using a manual track recording trolley at a six-monthly frequency.

65 The type of trolley used at Moor Street South junction was relatively lightweight, as with most measuring trolleys, and was therefore only able to measure the static geometry of the track. The trolley uses pre-defined parameters derived from the limits specified in NR/SP/TRK/001 to assess the acceptability of the geometry measured and warns the operator of exceedences of the limits and records the location type and value of the exceedences.

66 The previous trolley measurement for this section of track was in November 2007. On this occasion the trolley detected a number of geometry exceedences, but none were in the vicinity of the derailment. At the time, some difficulty was experienced when correlating the exceedences identified by the trolley with actual track geometry. Subsequent investigations revealed over-sensitivities with the measurement equipment and that the faults were not as severe in practice as identified by the trolley. The trolley fault was corrected, but as the trolley had been over-detecting it was deemed unnecessary to repeat the survey.

Measured track geometry

67 The train derailed on plain line within the up and down goods line on the approach to 677 points. A clear but light flangemark on the head of the rail enabled the point of derailment to be accurately identified. It was evident that a single wheel had climbed onto the head of the left rail 4.2 metres after a pair of *fishplated* rail joints and 2.5 metres before a fishplated joint on the right rail only, at approximately 128 miles 32 chains.

68 In the section of track at, and approaching, the point of derailment there were signs of the presence of significant voids. This was evident from the gap between baseplates and sleepers and the withdrawn position of elastic spikes.

69 The RAIB and Network Rail jointly surveyed the track to obtain the vertical geometry of the left and right rails at, and approaching, the initial point of derailment. This survey also included the measurement of voids using void meters.

70 From this data it was possible to derive the cross-level of the track and to calculate the track twist over a 3 metre base, as prescribed in NR/SP/TRK/001.

71 At the point of derailment the dynamic twist over a 3 metre base was 40 mm (1 in 74). There were four other locations within the 70 sleepers approaching the point of derailment where the twist was more severe than 1 in 200, the limit beyond which NR/SP/TRK/001 requires rectification (paragraph 46).

72 Network Rail's approved monitoring regime for this section of track was a manual track recording trolley. This measures track in its *unloaded* condition. If the trolley had been used to survey the track at the time of the derailment, it would have identified a static twist of 25 mm (1 in 120) over a standard 3 metre base at the point of derailment. There was one other location in the preceding 70 sleepers (12 sleepers before the point of derailment) where the static twist was more severe than 1 in 200.

Installed cant

73 In 1986, remodelling of the tracks in this area was carried out as part of the reopening of the line to Snow Hill station. Prior to this Moor Street station had been the terminus. As part of the remodelling a new down Snow Hill line was installed, broadly on the alignment of the previous up main line, and a new up Snow Hill line installed on redundant formation. These two lines were linked together through 678 crossover and both lines *canted* 20 mm for a left-hand curve when travelling northwards. There are no design records available for this section of line.

74 The old down main line became the up and down goods line and was connected into the new down Snow Hill line through 677 points. As the up and down goods line was also canted approximately 20 mm for a left-hand curve, and the levels of the up and down goods line and down main lines were similar, it was necessary to create a short section of *reverse cant* within the up and down goods line to allow the two lines to merge within 677 points. From approximately 29 sleepers prior to the point of derailment, the 20 mm left-hand cant reverses to 30 mm right-hand cant seven sleepers prior to the point of derailment and back to 20 mm left-hand cant by nine sleepers after the point of derailment. The latter change represents an average *cant gradient* of 1 in 225 over the 16 sleeper length (Figure 9).

Wagons

75 SSA wagons were constructed in the 1980s for specific traffic flows of loose metal scrap. New high sided box bodies were located on refurbished ex-hopper wagon underframes. Many were rebodied again in the late 1990s. They have a gross laden weight of 51 tonnes and a tare of either 15 tonnes or 15.5 tonnes.

76 The suspension system is a friction damped pedestal type with coil springs, and comprises a cast steel pedestal mounted to the underframe at the four wheel positions and a cast steel saddle to which the wheelset is mounted via a cartridge bearing.

Maintenance

77 The prescribed maintenance interval for SSA wagons since the late 1990s has been an annual *Vehicle Inspection and Brake Test* (VIBT), interspersed with six-monthly *Planned Preventative Maintenance* (PPM). Following previous incidents in 2005, English, Welsh and Scottish Railway took the decision to reduce the VIBT interval from 365 days to 122 days and remove the PPM requirement. This transition was completed in December 2005.

