Rail Accident Investigation Branch

Rail Accident Report

Derailment of a freight train at Marks Tey, Essex 12 June 2008

Department for Transport

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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.

Key Definitions

3 In this report, reference is made to the sizes of standard shipping containers, which are designed to conform to International Standards Organisation (ISO) requirements. Standard industry terminology defines such containers by their nominal length, width and height in feet with no metric equivalents.

4 The terms 'left' and 'right' are as seen when facing the direction of travel of the train at the time of the derailment.

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

- abbreviations, in appendix A; and
- technical terms (shown in *italics* the first time they appear in the report), in appendix B.

Summary of the Report

Key facts about the accident

6 At 14:05 hrs on 12 June 2008, a *wheelset* on a wagon within train number 4L41, the 08:05 hrs Daventry to Felixstowe service operated by Freightliner, derailed as it passed through Marks Tey junction, located on Network Rail's Great Eastern Mainline. A second wheelset on the same *bogie* subsequently also derailed.

7 Two members of staff received minor injuries as a result of the derailment, which also caused damage to the infrastructure and rolling stock involved. The line was re-opened fully on the morning of 13 June 2008.

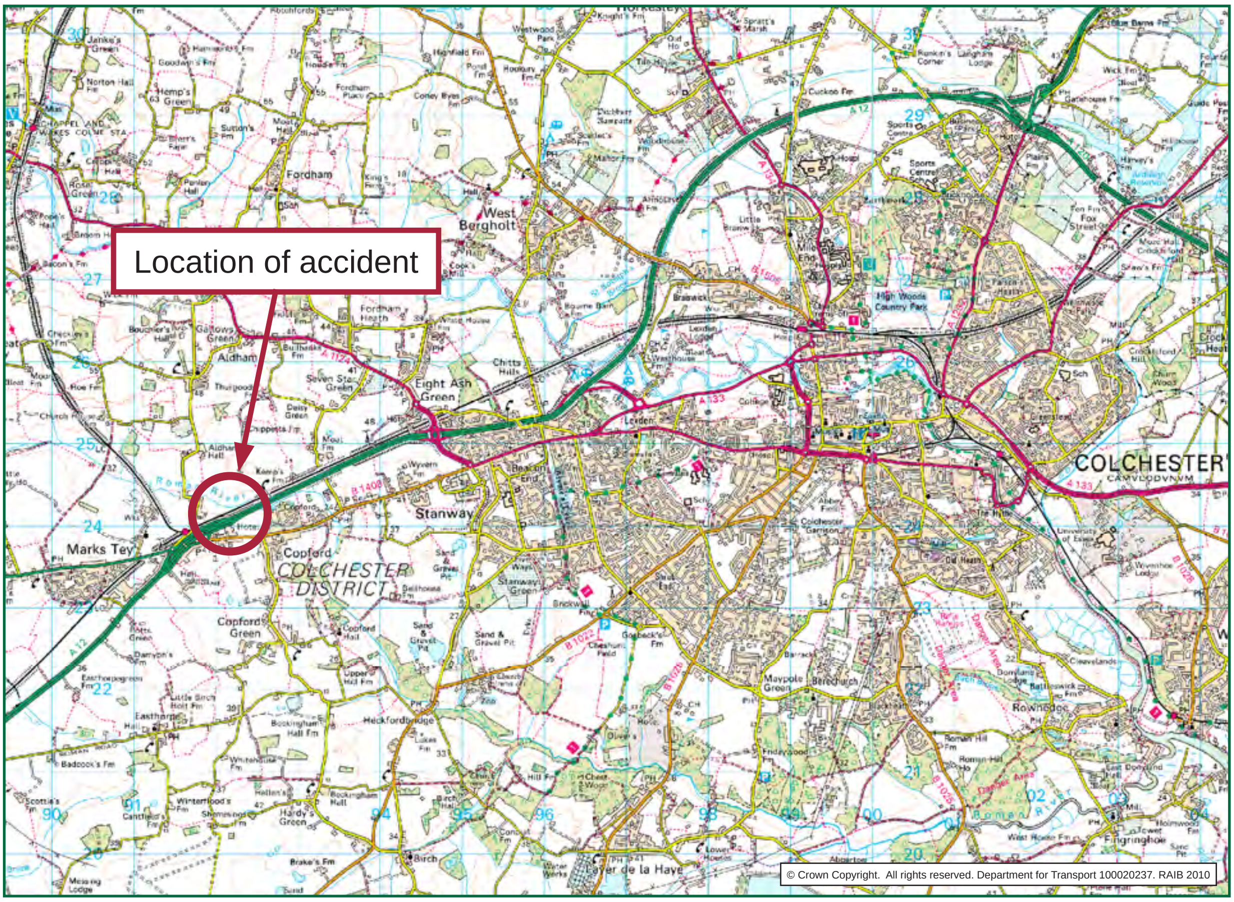

Figure 1: Extract from Ordnance Survey map showing location of accident

Immediate cause, causal and contributory factors, underlying causes

8 The immediate cause of the derailment was the left-hand wheel of the trailing wheelset of the rear bogie of the derailed wagon running over the *cess* rail head and derailing as train 4L41 traversed a section of plain line between *trailing points* 2390B and *facing points* 2392A at Marks Tey junction.

9 Causal factors were:

a. the unloading of the wheels of the rear axle of the trailing bogie of the derailed wagon;

b. a dip in vertical alignment of the track caused by the incorrect replacement of the *bearers* at the *heel* of 2390B points;

c. the presence of *cyclic top* shortly after these points; and

d. the permitted speed of the train.

10 Probable causal factors were:

a. the absence of an effective post-installation inspection of 2390B points on the night of 6/7 June;

b. the absence of an effective post-consolidation inspection of 2390B points;

c. the workload of a particular Assistant Track Section Manager;

d. the absence of briefing between two Assistant Track Section Managers prior to carrying out a supervisor's visual inspection on 11 June;

e. the absence of an effective supervisor's visual inspection of 2390B points on 11 June; and

f. the absence of an effective investigation and resolution of the track geometry defects at Marks Tey junction over a prolonged period.

Contributory factors

11 Contributory factors were:

a. the FTA/FSA wagon in the part-laden condition did not meet the vertical dynamic performance requirements of GM/RT 2141 Issue 2, having been introduced into service by British Rail prior to the issuing of this standard.

12 Probable contributory factors were:

a. an Assistant Track Section Manager did not arrange suitable protection to allow him to inspect 2390B points in line with the requirements of standard NR/SP/TRK/001 Issue 2; and

b. detailed points inspections were only undertaken at Marks Tey junction at night and within protection of limited duration.

13 Possible contributory factors were:

a. the lack of formal planning of the bearer replacement at the heel of 2390B points;

b. the lack of knowledge by track engineering staff of a broken rail action plan;

c. the lack of a hand-over between two Track Maintenance Engineers when they both moved post; and

d. confusion as to who was responsible for track engineering at Marks Tey junction.

Underlying factors

14 Underlying factors were:

a. the absence of action to address the vertical dynamic performance or previous derailments of the FSA/FTA wagon design.

15 Probable underlying factors were:

a. not replacing 2390B *switches* as scheduled in February 2009; and

b. poor communication and working relationships between some staff at Colchester Maintenance Delivery Unit.

16 Possible underlying factors were:

a. the absence of a requirement for preventative maintenance tasks to be planned and briefed in advance within standard NR/L3/TRK/002 Issue 4;

b. the lack of a requirement within Network Rail's procedures and processes for reviewing medium or long term actions intended to prevent the reoccurrence of broken rails;

c. the lack of action to permit access to the *red zone prohibited* area of Marks Tey junction to allow for its effective visual inspection;

d. the non-renewal of 2390B points with the remainder of the line in the 1990s;

e. the absence of effective drainage, drainage records and drainage inspection at Marks Tey junction;

f. the ambiguous requirements of standard NR/SP/TRK/001 Issue 2 as to when drainage should be inspected, and by whom; and

g. cable troughing being routed over *catch pits* with only minimal clearance, making effective inspection of drainage more difficult.

Additional observations

17 There is a road overbridge very close to the derailment site. It is possible that the wagon could have derailed further towards the cess side and struck one of the supports of this overbridge and thus caused a more severe derailment. This may have blocked the adjacent line, which was open to rail traffic.

18 The incorrect maximum gross laden weight was displayed on the side of wagon 608440.

19 Network Rail's work instruction for changing timber bearers does not include a requirement for a post-consolidation inspection of timber bearers, nor a timeframe for such an inspection.

20 Some of the basic visual inspection routes for the area for which the Track Section Manager Colchester was responsible were being unofficially altered by track engineering staff within the *patrol team*.

21 Both 2390B and 2392 points were fitted with the incorrect type of fishplates for *strengthened points*.

Recommendations

22 Recommendations can be found in paragraph 282. They relate to the following areas:

- reducing the risk of derailment of FSA and FTA wagons;
- competence, management of track recording, and access to the line for Network Rail's Colchester Maintenance delivery unit;
- the planning and briefing of preventative maintenance tasks; and
- the management of broken rails and timber bearer replacements.

The Accident

Summary of the accident

23 At 14:05 hrs on 12 June 2008, one of the wagons forming freight train number 4L41, the 08:05 hrs service from Daventry to Felixstowe, derailed at Marks Tey junction, near to Marks Tey station, Essex (figure 1).

24 The train was travelling at about 77 mph (124 km/h) when the rear wheelset of the rear bogie of the tenth wagon became derailed. The train ran for approximately a further 2.4 km before it came to a halt, and in this distance the second wheelset on the same bogie also derailed.

25 Two members of staff at the lineside received minor injuries as a result of the derailment, which also caused damage to track components, signalling equipment and to the derailed wagon. The line was completely closed to traffic for three hours, after which *single line working* was instigated prior to normal working recommencing on the morning of 13 June 2008.

The parties involved

26 Freightliner Group Limited operated the train, employed the driver and maintained the locomotive and wagons.

27 Network Rail owned and maintained the track on which the derailment happened.

28 Both Freightliner and Network Rail have freely co-operated with the investigation.

Location

29 Marks Tey junction is located on the Great Eastern Main Line, which runs from London Liverpool Street to Norwich.

30 All mileages at Marks Tey are given in miles and *chains* from a zero datum at London Liverpool Street station. The *down* direction is from London to Ipswich, and the *up* direction is from Ipswich to London.

31 The derailment occurred on the down main line at the Ipswich end of Marks Tey station. The train was travelling towards Ipswich when it derailed.

32 The railway at this location consists of a double track main line and a branch line to Sudbury, which joins the down main line via a *trailing junction*. There is also a *crossover* between the up and down main lines, which is separated from the branch line points[1] by a short section of plain line. There is additionally a set of points which give access from a loop line to the up main line. Collectively, these points are known as Marks Tey junction, of which the mid-point is nominally located at 46 miles 57 chains (figures 2 and 3).

33 At Marks Tey, the station platforms are staggered so that the point of derailment was just beyond the down main/Sudbury branch line platform, and opposite the up main platform (figures 2 and 3).

[1] See appendix D for details of the components of a set of points.