The wagons derailed in train 6M15

78 The four derailed wagons had been through their previous VIBT between 26 January 2008 and 12 March 2008. Three of the four also had minor repairs recorded since their last VIBT. VIBT intervals prior to the most recent varied from 101 days to 282 days. During the three previous VIBT cycles for these four wagons, only five of the twelve VIBTs were compliant with the 122 day interval specified in the current English Welsh and Scottish Railway maintenance specification.

79 The four derailed wagons were inspected on site and afterwards at Washwood Heath yard and Toton depot. The three wagons which travelled by rail to Washwood Heath were intact and had incurred only minor damage during the accident. The fourth wagon 470153, 16th in the train, had suffered significant damage to the left leading suspension, including the loss of its suspension springs and the displacement of the axle bearing housing. All four wagons were dimensionally checked for twist in their frames and found to be within the specified tolerance of 6 mm. Apart from the damage considered to be consequential to the derailment, no defects were found that could have contributed to or caused the derailment. However, because of the consequential damage of 470153, the pre-accident condition cannot be determined with certainty.

Wheelchex

80 Wheelchex is a detection system for excessively high dynamic wheel loads. A number of locations around the rail network are instrumented to monitor the wheel loads from passing rail vehicles. Data is recorded and in the case of exceptionally high values alarms are used to initiate a response by operation and rolling stock staff.

81 The regular service from Aldwarke to Handsworth does not pass through any Wheelchex sites. However, a similar service which hauls loaded scrap-carrying wagons to Margam passes through two Wheelchex sites at Eckington in Worcestershire and Marshfield in South Wales. An inspection of data at these sites for the period 1 January 2008 to 1 March 2008 indicates regular detection of high dynamic wheel loads in loaded SSA wagons. There is no indication in the records that would indicate fundamental imbalance in the wagons due to inherent twist in wagon frames or mismatched suspensions in similar wagons to those that derailed at Moor Street South junction. This supports the conclusion that no frame twist was present in the derailed wagons at Moor Street.

Train operation

82 The On Train Data Recorder data indicates that neither the operation of the train nor the actions of the driver contributed to the accident.

Analysis

Identification of the immediate cause[1]

83 The single flangemark on the head of the left-hand rail was clear evidence of a derailing wheel (paragraph 30). The rail head marks were long and light, which indicates a low vertical load and the absence of a large lateral force. From examination of the wagons in the train, due to the variation in the derailed running damage between the wagons, it was concluded that the left leading wheel flange of wagon 470152 rode over the left-hand rail at the location of the most severe track twist. This was the immediate cause of the accident.

Identification of causal[2] and contributory[3] factors

Track geometry

84 The 3 metre dynamic track twist at the point of derailment was 40 mm (1 in 74). This is more severe than the immediate action limit to close the line of a 1 in 90 twist (paragraph 71). The 3 metre static track twist at the point of derailment was 25 mm (1 in 120). This geometry defect is more severe than the 1 in 125 threshold set in NR/SP/TRK/001 and requires attention within 36 hours of discovery (paragraph 72). The point of derailment also occured at the start of a short right-hand curve, which would have increased the probability of contact with the left leading wheel flange. That the track geometry was non-compliant, and was not detected and remedied are causal factors.

85 The requirement for the up and down goods line to meet the geometry of the down Snow Hill line compromises the rate of change of cross-level within the length available through the reverse curvature (paragraph 74). The geometry is sensitive to small changes in track support before reaching the maintenance limit. This makes it more difficult to maintain the track within specification. The design geometry is a contributory factor.

Track inspection

86 The track recording trolley was used in November 2007. On this occasion no track geometry faults were detected within this section of track. Therefore the fault is likely to have developed between November 2007 and March 2008. The next use of the trolley was not planned until May 2008 (paragraph 64). The frequency of use of the trolley was not sufficient to ensure detection of the geometry fault's development, and is a probable causal factor.

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[1] The condition, event or behaviour that directly resulted in the occurrence.

[2] Any condition, event or behaviour that was necessary for the occurrence. Avoiding or eliminating any one of these factors would have prevented it happening.

[3] Any condition, event or behaviour that affected or sustained the occurrence, or exacerbated the outcome. Eliminating one or more of these factors would not have prevented the occurrence but their presence made it more likely, or changed the outcome.