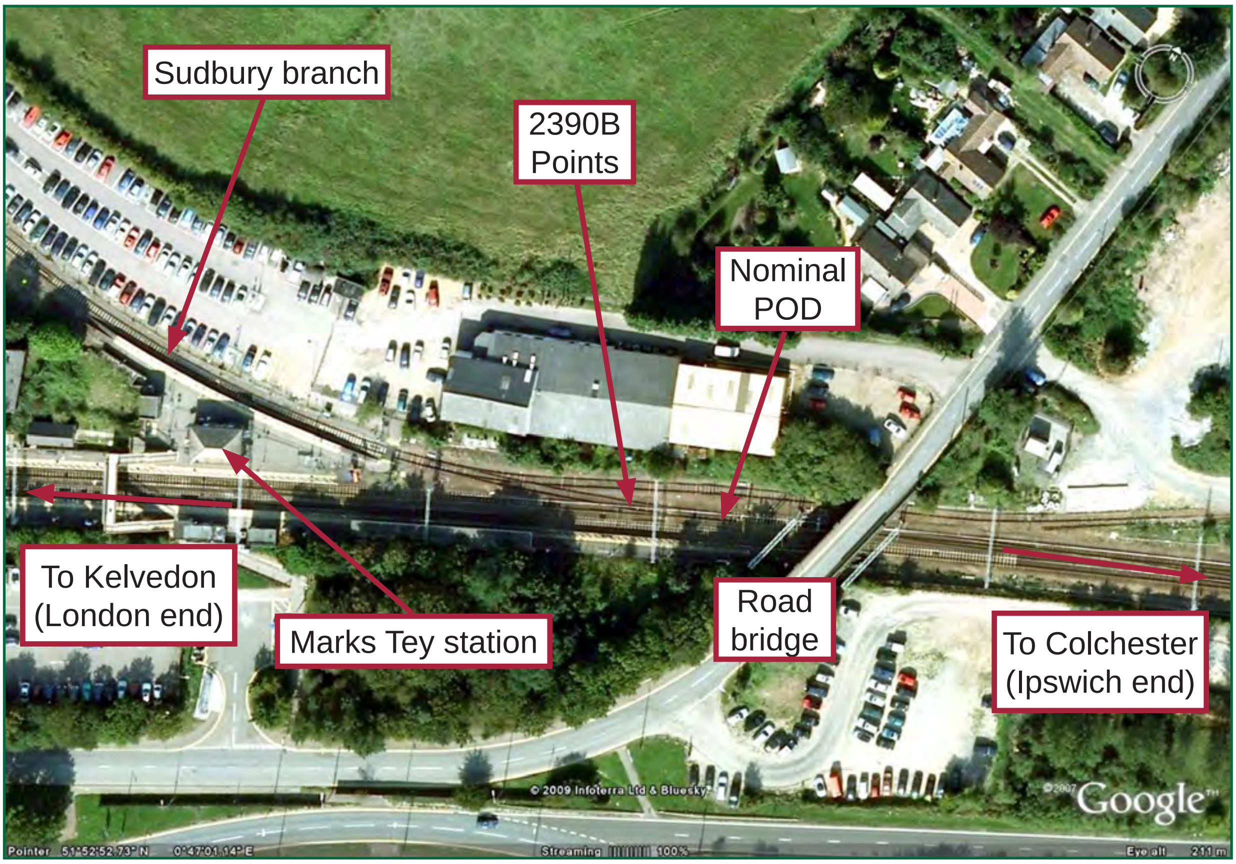

Figure 2: Aerial photograph of Marks Tey station and junction (image courtesy of Google Earth)

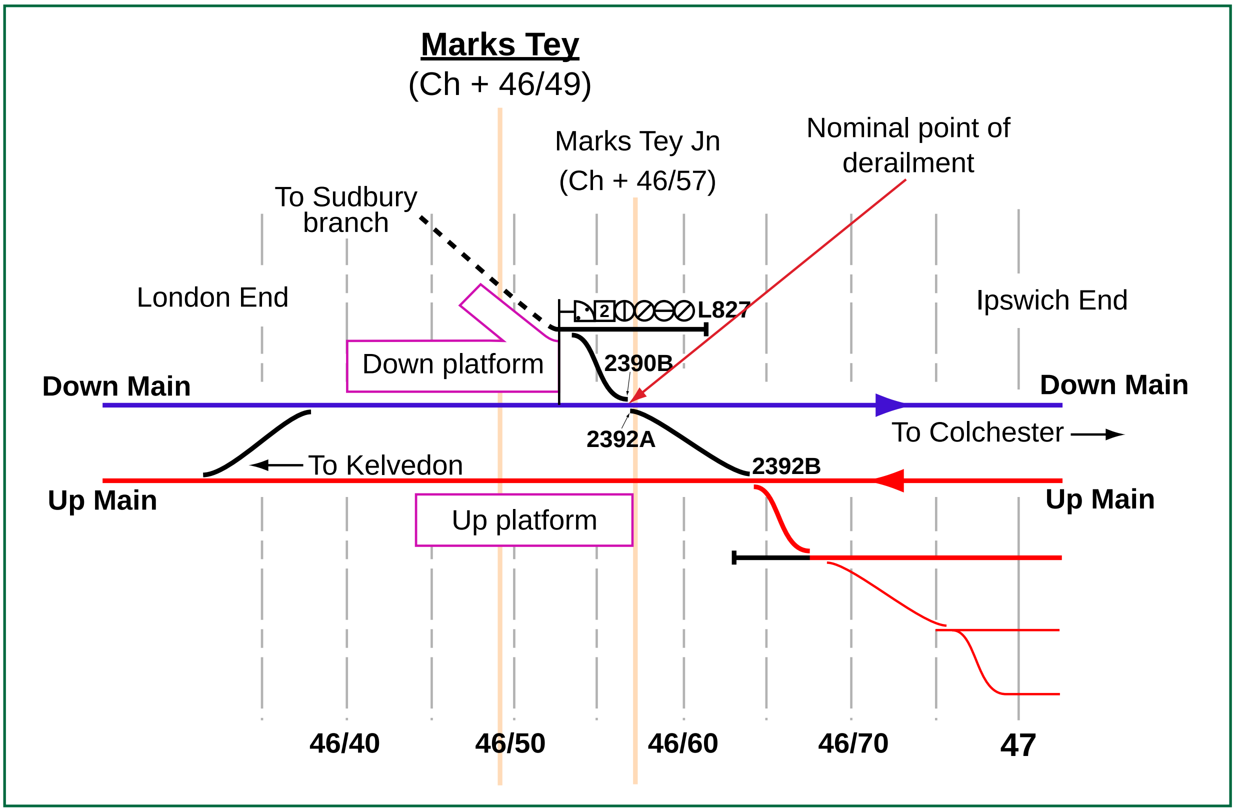

Figure 3: Plan of Marks Tey station and junction

34 The line curves to the right through both Marks Tey station and junction. A road bridge passes over the junction at the crossover.

35 The railway at Marks Tey is signalled using the *track circuit block system* and colour light signals and is controlled from London Liverpool Street Integrated Electronic Control Centre (IECC). The line is electrified at 25 kV AC via overhead power cables. The signalling and electrification systems had no bearing on the derailment.

External circumstances

36 The weather on the day was dry and clear, and played no part in the derailment.

The train

37 The train consisted of electric locomotive number 90 041 and 16 flat container wagons of the FEA, FSA and FTA types (see figures 4 and 5). FTA wagons and FSA wagons are essentially of the same design, except for differences in the *headstock* and *drawgear*.

38 The first four wagons were not loaded and the remaining twelve wagons carried empty containers. The derailed wagon, number 608440, was of the FSA type and was the tenth wagon from the front. The train document produced by the *total operating processing system* (TOPS) for the train, which was signed by the driver, correctly gave a maximum train speed of 75 mph (121 km/h).

Figure 4: Unladen FSA container wagon

Figure 5: FSA container wagon loaded with containers (wagon shown fitted with wheel skates)

39 Wagon 608440 was loaded with one container of the '40 foot high-cube' type to the front and one of the '20 foot' type to the rear. Both containers were empty.

40 FSA wagons have a nominal tare weight of 20.8 tonnes and are certified for a maximum gross laden weight of 87 tonnes[2], giving a carrying capacity of 65.2tonnes. The train document for train 4L41 showed wagon 608440 as having a gross laden weight of 27.8 tonnes, which would mean that the empty containers represented a load of about 7 tonnes.

41 FSA wagons are carried on two Y25 type bogies (see figure 6), each of which has two wheelsets. These bogies have a primary suspension consisting of nested pairs of coil springs, in which the outer spring of the pair (the 'tare' spring) is in use through all loading conditions and the inner spring (the 'laden' spring) engages progressively as the load on the wagon increases, making the suspension of the vehicle stiffer. In addition, part of the vertical force is applied to a friction face on the axle-box horn guide via an inclined link (known as the 'Lenoir' link) to provide vertical and lateral damping.

42 FSA wagons operate as part of pre-formed sets[3]. Wagon 608440 was the rear wagon of a pre-formed set of four wagons made up of two FSA ('outer') wagons at the ends and two FTA ('inner') wagons in the centre.

[2] In 2000, the FSA wagons maximum gross working load was increased from 82 to 87 tonnes. 82 tonnes remains the maximum gross working load weight marked on the vehicle's body.

[3] Wagons within pre-formed sets generally remained coupled together for prolonged periods. The set is treated as a single entity during normal working and individual wagons are not normally taken out of a set except for maintenance or to address a particular operational necessity.

43 Wagon 608440 was built in 1993 by Arbel-Fauvet Rail in France. It was introduced into service when British Rail was the owner and operator of both the infrastructure, and passenger and freight train services.

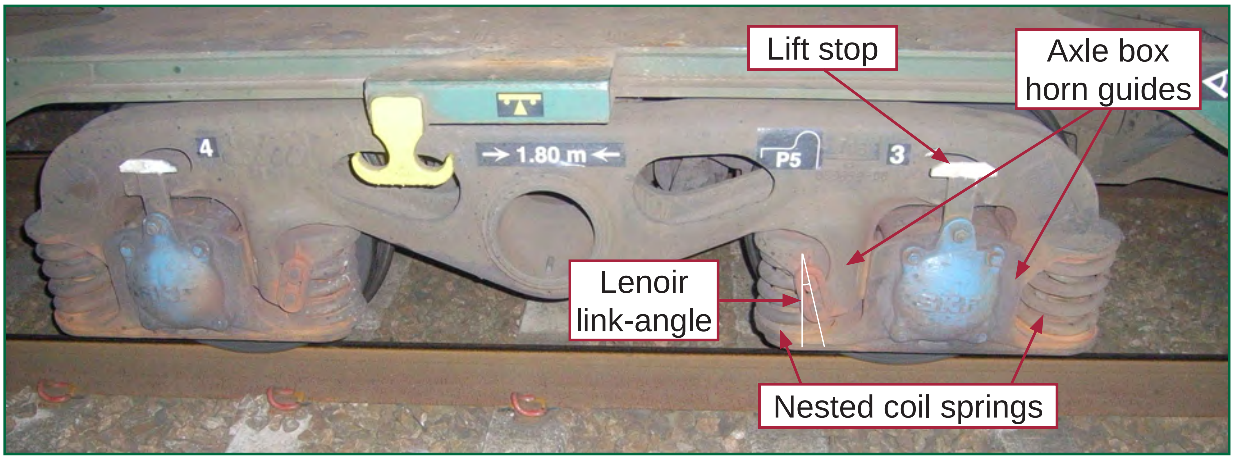

Figure 6: Y25 type bogies

The track

44 The railway at Marks Tey junction is a double track main line, with a maximum permitted line speed of 100 mph (160 km/h); individual trains may have a lower permitted speed than this maximum due to differing rolling stock characteristics, particularly between freight and passenger stock. At the derailment site the *cess rail* was the higher rail in order to counter-act the lateral forces introduced by the right-hand curve. The plain line track consisted of continuous welded 113 A *flat-bottom* rails secured by *Pandrol clips* to concrete sleepers, supported by granite ballast.