87 Visual inspection normally takes place on unloaded track. Track inspectors are trained and briefed to observe signs of the presence of voids in the track, during their regular inspections (paragraph 52). Track voids can be visible in a number of ways. When rail traffic passes, the rail and sleepers will be depressed and the vertical deflection can be observed. At locations where extensive or excessive voiding is present, there will be one or more tell-tale signs, for example abraded ballast on or adjacent to sleepers, signs of *pumping* sleepers, hanging baseplates or gaps under elastic spikes or *chairscrews*.

88 Visual detection of static geometry faults close to the 1 in 200 twist limit is a known difficulty, because of the small dimensional differences between compliant and non-compliant states. The RAIB have identified this issue in previous investigations into incidents at King Edward Bridge, Newcastle (report 02/2008) and Duddeston Junction, Birmingham (report 16/2008)[4]. The ability of inspectors to visually identify geometry faults at this location was reduced because of the asymmetric location of fishplated joints (paragraph 67). However, the presence of signs of significant voiding (paragraph 68) would have been a visible indicator of deteriorating dynamic geometry. This should have alerted the track inspectors and supervisors to take dynamic measurements or instigate corrective action. Not observing the signs of voiding and, consequently, not initiating remedial work is a probable causal factor.

89 The monitoring of the geometry was carried out using a manual measuring trolley. This is a lightweight unit which measures only static geometry. If monitoring of the up and down goods line using the trolley had been more frequent, or the trolley had been used immediately prior to the derailment, it would only have detected the 1 in 120 static twist. This would have initiated urgent corrective action within 36 hours. However the dynamic defect should have resulted in the line being blocked immediately, had it been detected. Therefore, if the manual trolley been used, it could have resulted in the line remaining open for another 36 hours. The use of the trolley to measure track geometry in this area is a possible causal factor.

90 The individuals who carried out the recent basic visual inspections were experienced and competent, but did not identify and record the track twist and large voids at this location. The following are feasible explanations as to why this occurred:

a) Their attention may have been focussed on the inspection of the adjacent high-speed passenger route to the detriment of fully observing defects on the up and down goods line.

b) The environmental and operating circumstances at the time of the various inspections are unknown. The weather or available light may have been such that defects were less easily identified.

c) The experience of the inspectors may not previously have exposed them to all types of geometry defect. Not withstanding the competency assessment system it is possible that they failed to recognise the defects.

91 The three supervisor's inspections were conducted in compliance with NR\SP/TRK/001, however these inspections also did not detect the defect.

[4] RAIB reports are available at www.raib.gov.uk.

Wagons

92 The wagons involved in the derailment were inspected and no defects were found, although the wagons were damaged as a consequence of the derailment. No specific defects were found in the 16th wagon to explain why it was the first to derail.

Identification of underlying[5] causes

93 Paragraphs 62 to 66 explain how the trolley recording of geometry was applied at the location of the derailment. Paragraphs 51 to 60 explain how the various track inspections took place according to the specified frequencies, but did not observe the track under load.

94 There was a greater focus given to tracks which were considered a more significant risk, although these were measured using a track recording vehicle, and a belief that the six-monthly trolley measurement would provide sufficient reassurance of the track geometry on the up and down goods line.

95 As a result there was insufficient focus on the degree of voiding present, which developed to create a high derailment risk.

96 The underlying cause is not recognising the contribution to derailment risk from the development of voids, in an area not monitored by track recording vehicles, and not implementing specific measures to address this.

Severity of consequences

97 During the course of the derailment, the derailed wagons deviated to the left and one contacted the brick parapet of the viaduct structure. The deviation from the wagon's intended direction of travel was relatively small. In many locations this would not have resulted in a significant risk to anyone outside of the railway boundary. In this instance, because of the height of the viaduct and low integrity of the brick parapets, debris fell into a public area and could have had severe consequences. The location of the accident is contributory to the potential severity of the consequences.

98 The *Safety Risk Model* (SRM) identifies the overall risk to the public from vehicular excursions and major structural collapse following a derailment. No specific risk is identified in regard to consequential debris falling or being projected, following derailments and other incidents, presenting a risk to the general public. The only recorded instance of consequential debris risk is following the Potters Bar derailment in 2002, where a passer-by on a footway adjacent to the railway was killed by falling concrete.

[5] Any factors associated with the overall management systems, organisational arrangements or the regulatory structure.

Conclusions

Immediate cause

99 The immediate cause of the accident was that the left leading wheel flange of wagon 470152 rode over the left-hand rail at the location of the most severe track twist on plain line on the approach to 677 points (paragraph 83).

Causal factors

100 The causal factors were:

a. non-compliant track geometry (paragraph 84); and

b. the track twist was not detected or corrected (paragraph 84).