45 Access to the main line from the single track Sudbury branch line is via a trailing junction, formed by two set of points, known as the 'A end' and the 'B end' respectively. The B end of this junction are trailing points for trains approaching on the down main in the normal direction of travel[4] . 2392 points are a crossover between the up and down main lines; the A end of this crossover, 2392A points, are facing points for trains approaching on the down main in the normal direction of travel. Figure 3 shows the layout of the crossovers.

Events preceding the accident

46 During the night of 6/7 June 2008, maintenance staff from Network Rail replaced four timber bearers located at the heel of 2390B points.

[4] 2390B points form the trailing junction of the Sudbury branch single line with the down main, whilst 2390A points provide a connection between the branch line and the engineer's siding. The A and B points operate in unison to provide protection against an unauthorised movement from the branch line fouling the down main.

Events during the accident

47 At 14:05 hrs on 12 June 2008, the *On Train Data Recorder* (OTDR) fitted to the locomotive of 4L41 recorded a speed of 77.3 mph (124 km/h) as the train passed through Marks Tey station.

48 A closed circuit television (CCTV) recording made at Marks Tey station shows that wagon 608440 was running correctly as it entered Marks Tey junction.

49 Whilst running on plain line between 2390B and 2392A points the rear wheelset of the rear bogie of wagon 608440 derailed towards the cess.

50 The train continued forward initially without slowing significantly, as the driver was unaware of the derailment. The leading wheelset of the rear bogie subsequently also derailed towards the cess.

51 At some point after the derailment, the brake pipe between the twelfth and thirteenth wagons became disconnected, possibly due to the impact of ballast being thrown up by the derailment. The resultant loss of brake pipe pressure automatically applied the brakes on the train, which then came to a halt around 2.4 km beyond Marks Tey junction.

Consequences of the accident

52 Two members of Network Rail staff ultrasonically testing the line beyond Marks Tey received minor injuries as a result of being struck by flying ballast.

53 The derailment caused damage to sleepers and rail fastenings on the down main and to lineside signalling equipment. Wagon 608440 suffered damage to its wheels, suspension and braking system.

Events following the accident

54 The driver observed the loss of brake pipe pressure and looked back along his train. On observing a large plume of dust rising from the rear to the cess side, he realised that the train had derailed. He reported this via his cab radio to the signaller and, once the train had stopped, he descended from his cab and undertook *emergency protection* of both lines.

55 Both the up and down main lines were closed immediately following the accident, with single line working being introduced on the up main from 18:37 hrs. The derailed wagon was removed from site and the track sufficiently repaired to re-open the railway in both directions at 08:00 hrs the following morning, 13 June 2008.

The Investigation

Investigation process and sources of evidence

56 The following sources of evidence were used as part of the investigation:

- the locomotive's On Train Data Recorder (OTDR);
- examination of the track and locality;
- site track survey and previous track recording data;
- examination of the derailed wagon and other wagons within train 4L41;
- TOPS, *TRUST* and *ERIC* data for train 4L41;
- information relating to the repair and return to service of wagon 608440;
- relevant certificates of engineering acceptance and of conformance for vehicle design for FSA/FTA wagons, including supporting technical submissions where appropriate;
- relevant maintenance records for wagon 608440 and for a comparable sample wagon from the train;
- relevant vehicle maintenance instructions for FSA/FTA wagons;
- Freightliner instructions and standards for the loading and operation of intermodal wagons;
- VAMPIRE® (Vehicle Dynamic Modelling Package in Railway Environment) modelling;
- track quality data;
- track patrol, work bank and work records for Marks Tey;
- drainage survey for Marks Tey; and
- witness testimony.

Key Information

History of the track and formation

57 Network Rail's Geography and Infrastructure System (GEOGIS) recorded that the track at Marks Tey was laid in 2001, although the rails are dated 1998. The GEOGIS system also reported that the ballast dated variously from 1975 or 1986.

58 2390B points dated from the mid-1970s and were made of full-depth CV[5] 113A type switches and a *cast crossing* at an angle of 1 in 10. They were not replaced during the general renewal of track which took place at Marks Tey in the 1990s. The consequences of this were that 2390B points and their supporting timber bearers were older and more worn than the surrounding track. It also meant that the formation under the junction differed from that on either side.

59 2392A points dated from around the late 1990s and were made up of *shallow depth* FV 113A/U54 switches and a 1 in 28 cast centre block *crossing*.

Derailment marks

60 Marks on the cess rail showed that a *wheel flange* had ridden on the rail head on a short section of plain line of around 16 metres in length, located between the toes of trailing points 2390B and facing points 2392A. The exact point where the wheel had started to climb was not clear and so for the ease of reference a nominal point of derailment was defined, known as 'Sleeper 0' (figures 7 and 8).

61 The position of sleepers relative to the nominal point of derailment is defined by the use of positive values on the approach to the nominal point of derailment and negative values beyond it e.g. sleeper 5 is the fifth sleeper on the approach to sleeper 0, and sleeper -5 is the fifth sleeper beyond it in the direction of travel of the train.

62 The beginning of the flange mark was at the upper *gauge corner* of the cess rail head from around sleeper -6 (about 0.39 metres beyond the nominal point of derailment). This flange mark crossed progressively over the crown of the rail head to its *field side*, before dropping into the cess between sleepers -15 and -16 (around 9.7 to 10.5 metres beyond the nominal point of derailment, see figure 9).

63 On the six-foot rail head there was a 'drop-in' mark between sleepers -14 and -15 (around 9.1 to 9.7 metres beyond the nominal point of derailment). This mark was caused by the tread corner of a wheel as it left the rail head and entered the *four-foot*. Contact marks on track components confirm that a wheelset was running derailed beyond this point.

64 There were additional flange marks on the cess rail head around sleeper -7 (approximately 4.5 metres beyond the nominal point of derailment), indicating that a number of other wheels had climbed onto the rail head. These flange marks stayed on the rail head before returning to the gauge side of the rail head in the vicinity of sleepers -15, -16 and -17 (around 9.7 to 11 metres beyond the nominal point of derailment, see figure 9).

[5] The length of a switch is classified by a letter of the alphabet, with A representing the shortest switch. In the case of 2390B points the switches were classified CV (the V standing for vertical).

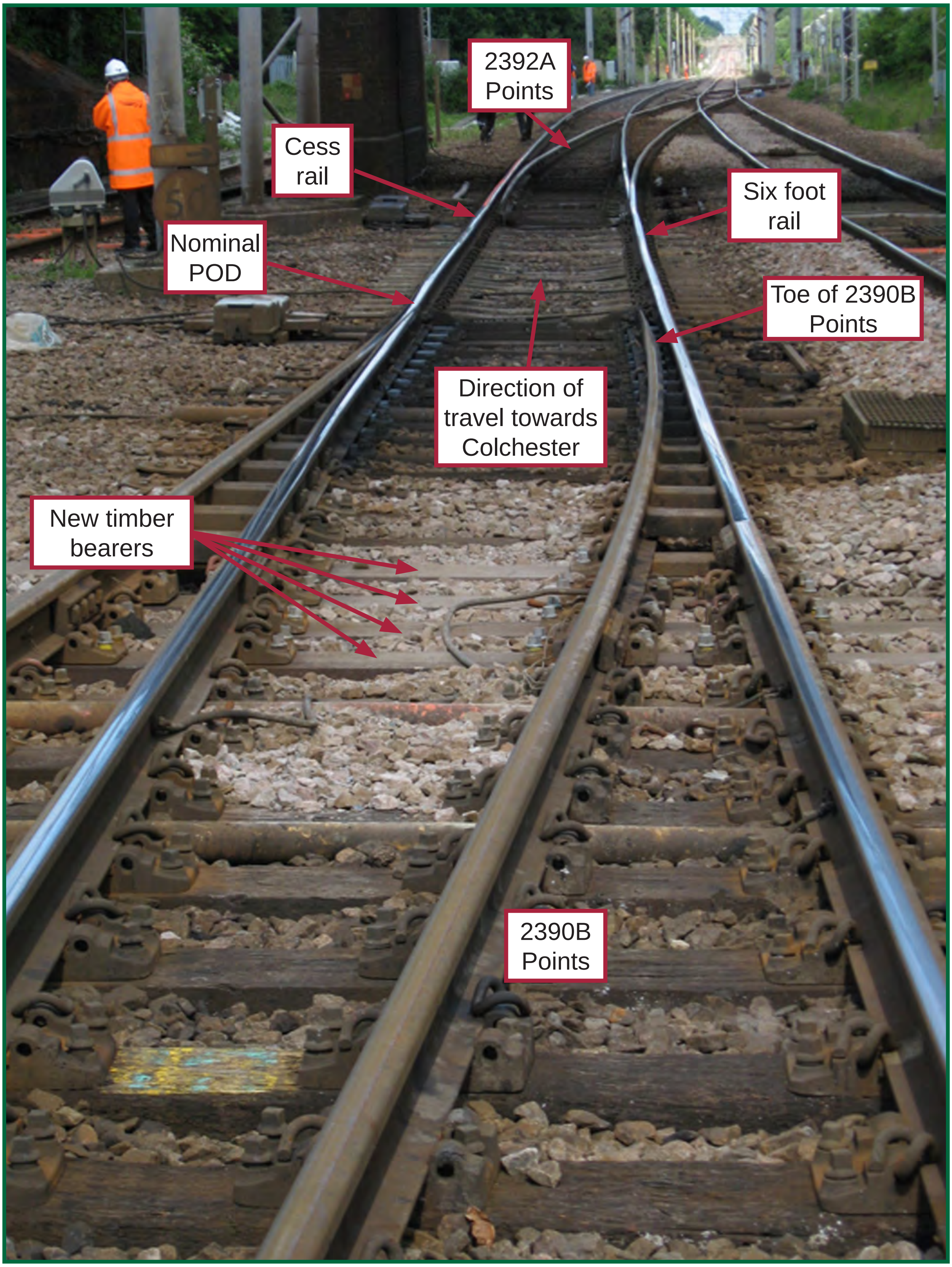

Figure 7: Nominal point of derailment, facing the direction of travel

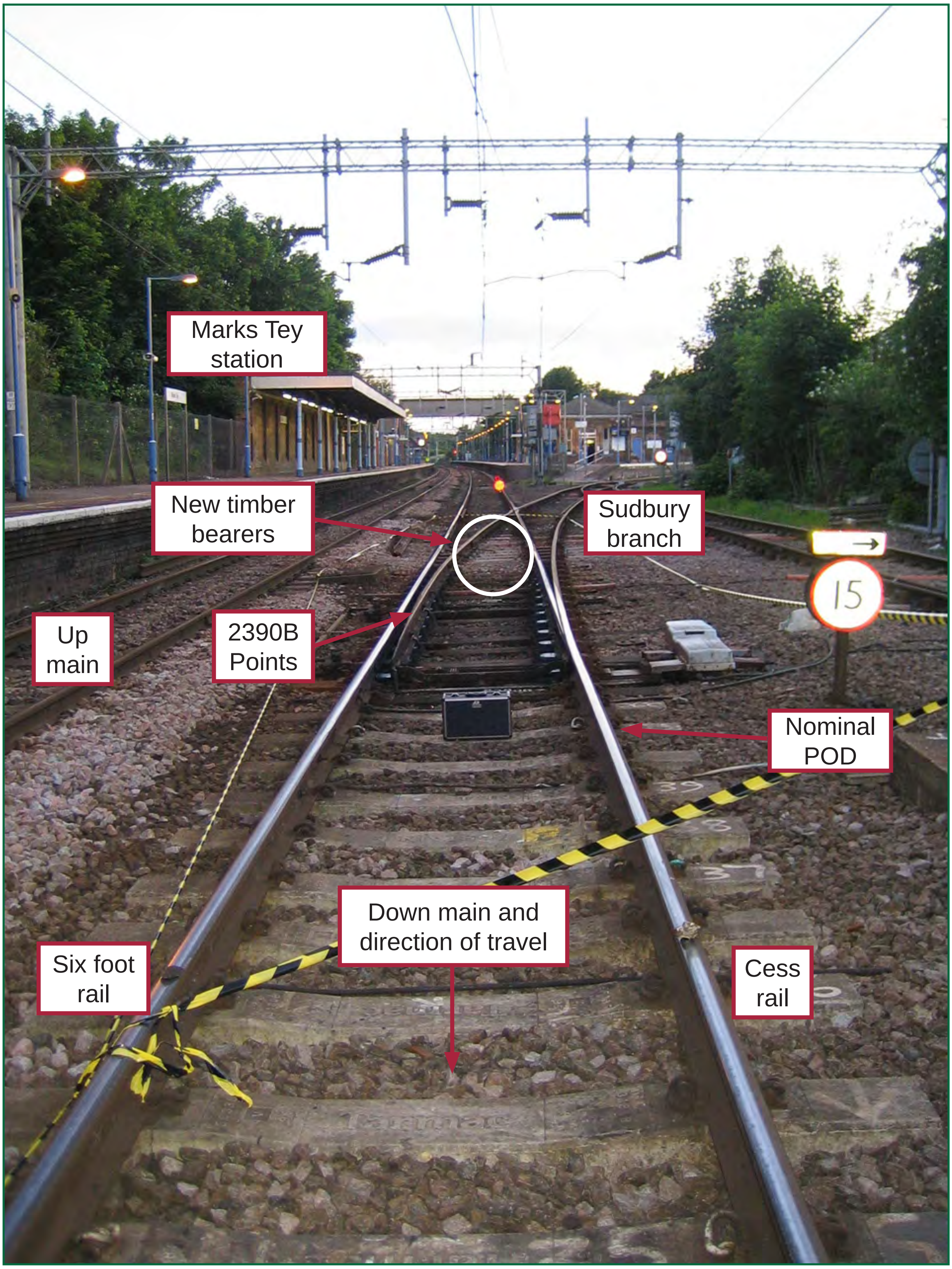

Figure 8: Nominal point of derailment, facing against the direction of travel (photograph courtesy of Delta Rail)

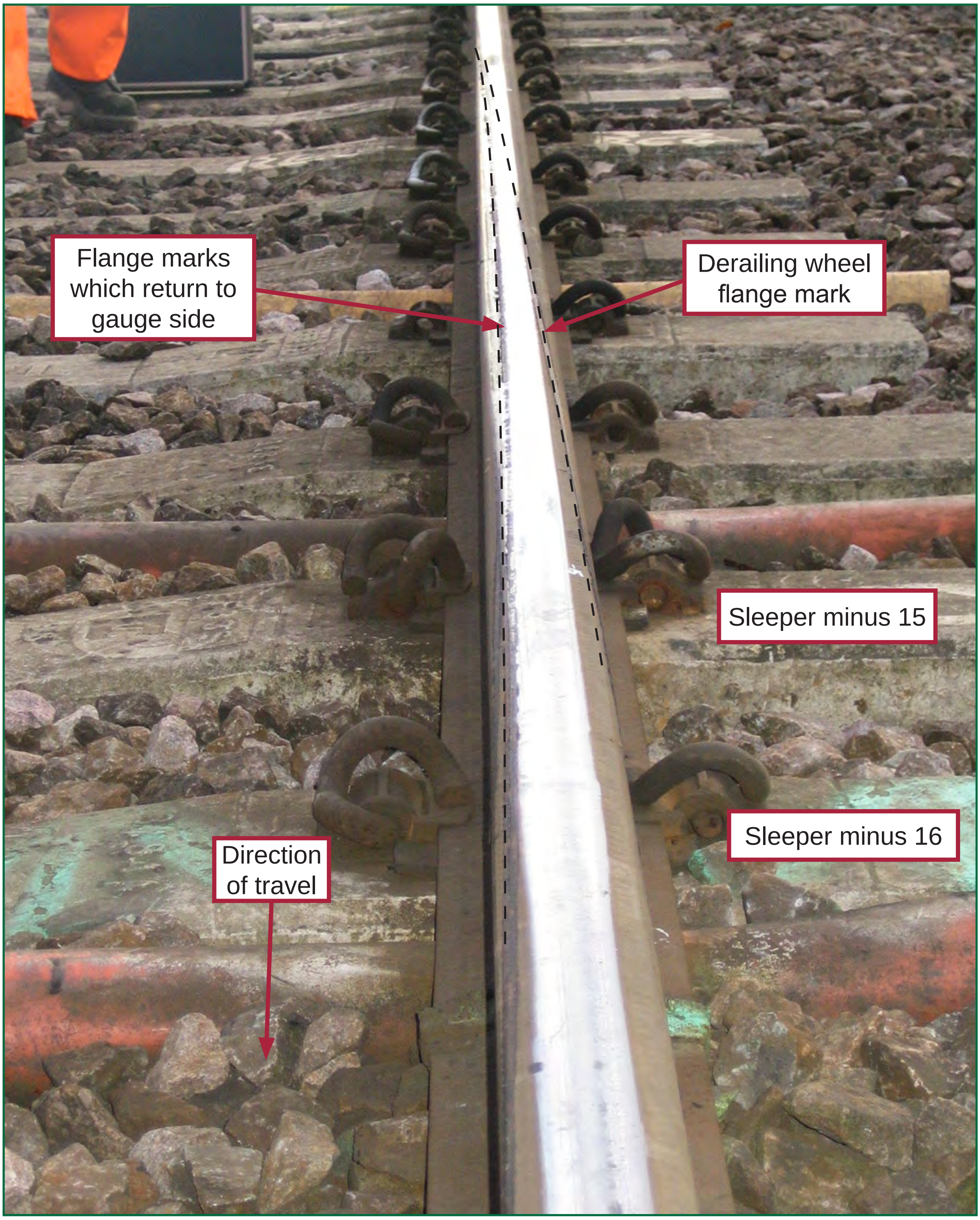

Figure 9: Flange mark on cess rail, facing against direction of travel (photograph courtesy of Delta Rail)

65 On the six-foot rail head there was also evidence of rolling marks from wheel tread corners which started suddenly around sleepers -10 and -11 (around 6.5 to 7.2 metres beyond the nominal point of derailment) and continued for a few metres. Taken together with the flange marks found on the cess rail head, this shows that several wheelsets ran partially derailed for a short distance before returning to normal running.

66 There were bright marks on the gauge corner of the left-hand rail in the vicinity of sleeper 0, which provided evidence that heavy flange contact had occurred. An inspection of 2390B points two days before the accident (paragraph 159) did not find any evidence of excessive *sidewear*.

Track condition

Track Examination

67 An examination of the track near to the nominal point of derailment showed that:

- both 2390 and 2392 points, which were strengthened points and so intended to take thermal loads, were fitted with *non-strengthened fishplates*;
- a *rail clamp* had been applied to the *four-foot stock rail* of 2390B points;
- there was a visible dip at a staggered *insulated rail joint* at the heel of 2390B trailing points, under which four timber bearers had recently been replaced - these were sleepers 22 to 19 (around 15 to 13 metres before the nominal point of derailment);
- there also was a visible dip at the welded stock rail of 2390B trailing points at sleeper 3 (around 2 metres before the nominal point of derailment).
- Pandrol rail fastenings were missing from some of these replacement timber bearers - rust markings on the rails indicated that the fastenings had probably been in place until a few days prior to the derailment (figures 10 and 11); and
- contrary to normal practice, new insulating rail pads had not been fitted to the replacement timbers - in some cases old pads had been reused (however, there is no requirements in standards for such replacement).

68 An examination of the down main line through Marks Tey station showed a succession of dips in the vertical alignment of the track, which became more apparent when viewed at track level. These dips were later found to correspond approximately to the position of drainage catch pits from the centre track drain (see paragraph 72).

Track survey

69 A survey of the down main line was conducted from a point 170 sleepers (about 115 metres) before, to 60 sleepers (about 40 metres) after, the nominal point of derailment. The survey measured the track's vertical alignment, lateral alignment, gauge and cant. *Voiding* was also measured on both rails, using a Class 66 locomotive.

70 The survey showed that cant varied between 58.5 and 28 mm, with a typical value of around 40 mm. The highest values found for dynamic 3-metre *track twist* were 1 in 226, found at sleeper 19 and 1 in 256, found at sleeper 2. These were outside the 1 in 300 maintenance limit specified in Network Rail Company Standard NR/SP/TRK/001 Issue 2 'Inspection and Maintenance of Permanent Way'[6], but within the intervention limit of 1 in 200.

[6] NR/SP/TRK/001 Issue 2 has now been superseded (see paragraph 278) but was current at the time of the derailment.