101 The probable causal factors were:

a. not observing the signs of voiding and initiating remedial actions (paragraph 87);

b. Network Rail was monitoring the crossover at a frequency which did not ensure that the geometry was maintained in a compliant state (paragraph 86); and

c. the track construction at this location was such that visual identification of a twist fault was masked by the relative locations of the rail joints (paragraph 88).

102 A possible causal factor was:

a. Network Rail were monitoring the geometry using a method which did not detect the worst case (dynamic) geometry (paragraph 89).

Contributory factor

103 That the crossover design geometry was near to the maintenance limits (paragraph 85, Recommendation 1) was a contributory factor.

Underlying factor

104 The underlying cause was that Network Rail did not identify the contribution to the risk of derailment from the development of voids in an area that was only statically measured and implement specific measures to assess and control it (paragraph 96 and Recommendation 2).

Additional observation

105 The SSA wagons directly involved in this accident had not always been maintained in accordance with the VIBT periodicity stated in the English Welsh & Scottish Railway 2005 revised maintenance specification. However, no factors were found as a result which had any bearing on this derailment (paragraph 78 and Recommendation 3).

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

106 RSSB have confirmed that this accident and the factors relevant to the damage and risks outside of the railway boundary constitute an additional data point and will be considered at the next review of the SRM (paragraph 98).

Completed actions which address factors in the report so avoiding the need for the RAIB to issue a recommendation

107 The geometry defects at the point of derailment have been corrected.

108 Network Rail West Midlands area have identified locations where reverse curves exist in track which is not measured by the track recording vehicles and where the rate of change of cant may make the visual identification of geometry faults difficult. These locations have been physically marked on the track and a local instruction given to ensure that measurements of cant are taken.

109 The following recommendation was made by the RAIB as a result of the investigation into a derailment at King Edward Bridge, Newcastle Upon Tyne (report reference 02/2008 Recommendation 4):

> "Network Rail should include guidance in NR/SP/TRK/001 section 11.4.2 to seek to ensure that additional consideration is given to geometry monitoring frequency and methodology for locations where dynamic track geometry is more likely to deteriorate and exceed maintenance limits, without otherwise being detected. This may occur because of the proximity of the design to the geometry maintenance limits, where there is difficulty identifying the geometry or where the geometry deterioration rates are high".

This recommendation addresses the factors listed in paragraphs 101a, b, and c of this report. It is not remade to avoid duplication. However, had this recommendation not been made previously it would have been made as a result of this incident. Network Rail report that they issued 'Letter of Instruction' 105 version 2 on 14 January 2009, which defined the detail necessary to meet the requirements of NR/SP/TRK/001 section 11.4.2.

Recommendations

110 The following safety recommendations are made[6]:

Recommendations to address causal and contributory factors

1 Network Rail should review and amend the design and maintenance of the layout at Moor Street South junction or implement other measures to reduce the risk of it becoming out of specification within the monitoring interval (paragraph 103).

2 Network Rail should develop methods to improve the identification of voids in lightly used track and provide this as guidance to their inspection staff. Where this is a critical factor, consideration should be given to other methods of determining voids by measurement. This may include use of a track recording vehicle or void measurement using void meters (paragraph 104).

Recommendations to address other matters observed during the investigation

3 DB Schenker Rail (UK) Ltd should review their maintenance and operation procedures so that VIBT intervals are compliant with the stated specification (paragraph 105).

[6] 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 ORR/HMRI to enable it to carry out its duties under regulation 12(2) to:

(a) ensure that recommendations are duly considered and where appropriate acted upon; and

(b) report back to the 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.

Appendices

Appendix A - Glossary of abbreviations and acronyms

MSP	Measured Shovel Pack
OTDR	On Train Data Recorder
PPM	Planned Preventative Maintenance
POD	Point of Derailment
S&C	Switches & Crossings
SRM	Safety Risk Model
VIBT	Vehicle Inspection and Brake Test