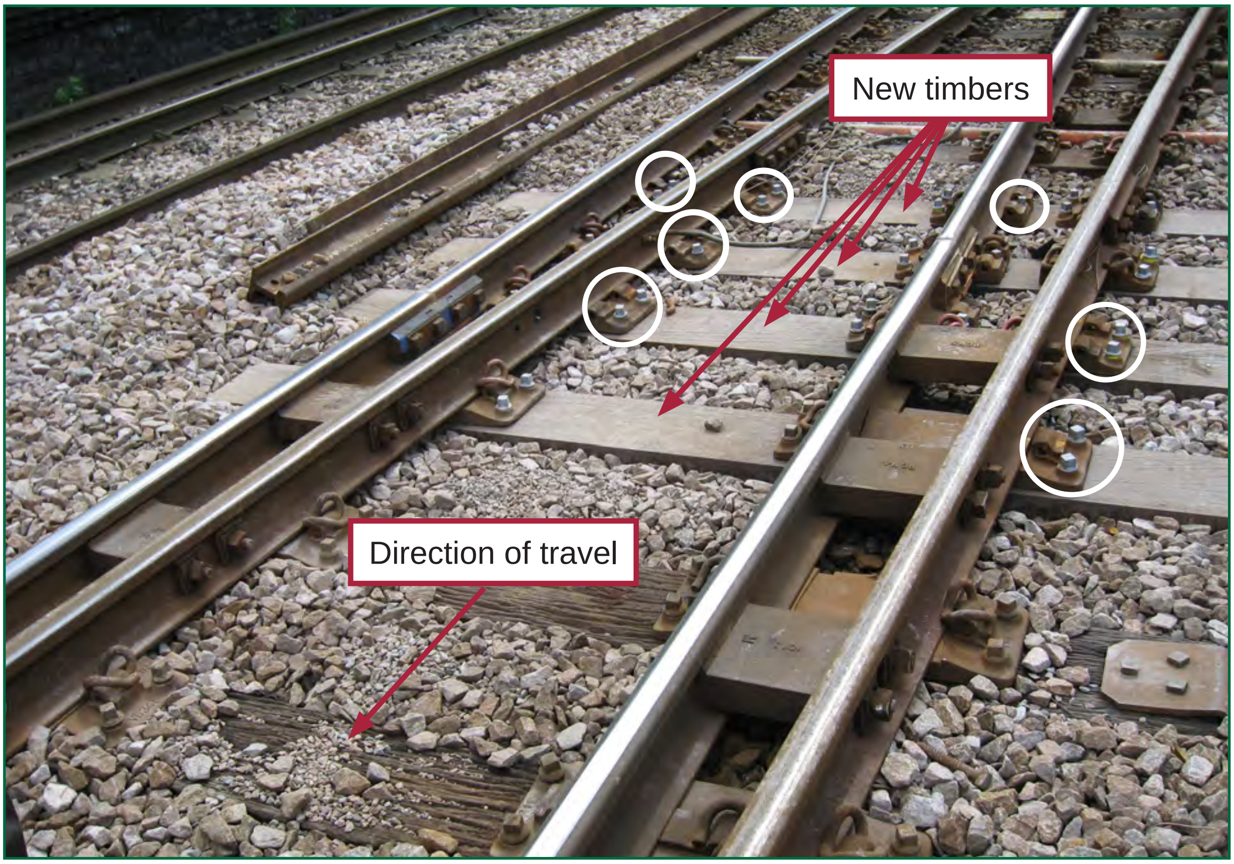

Figure 10: New timbers fitted to heel of 2390B points; missing fasteners highlighted

Figure 11: Close up of baseplates with missing fasteners

71 The survey found that significant voiding was present in two distinct areas – between sleepers 22 and 19 and between sleepers 10 and 7. In both areas the voiding increased on both rails; although it was not exactly matched in each rail, the overall effect was to produce a dip in the vertical profile, rather than a twist. The area of voiding found between sleepers 22 and 19 corresponded exactly with four new timber bearers which had been replaced at the heel of 2390B points. The survey data showed the presence of cyclic top at this point; this defect was within the Level 2 limits for the presence of cyclic top in both rails laid down within NR/SP/TRK/001 Issue 2.

Drainage Inspection

72 Because of the presence of dips in the track as it passed through the station (see paragraph 68) Network Rail undertook a full inspection of the drainage catch pits located around Marks Tey station and junction following the derailment (figure 12).

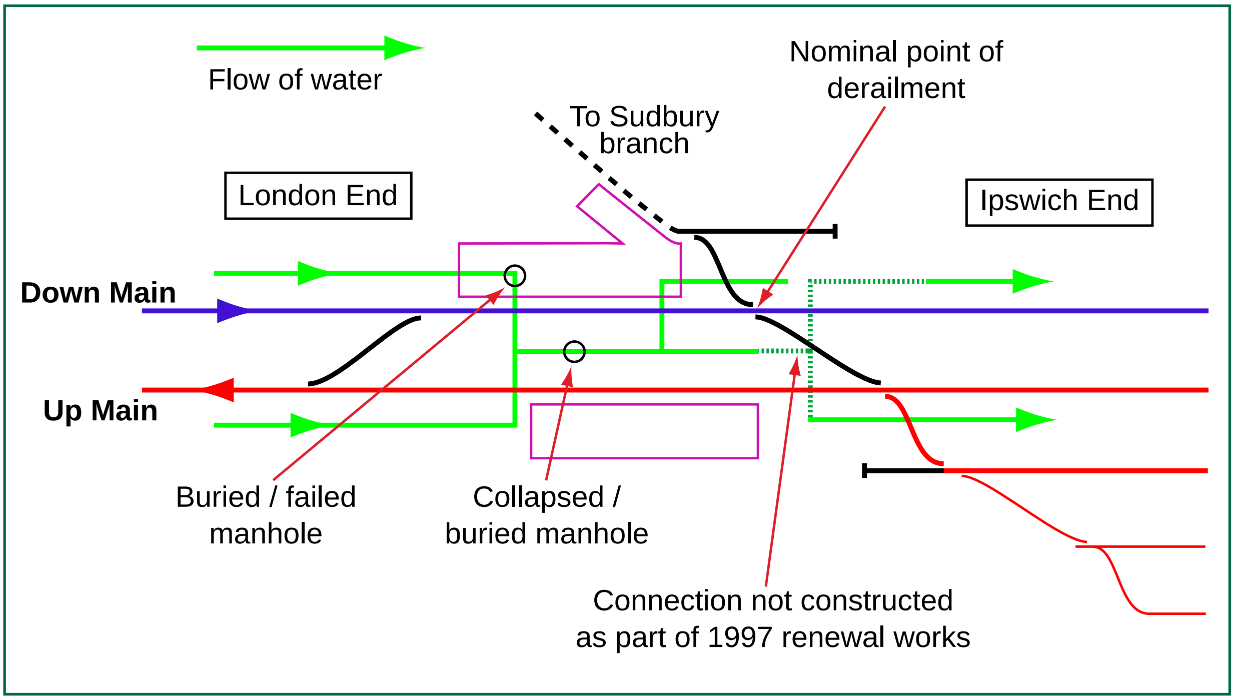

Figure 12: Drainage layout (not to scale)

73 This inspection found that the catch pits either contained still water and debris, or that they could not be accessed for inspection because they were covered in ballast or had been built over. At the London end a catch pit in the down cess drain had been buried under a platform extension and had failed, thus blocking the drainage system at this point. At around the mid-point of the platform a catch pit in the centre track drain had either collapsed or was buried, again possibly blocking the drainage system.

74 At the Ipswich end of the station the centre drain ended short of Marks Tey junction with no connection to the cess drains on either side. This represented a further blockage in the drainage system. A connection to the cess drain was meant to have been installed as part of track renewal works in 1997, but this had not been carried out.

75 The drainage inspection could not be completed on the Ipswich side of the station as the catch pits had been covered in ballast.

Wagon condition

Wagon maintenance

76 There was no evidence of any relevant outstanding maintenance action on wagon 608440. It underwent its last six-monthly planned preventative maintenance examination prior to the accident on 12 March 2008, when a wheelset in the leading bogie was replaced. The wagon had its last annual vehicle inspection and brake testing examination prior to the accident on 8 September 2007.

Wagon examination

77 The RAIB and Network Rail's representatives examined wagon 608440 at Colchester.

78 Because of the presence of flange marks showing a partial derailment and re-railing at the accident site, it was also decided to examine other wagons from the incident train at Colchester and Ipswich. The findings of these examinations which are of relevance are as follows.

Wagon 608440

79 Examination of the front bogie of wagon 608440 revealed contact marks high on the flange of the left-hand wheel of the leading wheelset and a possible climb mark on the left-hand wheel of the trailing wheelset (figure 13).

Figure 13: Possible climb marks on the left-hand wheel of the trailing wheelset of the rear bogie of wagon 608440

80 The wheels of the leading and trailing wheelsets of the rear bogie were damaged by running derailed, with the trailing one having sustained the most damage, consistent with it having derailed first.

Wagon 607129

81 Wagon 607129 was the 9th wagon back from the front of the train and so was directly in front of wagon 608440.

82 Examination of the front bogie showed contact marks on both leading and trailing wheelsets, showing that the left-hand wheels had ridden high on the wheel flange.

83 The rear bogie leading wheelset showed contact marks indicating that the left-hand wheel had also ridden high on the wheel flange. The trailing wheelset of the rear bogie had contact marks on the tip of its left-hand wheel flange; this wheel also had a fresh mark on its tread that was indicative of it having dropped onto a rail head (figure 14). There was a possible contact mark on the right-hand wheel of this wheelset, and evidence of contact on the underside of the lift stop on the right-hand wheel of the trailing wheelset (figure 6), indicating that the bogie frame may have applied a lifting force to this wheel.

Figure 14: Contact marks on the left-hand wheel of the trailing wheelset of the rear bogie of wagon 607129

84 These marks demonstrate that this wagon had run partially derailed prior to returning to normal running. Paragraphs 204 to 217 explore how this might have happened.

85 The wagon was found to have an overall body twist of 10 mm, which was not considered to be significant.

86 No issues of relevance were recorded with respect to the wheel profiles and diameters of the wheels which displayed contact marks.

Wagon 608181

87 Wagon 608181 was the 12th wagon from the front of the train, and so was in the portion of the train behind wagon 608440.

88 Examination of the rear bogie's leading wheelset showed contact marks indicating that the left-hand wheel had ridden high on the wheel flange, and also a possible landing mark on the right-hand wheel of this same wheelset.

89 These contacts marks demonstrate that this wagon may have come close to derailment.

90 The wagon was found to have no significant overall body twist.

91 No issues of relevance were recorded with respect to the wheel profiles and diameters of the wheels which displayed contact marks.

WheelChex

92 4L41 passed over a '*WheelChex*' installation at Ingatestone, approximately 23 route miles before passing through Marks Tey. The output data from this installation did not highlight any issues of relevance relating to this derailment: the wagons were loaded evenly, and within loading limits.

Dynamic Modelling

93 In order to reach a more definite understanding of the derailment a series of dynamic modelling simulations was undertaken using the VAMPIRE® computer simulation package.

94 Nadal's criterion[7], which has been in use since 1908, specifies the wheel flange loading criteria that can lead to derailment by comparing the horizontal forces (Y) and vertical forces (Q) on the wheel flange, and stating that there is a critical ratio of these two forces, which, if exceeded for a sustained distance, can lead to derailment. *Railway Group Standard* GM/RT 2141 Issue 2[8] 'Resistance of Railway Vehicles to Derailment and Roll-Over' specified that, for a vehicle to be used on the Network Rail system, the Y/Q ratio, measured on a sliding mean over a 2 metre length, should not exceed a value of 1.2 for the wheel and rail conditions under consideration.

95 Another measure of the propensity to derail is wheel unloading, expressed as Delta Q/Q (DQ/Q). When the DQ/Q ratio reaches +1.0 it indicates complete wheel unloading, i.e. there is no vertical load on the wheel, and a modest lateral force can cause a wheel to derail.

[7] Iwnicki. S, *Handbook of Railway Vehicle Dynamics*, CRC Press, 2006, ISBN 978-0849333217; Nadal, M.J., *Locomotives à vapeur,* Collection Encyclopédie scientifique / Bibliothèque de mécanique appliquée et génie, 1908.

[8] GM/RT 2141 Issue 2 was in force at the time of the derailment. In June 2009 this was superseded by GM/RT 2141 Issue 3, which has retained the same Y/Q limit.

96 A track model was created using data from the track survey of the site. The model was processed to remove the effect of the slight gradient. The track data was then smoothed and the resulting geometry compared with that produced by a track recording train when it passed over Marks Tey junction on 27 May 2008 (see paragraph 166). This generally showed agreement between the two outputs, with the exception of the area where the four new bearers had been fitted to 2390B points (paragraph 118). This showed that the dip measured at the heel of these points by the track recording train (paragraph 167) had become significantly worse when measured by the post-accident manual survey.

97 Two vehicle models were produced both of which modelled wagons in the 'part-laden' condition i.e. a wagon loaded only with empty containers. One model was designated as a 'nominal' vehicle with new wheels (of a P5 profile) and un-worn Lenoir links (giving nominal levels of friction damping). The second model was modified to simulate the effect of wear on the wheels (i.e. a reduction in wheel diameter) and suspension (i.e. a reduced Lenoir link angle and thus an altered level of friction damping – the Lenoir link angle used was in the mid-range of those measured on the incident wagons post-accident). This model was known as the 'Marks Tey condition' vehicle.

98 Three phases of simulation were run. New P5 wheel profiles and 113A plain rail profiles were used throughout the modelling as the dominance of vertical behaviour in the derailment mechanism meant that the influence of wheel and rail profile would be very small. The model was validated against actual test results.

99 The results of the dynamic modelling simulations are analysed in paragraphs 195 to 217.

Track Inspection and maintenance[9]

Tonnage and track category

100 Network Rail classifies its routes based on criteria[10] which take into account the speed of trains and the tonnage carried. The resulting category specifies at what interval visual inspections, ultrasonic testing and geometry recording should be undertaken. Track categories are re-assessed periodically to reflect changing traffic levels.

101 In June 2008, the line through Marks Tey was track category 1A, which requires the most frequent inspection, testing and recording of any category. It was previously designated as track category 2, and was reclassified to the higher category in mid-2007, as a result of an increase in the tonnage passing through.

Local maintenance organisation

102 Network Rail's maintenance team based at the Colchester Maintenance Delivery Unit were responsible for the maintenance and inspection of Marks Tey junction. The organisation as it existed in January 2008 and in June 2008 is described below.

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[9] Appendix E gives a summary timeline of the key infrastructure issues in this derailment.

[10] At the time of the derailment this criteria was contained within standard NR/SP/TRK/001 Issue 2.

The Track Maintenance Engineer Colchester organisation in January 2008

103 Figure 15 shows the local maintenance organisation at Colchester Maintenance Delivery Unit as it was in January 2008. The Track Maintenance Engineer Colchester at this time was Track Maintenance Engineer A, who was responsible for two Track Section Managers, one of whom, Track Section Manager B, was occupying the post of Track Section Manager Colchester and so was responsible for Marks Tey.

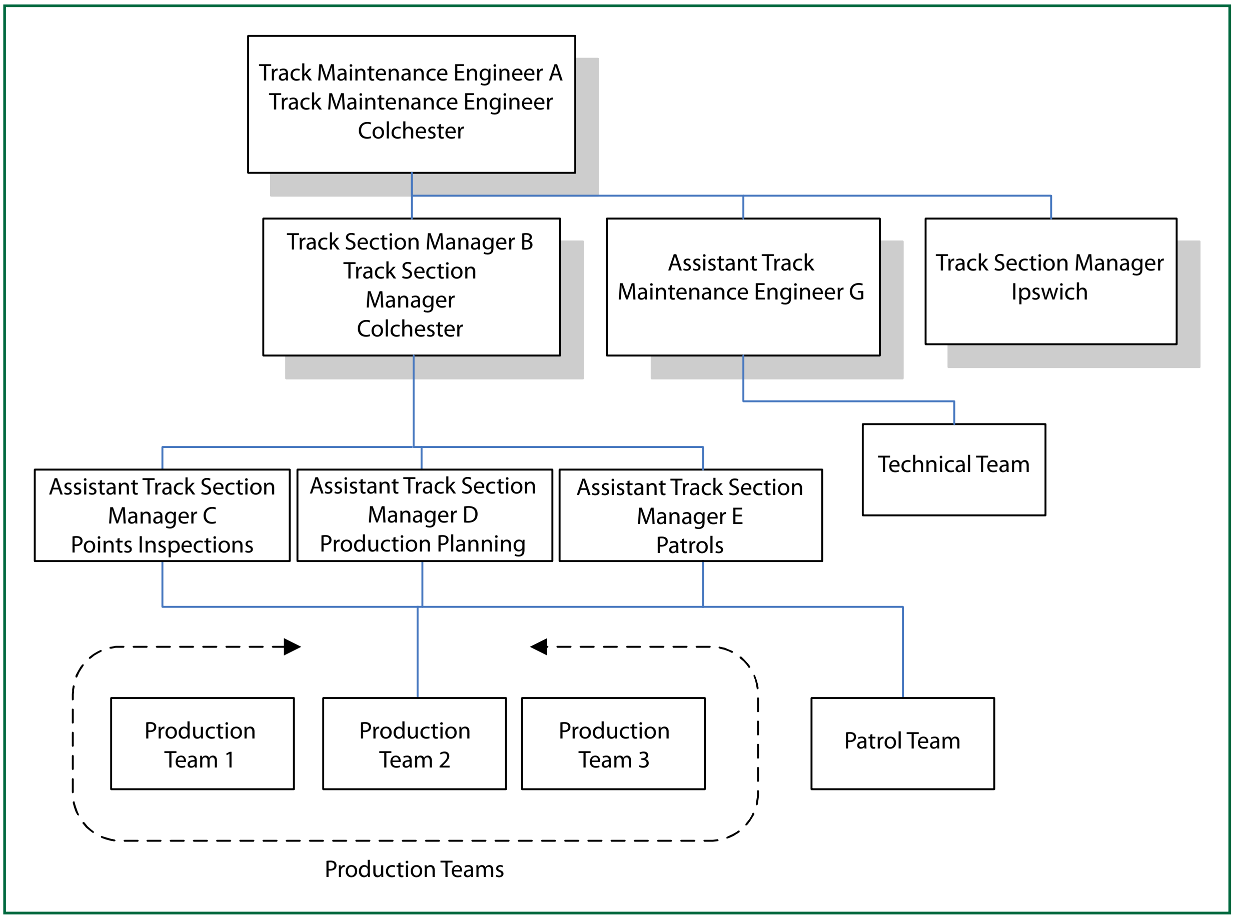

Figure 15: Track Maintenance Engineer Colchester organisation in January 2008

104 Track Section Manager B in turn had three Assistant Track Section Managers reporting to him, Assistant Track Section Managers C, D and E. There were also three *production teams* and a patrol team, all formed of track engineering staff. Assistant Track Section Manager C was responsible for point inspections, Assistant Track Section Manager D was responsible for the production teams and Assistant Track Section Manager E was responsible for the patrol team. Although production planning was undertaken by Assistant Track Section Manager D, any of the Assistant Track Section Managers would issue tasks to the production teams, as required.

105 Following an incident in November 2007, when a track geometry recording train found a twist fault which required the line through Colchester station to be blocked to traffic, a local investigation conducted by Track Maintenance Engineer A concluded that:

- because of staff absence, the duties of the Track Section Manager Colchester and one of the Assistant Track Section Managers were being undertaken by staff 'acting-up' in these roles;
- another Assistant Track Section Manager position had not been occupied for several weeks;
- supervisory positions within the production gangs were in some cases also being filled by staff 'acting-up';
- the quality of the repair of track geometry defects was not being checked by the Assistant Track Section Managers to an acceptable degree, because the staff lacked competence, and because of a general increase in workload caused by the absences;
- the general management of repeated discrete geometry faults (known as 'Level 2 repeats') had degraded since a 'Special Inspector' role had become vacant early in 2007;
- *tampers* were '*…a valuable resource in short supply…*';
- attempts by the Maintenance Delivery Unit Manager and Track Maintenance Engineer A to obtain extra resources from within the wider area in order to support Colchester had not been successful; and
- because of difficulties gaining access, production team leader were not observing rail traffic pass over some repairs before leaving site[11].

106 The investigation recommended that actions be taken to address the specific track fault at Colchester, that the vacant 'Special Inspector' role be filled urgently and that support be provided to the Assistant Track Section Managers to allow them to delegate some routine work and concentrate on supervisory tasks. It also recommended that, in future, special arrangements be put in place to allow production team leaders to observe traffic passing over some repairs, where there were access difficulties.

107 In February 2008, a broken rail was discovered at Marks Tey junction; this is discussed in more detail in paragraph 117.

108 At the end of February 2008 a technical audit of track maintenance at Colchester Maintenance Delivery Unit was undertaken by a Network Rail team drawn from other parts of East Anglia. The report of this audit stated that '*…at Colchester depot significant failures with both inspection regimes and track geometry were discovered*'. These failures included the inspection and management of track geometry quality, and poor or non-existent drainage records. It specifically identified that key data was missing for urgent remedial works and that there was no coherent action plan in place for sites with poor ride quality (paragraph 170).

[11] Observing rail traffic pass over section of the line can assist in detection of dynamic faults such as voiding.

109 Shortly after this audit, Track Maintenance Engineer A left the post of Track Maintenance Engineer Colchester, which was then occupied by Track Maintenance Engineer F. There was no opportunity for a hand-over to take place between them, and Track Maintenance Engineer F had not previously directly worked on track maintenance in the locality.

The Track Maintenance Engineer Colchester organisation in June 2008

110 Figure 16 shows the local maintenance organisation as it was in June 2008. The Track Maintenance Engineer Colchester at this time was Track Maintenance Engineer F. Track Section Manager B remained the Track Section Manager Colchester with Assistant Track Section Managers C, D and E as his direct reportees.