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

113A full depth vertical design	Switches in which the stock rail and switch rail are both made from 113A rail. Such switches are vertical switches.*
Ballast shoulder	The Ballast placed at the ends of the sleepers, timbers or bearers to give lateral stability to the track.*
Baseplates	A cast or rolled steel support for flat bottom rails (FB).*
Block trains	A train timetabled to run between two points on a regular basis with the same consist every time. An alternative term is unit train.*
Brake pipe	In an air brake system, this pipe is pressurised to release the brakes of the vehicles in the train. The actual air pressure required to operate the brake cylinders is provided by the train pipe, which is kept permanently pressurised to supply reservoirs on each vehicle.*
Cant gradient	The rate at which the cant changes in a cant transition. Values are given as 1 in X, where X is a minimum of 400. It is recommended that X does not exceed 1600, as cant gradients this flat are difficult to maintain.*
Canted	Track on which one rail is raised higher than the other, see Cant.*
Caution	An indication or instruction requiring the driver to be ready to stop. Such an indication or instruction can be given by fixed signals, handsignals, signs or verbal communication (e.g. from a pilotman or signaller).*
Chains	A unit of length equal to 66 feet or 22 Yards (approximately 20117 mm). There are 80 Chains in one standard mile. Chains are the standard subdivision of miles used in the National Railway Network (NRN) operations.*
Chairscrews	A specialised type of screw used to secure chairs and baseplates to timbers and bearers. The term chairscrew is commonly used irrespective of what it is used to secure.*
Clamplock	A hydraulic ram arrangement that operates and positively clamps the closed switch to the stock rail. It is actuated by a small electrically operated hydraulic pump located adjacent to the switch toe.*
Closure rail	In a switch and crossing layout (S&C layout) the rail between the switch rail and common crossing or between the obtuse crossing point rail and common crossing.*
Crossing	An assembly that permits the passage of wheel flanges across other rails where tracks intersect.*

Cross-level
The measured difference in level between the two running rails of a track. This value should equal the designed value of cant at that location.*

Crossover
Two turnouts (TO) or single leads connected to permit movements between parallel tracks. Crossovers thus may be facing or trailing.*

Down
In a direction away from London, the capital, or towards the highest mileage. Up is the opposite direction.*

Dynamic
When applied to a measurement such as cross-level, envelope or twist, dynamic indicates that the measurement is taken whilst trains are in motion.*

Elastic spikes
A form of rail fastening used on wooden sleepers consisting of an inverted J- shaped spring steel spike which secures a flat bottom rail (FB) onto a BR1 baseplate simultaneously.*

Ellipse
Network Rail's (NR) work planning system, formerly known as MIMS.*

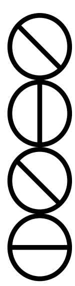
Facing crossover
A crossover where the switches are installed in the facing direction in the more important track. Also 'facer'. The opposite is trailing crossover.*

Facing points
A set of points or set of switches installed so that:
- two or more routes diverge in the direction of travel; and
- traffic travels from switch toe to switch heel in the normal direction of traffic.*

Fishplate
Specially cast or forged steel plates used in pairs to join two rails at a fishplated rail joint. Two, four or six fishbolts are used through the fishplates and rail ends to secure the fishplates to the rail ends. This curious term may originate from the old French word "fiche", meaning peg, combined with "plate"; so literally a peg-plate.

Four aspect colour-light signals
A colour light signal capable of displaying four aspects:

Green (G)	– Proceed aspect, the next signal may be displaying green or double yellow.
Double yellow (YY)	– First caution (Preliminary Caution), two signal intervals to the stop signal. The next signal may be displaying a single yellow.
Single yellow (Y)	– Caution aspect, the next signal may be displaying a red stop aspect.
Red (R)	– Stop aspect.*



Linespeed	The maximum speed at which trains may run when not subject to any other restriction. Because all speed limits are published and denoted by signs, this term no longer has a formal usage in this sense. Colloquially, the maximum speed of trains at a particular location.*
Loaded	Under the influence of load. When applied to track geometry is the same as dynamic geometry.*
Measured shovel pack	A manual technique for accurately addressing small vertical errors in the track. The lift required is measured, and an appropriate number of cans of chippings are introduced under the sleeper to achieve this lift. Pneumatic ballast injection (PBI, commonly stone blowing) is the mechanised development of this system. Its primary advantage is that the surrounding compacted ballast is not disturbed, considerably reducing settlement and improving the finished product.*
On Train Data Recorder	A data recorder fitted to traction units collecting information about the performance of the train. Including: ● speed; ● regulator and brake control positions; ● activations of horn, DSD and AWS cancel button, etc.*
Pan 11	A type of baseplate designed to use pandrol clips, pandrol rail Fastenings. The *x* denotes the particular type; 1, 3, 6, 9, and 11 are common.*
Pandrol clips	A rail clip for flat bottom rail (FB) manufactured by the Pandrol company.*
Parapet	The low wall or railing built along the edges of a bridge deck or arch to prevent Ballast, pedestrians or vehicles straying over the edge and onto that which lies beneath.*
Pedestal	A type of wagon suspension in which axle ends move on fixed vertical slides. Springing is normally by coil springs.*
Plain line	Track without switches and crossings (S&C).*
Planned Preventative Maintenance	Maintenance for rail vehicles which is planned to take place on regular basis. Prescriptive schedule of component replacement, eg brake blocks, or service activities and adjustments to reduce the incidence of failures in service.
Point of derailment	In a Derailment, the precise point where the first wheel derailed. The sleeper closest to this point on site is normally designated as sleeper zero.*
Points	Another name for a set of switches. These terms are used interchangeably. The term points is preferred by signalling and railway operations staff, switches by permanent way types.*

Pumping	A failure mode of the formation, where fine material is forced up through the ballast by the action of passing trains.*
Reverse cant	Cant that changes from one hand to the other within a track layout.*
Running gear	The equipment fitted to a rail vehicle directly associated with movement and stopping, including axles, axleboxes, bogies, brake linkages, wheels, yaw dampers, etc.*
Running-round	The act of moving a locomotive from one end of a train to the other.*
Switches & Crossings (S&C)	track consisting of switches and crossings forming connections between lines.*
Safety Risk Model	A computerised model managed by the RSSB which is a quantitative representation of the potential accidents resulting from the operation and maintenance of Britain's rail network.*
Single Line Working	The temporary use of one track for traffic working in both directions.*
Sleepers	A beam made of wood, pre- or post-tensioned reinforced concrete or steel placed at regular intervals at right angles to and under the rails. Their purpose is to support the rails and to ensure that the correct gauge is maintained between the rails.*
Static	Not moving, not under load. The opposite is dynamic.*
Stock Rail	The fixed rail in a switch half set. The other rail is the switch rail. Also back rail.*
Stretcher Bar	A bar that links the two switch rails in a set of switches (set of points) and maintains their correct relationship, e.g. one is open when the other is closed. Long switches can have as many as six, and the minimum is normally two, to guard against failure. The stretcher bar nearest the switch toe is the front stretcher bar or first stretcher bar. On power operated switches there will be two first stretcher bars, one (the first signalling stretcher bar) relating to the switch detection and the other (the first permanent way stretcher bar) being the one actually holding the switch rails in the correct relationship. Stretcher bars are normally attached to the switch rails by means of bolted brackets.*
Switch Rail	The thinner movable machined rail section that registers with the stock rail and forms part of a switch assembly. Also 'switch blade', 'tongue rail'.*
Tare (weight)	The weight of a rail vehicle capable of carrying a load when it is not carrying any load.*
Timbers	Collective term for the wooden bearers used under switch and crossing layouts (S&C layouts).*

Track category	A description of the use a track gets, ranging from 6 (little used, low speed) to 1a (very high speed, very high annual tonnage). These classifications are derived from the enhanced permissible speed (EPS), permissible speed (PS) and equivalent million gross tonnes per annum (EMGTPA) figures for the track concerned. *
Track circuit block	A signalling system where the line beyond is proved clear to the end of the overlap beyond the next signal using track circuits (TC). Track circuit block can also be implemented using any automatic train absence detector system, such as axle counters.*
Twist	A rapid change in cant (C, E) or crosslevel. Twist calculated by measuring the cross-level at two points a short distance (5 m, 15 feet) apart, and then expressing the difference as a 1 in x.*
Track Maintenance Engineer	The Network Rail manager responsible for the delivery of track maintenance, and the line management of the Track Section Managers, within a defined area*.
Track type	A standard designation denoting whether track is of jointed (Jtd.) or continuously welded rail (CWR) construction.*
Trailing	Aligned in a direction towards the direction to which trains normally depart. The opposite is facing.*
Unloaded	Not under the influence of load. The opposite of loaded. When applied to track geometry is the same as static geometry.*
Up	In a direction towards London, the capital, or the lowest mileage. The opposite direction is down.*
Vehicle Inspection and Brake Test	A regular inspection performed on all rail vehicles. Identifies any work required and checks functionality of brake systems.*
Void meters	A device that measures the vertical deflection of the track under passing trains, and hence the size of the voids under the sleepers or bearers. This information can then be used to determine the dynamic cross-level, dynamic level and dynamic twist.*
Wheelset	Two rail wheels mounted on their joining axle.*
Workbank	A database of outstanding work items.*
Yaw	A mode of movement of a rail vehicle travelling at speed, characterised by the ends of the vehicle moving repetitively from side to side in opposite directions.*

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