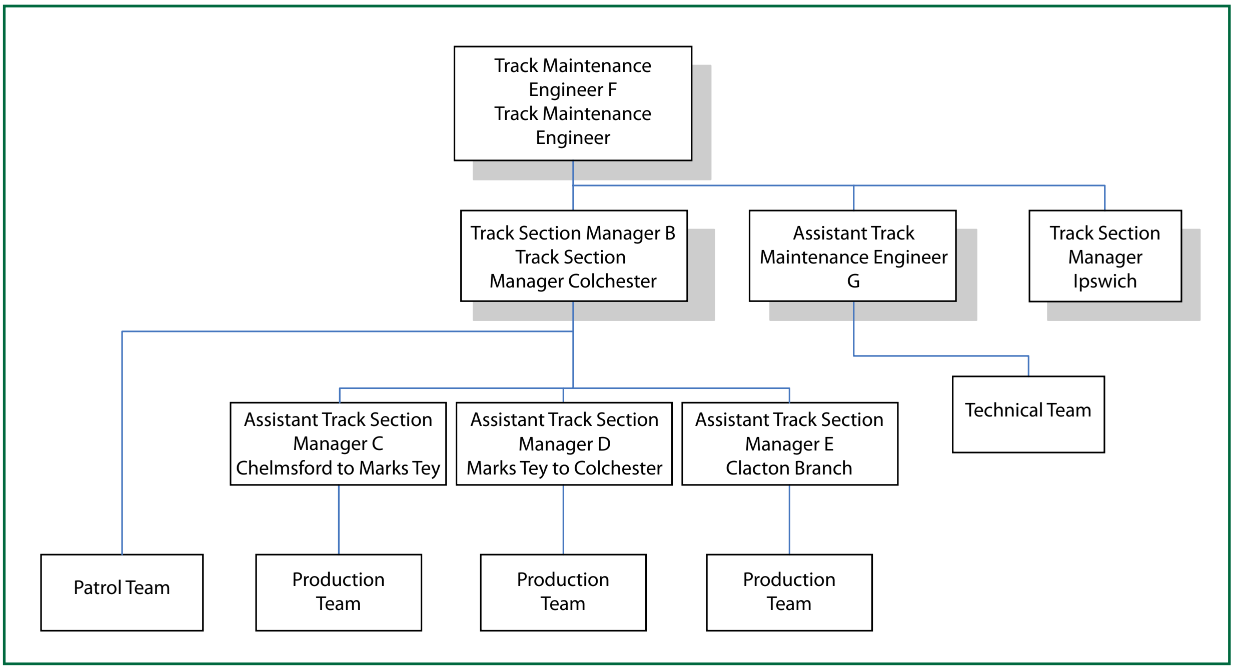

Figure 16: Track Maintenance Engineer Colchester organisation in June 2008

111 Aware of the results of the technical audit, Track Maintenance Engineer F tried to address the deficiencies identified. Amongst the actions he adopted was the enforcement of the use of ELLIPSE as the sole method for the planning and recording of work and inspections, and he also brought in additional supervisory staff from another area to assist him with inspecting the track. He also required that *patrol diagrams* be reviewed and re-issued (paragraph 137).

112 Track Maintenance Engineer F required that the structure of the Track Section Managers' organisations was changed so that each Assistant Track Section Manager would have his own section of track to look after, within defined geographic boundaries (this section was known as a 'length'). Each would also have assigned to him one of the three production teams on a permanent basis in order to undertake work within the length. In this way Track Maintenance Engineer F hoped that a sense of ownership of the track would develop. The limits of each length were chosen by Assistant Track Maintenance Engineer G to coincide with the boundaries of the basic visual track inspection patrols (see paragraph 135), although it was intended that the patrol team would now report directly to Track Section Manager B, who would review the patrol reports and pass them on to the Assistant Track Section Managers as required by the findings of the reports. Assistant Track Maintenance Engineer G is reported to have circulated a formal document detailing the geographic boundaries of each assistant track section manager's length, but this has not been made available to the RAIB.

113 Assistant Track Section Manager C was given responsibility for the line between Chelmsford Station to the mid-point of Marks Tey station at 46 miles and 50 chains. The mid-point of Marks Tey station was also the boundary between track visual inspection Patrol 4, which covered the line between Kelvedon and Marks Tey, and Patrol 5, which covered the line from Marks Tey to Colchester.

114 Assistant Track Section Manager D was given responsibility for the line between the mid-point of Marks Tey station at 46 miles and 50 chains to Ardleigh. This included Marks Tey junction. However, Assistant Track Section Manager D understood his boundary to be at 46 miles 60 chains, which was also the understanding of Track Section Manager B. This was the boundary point between two supervisor's on-foot visual track inspections (see paragraph 135), which was not a common one with the basic visual inspection patrols. For this reason, Assistant Track Section Manager D either did not know, or did not accept, that he had responsibility for Marks Tey junction.

115 Track Section Manager B required Assistant Track Section Managers C, D and E to retain responsibility for the tasks which they had undertaken previously. This meant that Assistant Track Section Manager C remained responsible for point inspections across the entire area. Once aware of this, Track Maintenance Engineer F briefed Track Section Manager B that each Assistant Track Section Manager should only look after tasks within their own length. However, Track Section Manager B either did not understand, or did not act on, this briefing. Assistant Track Section Manager C therefore retained responsibility for all point inspections on the Colchester Track Section.

116 Evidence from witnesses was that, in the months immediately prior to the derailment, the problems brought to light by the investigation into the Colchester station incident (paragraph 106) and the February 2008 technical audit (paragraph 108) continued to have an impact within Colchester Maintenance Delivery Unit. Although many of the issues were being addressed under the leadership of the new Track Maintenance Engineer, witness evidence was strongly indicative that this earlier period had left a legacy of mistrust and poor communication between some track engineering staff that was adversely affecting their ability to work together effectively.

Replacement of the bearers in 2390B points on 6/7 June 2008

Rail break on 6 February 2008

117 On 6 February 2008 a rail break occurred on the heel of the stock rail of 2390B points. This took the form of a longitudinal crack in the rail head at the site of an insulated rail joint, which propagated to allow a section of the rail head to break away. The investigation into the rail break, conducted by Track Maintenance Engineer A, identified that the track quality had been repeatedly graded as 'Very Poor' (see paragraph 169), that '…*general maintenance quality is poor...*' and that access was very limited (Marks Tey junction was in a red zone prohibited area, see paragraph 139).

118 The defect was immediately rectified by installing a new *closure rail* to form a new insulated rail joint. A remedial broken rail action plan was also created containing medium term actions, including the replacement of the timber bearers and switches in 2390B points and improvements to joints and track quality. The action plan stated that the switches had been planned for replacement on 9 February 2008, but that the non-availability of the required components (which had been used elsewhere) had led to the work being deferred until the following financial year.

119 The broken rail action plan did not propose actions to address the general track quality (although a track quality action plan was created in the same month, see paragraph 170) or the access difficulties at this location. Track Maintenance Engineer A had previously obtained *T12 protection* periods for the patrol which passed through the station platforms (paragraph 141) but he had not been asked to extend this to Marks Tey junction by any of his subordinates and had not done so.

Replacement of the bearers on 2390B points

120 The following paragraphs, 121 to 187, are based on a review of the documents available to the RAIB, and on the witness evidence supplied to it.

121 On 16 May 2008, around two weeks before the derailment, the Area Track Engineer, on behalf of the Territory Engineer (Track), requested a progress report from Track Maintenance Engineer F in respect of the broken rail action plan created in February. The Area Track Engineer sent a copy of the plan, which Track Maintenance Engineer F then discussed with Assistant Track Section Manager C. Neither had previously been aware of the existence of the action plan. Assistant Track Section Manager C confirmed to Track Maintenance Engineer F that none of the medium term actions within it had been undertaken.

122 Although Assistant Track Section Manager C felt that 2390B points lay outside of the boundary of his area of responsibility, he decided to progress these actions himself. In the absence of available new switches, the replacement of the timber bearers was the only part of the plan which could be addressed. He discussed this with Track Section Manager B, who agreed that the work could be done if sufficient volunteers could be found to work the overtime needed, given that access restrictions would mean the work would have to be undertaken on a Friday, Saturday or Sunday night.

123 It was originally planned that the bearer replacement would be completed within possessions granted for other track work during the weekend of 31 May/1 June 2008. Staff shortages during this weekend meant that Assistant Track Section Manager C re-planned the work for the night of Friday 6/7 June 2008, once again using staff working overtime. The team assembled to undertake the task were drawn from separate production teams and was led by Leading Trackman H. Trackman J was designated as the *Controller of Site Safety* (COSS) and as such was the member of the team responsible for establishing a safe system of work. At that point Trackman J had only recently qualified as a COSS and had worked on the railway for less than a year.

124 Although plans were required to be made for work packages scheduled in advance, 'overtime' work at Colchester Maintenance Delivery Unit was not normally included in this planning. Work plans normally contain the objectives of the work, the organisation of the task, details of the safe systems of work, the labour, material and equipment needed and any preparatory and follow up work required. They also require that any records or reports resulting from the work be reviewed by the Track Section Manager. Network Rail company standard NR/L3/TRK/002 Issue 4 'Track Maintenance Handbook' had no requirement for 'preventative maintenance' tasks (under which bearer replacements are categorised) to be subject to work planning.

125 Witness evidence available to the RAIB indicates that Assistant Track Section Manager C had originally intended to brief Leading Trackman H on the work required during a site visit during the day of 5 June 2008. However as Leading Trackman H was working a night shift on this date, the work briefing was instead given to Trackman J. Assistant Track Section Manager C felt that this was acceptable as the six timbers to be replaced had already been clearly marked and the new timbers were ready at the lineside. He also thought that Leading Trackman H had been involved in the replacement of the broken rail at this location earlier in the year and so would be familiar with both the location and the work required.

126 Once on site on the night of 6/7 June 2008, Trackman J was asked by Leading Trackman H to show him what work needed to be done. Contrary to Assistant Track Section Manager C's belief, Leading Trackman H had not been involved in the replacement of the broken rail in February and was not particularly familiar with the junction, because it was red zone prohibited (see paragraph 139). Leading Trackman H was, however, satisfied with the briefing from Trackman J and felt that everyone in the seven person team, whom he described as experienced staff, knew what was required. Leading Trackman H was clear that he was responsible for leading the team in completing the bearer replacement.

127 Trackman J then gave his safety briefing as the COSS. The site of the work was protected on the down line by a *T3 possession* and by *T2H protection* on the up line. This meant that the work was being undertaken within *green zone protection* and without traffic passing on either line.

128 Document NR/L3/TRK/002/G06 Issue 2.0 is Network Rail's work instruction for changing timber bearers. Leading Trackman H stated that, although copies of work instructions were kept in the hut used by his production team, he would consult them only if there was something about which he was unsure. In the case of bearer replacements, his training had been undertaken on the job by working with more experienced staff over a period of years and so he understood the task sufficiently without needing to refer to the instruction. The method chosen to replace these bearers was to slide the old bearers out one at a time and to replace each one before moving onto the next. Each time a replacement bearer was fitted the gauge was measured and the rails and chairs were fitted and secured. Once all six timbers were replaced, the ballast was back-filled manually using shovels. Leading Trackman H stated that the track was then checked and found to have an acceptable gauge, cross-level, vertical profile and alignment.

129 After the team left site, a form entitled '*Work Arising Identification Form: Daily record of re-directed work*' detailing the work undertaken was completed by Leading Trackman H. No record was made of the results of the checks undertaken immediately after the work was completed. Although the form was completed by Leading Trackman H, it was signed in the 'Team Leader Signature' box by Trackman J and dated 9 June 2008.

130 Leading Trackman H stated that he had only completed the form to the extent that he had because Trackman J had not completed one before and was unsure as to how to do it. In his opinion, as Trackman J had been given the briefing, then he needed to sign the form in the 'Team Leader Signature' box. Leading Trackman H accepted that he had been the team leader for the task but stated that it was not unusual for a trackman to sign off work in this way. This contradicts the requirements of Network Rail's Track Maintenance Handbook; for preventative maintenance this states that '*…The work order record…is signed by the team leader responsible for the work site. In doing so they confirm that the work performed is compliant with…standards…and meets…the Work Instruction…'*

131 At the end of the work, the team left site without having watched traffic pass over the replacement bearers; trains were not running on the line at that time because of the protection that was in place. Leading Trackman H stated that, because the work was undertaken at night, this would have in any case prevented him from seeing any voiding under a passing train.

132 Work Instruction NR/L3/TRK/002/G06 does not require the site of a bearer replacement to be revisited for inspection after a period of time has elapsed. Track Maintenance Engineer A had, in his investigation report after the broken rail, recommended such investigations be carried out, but there is no evidence of this being made a formal requirement. However, witness evidence from track engineering staff was that an inspection to check on the effects of any ballast consolidation caused by the passage of trains would normally be undertaken within a period of several days. Leading Trackman H was aware of this and, because his shift pattern of working nights prevented him from carrying out the check himself, left a message on the answer-phone at Track Section Manager Colchester's office, requesting that someone carry out the inspection.

133 Assistant Track Section Manager C was aware that a post-consolidation inspection was required and had intended to carry this out on Monday 9 June 2008, a few days after the work had been completed. However, when he arrived for work on that day, he found that he had a substantial quantity of point inspection documents which required review and sign-off. Assistant Track Section Manager C stated that a recent re-design of these forms had made them much less easy to read and therefore had extended substantially the time required to review them. This meant that he had insufficient time left on that day to conduct the inspection of 2390B points. As Assistant Track Section Manager C had a scheduled inspection to undertake at another location on the Tuesday, he decided that he would do the post-consolidation inspection of the bearers during the supervisor's visual track inspection of the line between Kelvedon and Marks Tey, which he was already scheduled to undertake on Wednesday 11 June 2008.

134 Assistant Track Section Manager C was, however, asked by Track Maintenance Engineer F to undertake other duties on 11 June. This meant that the supervisor's visual track inspection scheduled for that day was instead undertaken by Assistant Track Section Manager D. Assistant Track Section Manager C did not specifically request that Assistant Track Section Manager D undertake a 'post-consolidation' inspection of 2390B points, as he felt that the presence of the new bearers would be obvious. Assistant Track Section Manager D undertook this supervisor's visual track inspection as scheduled (see paragraph 148); Assistant Track Section Manager C did not carry out any 'post-consolidation' inspection of 2390B points, prior to the derailment.

Inspection of the line

135 Marks Tey junction is *continuous welded rail* track. As the line was classified as track category 1A, NR/SP/TRK/001 Issue 2 required the following minimum inspection frequencies:

- a basic visual track inspection every week by patrollers;
- supervisor's visual track inspection on-foot every two months;
- track maintenance engineer's on-foot visual track inspection every two years;
- supervisor and track maintenance engineer's visual track inspections via cab riding every month and two months respectively;
- track geometry recording runs every three months; and
- the switches at Marks Tey junction were subject to a detailed inspection at least every 13 weeks, and normally every 6 weeks, in accordance with the requirements of Network Rail company standard NR/L2/TRK/053 Issue 4 'Inspection and repair to reduce the risk of derailment at switches'.

Inspection reports relevant to the accident are detailed in the following paragraphs.

Basic visual track inspection

136 As stated by NR/SP/TRK/001 Issue 2, patrollers carried out basic visual inspections, or patrols, to '*identify defects which, if uncorrected, could affect the safety or reliable operation of the railway before the next inspection*'.

137 Patrol routes are laid down within formal diagrams; because of concerns raised during the audit of February 2008 (paragraph 108) about the validity of the diagrams in place at Ipswich depot, Track Maintenance Engineer F had requested that the track section managers in both depots review the diagrams for which they were responsible, if necessary by walking the routes with the patrollers. Following the review, the track patrol diagrams were certified as accurate by the track section managers and re-issued in late March 2008.

138 Marks Tey junction was covered by Patrol 5, which was split into diagrams 5A and 5B. 5A started at the mid-point of Marks Tey station at 46 miles 50 chains and ran to Colchester station, with the patroller walking on the up main towards traffic whilst looking over to the down main. 5B was exactly the reverse; 5A and 5B would be conducted alternately over each fortnight, meaning that Patrol 5 was undertaken weekly, normally on a Friday. Members of the patrol team rotated through the diagrams and normally did each patrol every 8 weeks.

139 The diagrams for Patrol 5 identified that the line between 46 miles 44 chains and 46 miles 60 chains on both the up and down main lines were red zone prohibited. This meant that, for their own safety, patrollers following the diagrams were not permitted to walk on either line through Marks Tey station or Marks Tey junction under the red zone protection which they used for the remainder of the patrol[12] (figure 17).

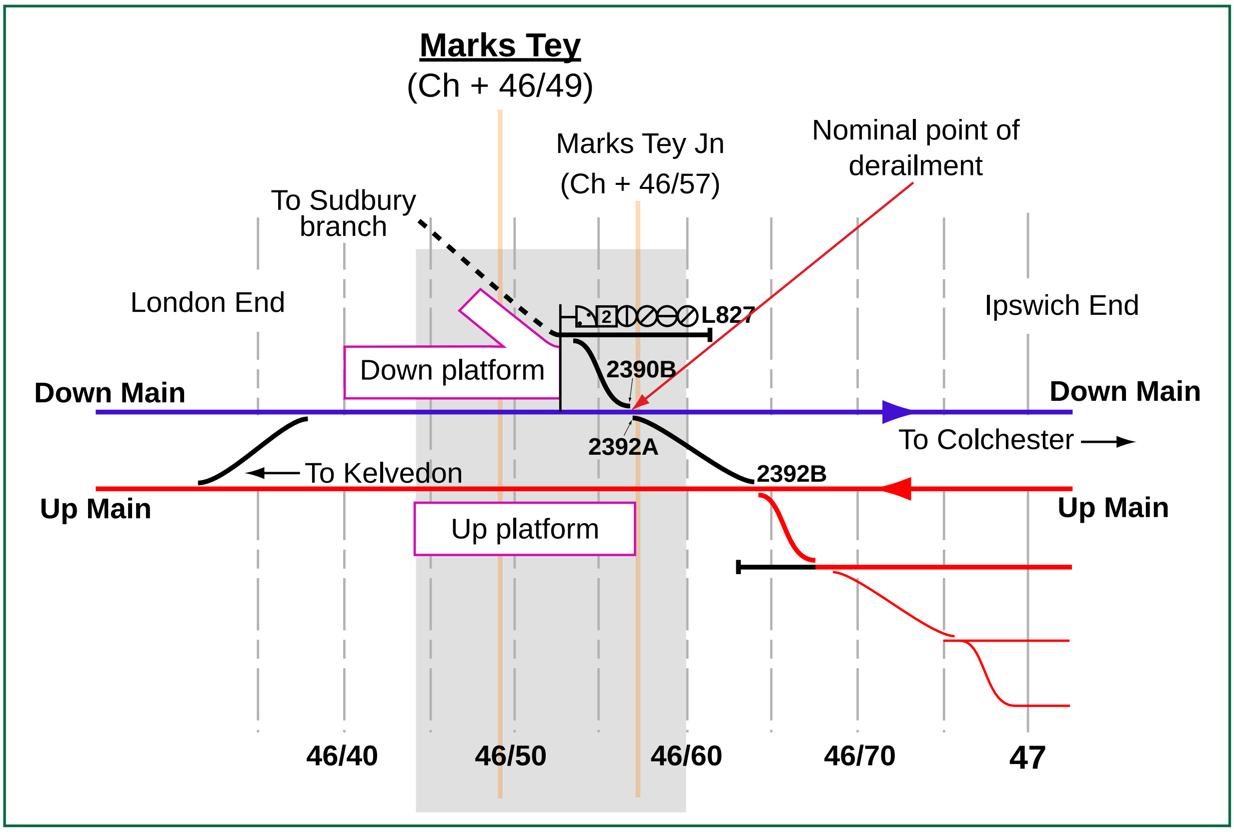

Figure 17: Extent of red zone prohibited area at Marks Tey

[12] With the exception of Colchester station, which was also red zone prohibited.

140 The diagrams instructed that for these red zone prohibited areas, the line should be inspected from the platform. Marks Tey junction was within this prohibited area but not adjacent to a platform and so would instead be inspected from the adjacent cess. Standard NR/SP/TRK/001 Issue 2 allowed only the line adjacent to a platform to be inspected in this way, meaning that patrollers would have to walk through both platforms to the station mid-point in order to complete the patrol. The route which the patrollers were to take over the platforms was not laid down in the patrol diagrams. Interviews with patrolling staff revealed that they took a variety of routes to cover the platforms, depending on whether 5A or 5B was being walked and which side of the station the patroller had started at. There was also evidence from the basic visual inspection reports reviewed by the RAIB that Patrol 5 was often unofficially split into shorter diagrams by the patrollers, probably because of its length.

141 Witness evidence also showed that the patrollers undertaking Patrol 5 were not always patrolling through the platform. This was because some of them believed that the patroller undertaking Patrol 4, which covered the line from the mid-point of Marks Tey station to Kelvedon, would check the Patrol 5 part of the platform, using the pre-arranged period of T12 protection for Patrol 4, which would allow them to walk safely on the track through the full length of the platform. Although Patrol 4's diagrams actually ended at the mid-point of the platform, witness evidence was that patrollers would occasionally use this protection to walk through the track to the platform end, (paragraph 145) which lay within Patrol 5, and also possibly across the junction (although this latter area was outside the limits of the T12, which ended at signal L827). Patrol 4 normally took place on a Thursday.

142 Cyclic dips in the vertical alignment of track are much more visible when viewed at track level than from a platform, as the eye can more easily see them when looking along the line of the rails[13].

143 Witness evidence from track engineering staff was inconclusive as to whether they felt that the points at Marks Tey junction could be effectively visually inspected from the cess.

144 Relevant information from the Patrol 5 reports for the two months preceding the accident is:

- On 23 May 2008, the patroller undertaking diagram 5A reported that there were dipped joints on the down main line at the insulated rail joint at 46 miles 55 chains (2390B points) and 46 miles 60 chains (2392A points). Both were marked as 'Urgent' on the form. The patroller requested that these joints be packed; this report was signed off by Assistant Track Section Manager E and the work entered into the ELLIPSE system with priority for completion within one month (see paragraph 138);
- On 30 May 2008, the patroller undertaking diagram 5B reported that there were dipped and voiding insulated rail joints at 46 miles 60 chains. Measured shovel packing was requested; this report was signed off by Track Section Manager B and the work entered into the ELLIPSE system and prioritised for completion as soon as possible and within no later than one month; and

[13] The Permanent Way Institution, *British Railway Track, Volume 4, Plain Line Maintenance*, 2001. Paragraph 8.10.2 describes how vertical alignment can be 'eyed in' as a qualitative method of identifying and removing rail dips.

- On 6 June 2008, which was the last patrol prior to the derailment, the patroller undertaking diagram 5A made no reports regarding 2390B or 2392A points. This report was signed off by Assistant Track Section Manager E. The inspection took place before the bearer replacement activity on the night of 6/7 June.

Each of these patrols was undertaken by a different patroller. All involved allocated priorities according to their personal judgement.

145 Relevant information from the Patrol 4 reports for the two months preceding the accident is:

- On 12 May 2008, the patroller undertaking diagram 4B recorded having patrolled through the station from 46 miles 60 chains; he made no report of any findings; and
- The patrol due for 11 June 2008 was not undertaken; a supervisor's visual track inspection was substituted for this patrol, as is permitted by NR/SP/TRK/001 issue 2.

Supervisor's visual track inspection

146 Standard NR/SP/TRK/001 Issue 2 stated that supervisor's visual track inspections determined the actions necessary to respond to the patroller's reports. Persons undertaking these inspections were required to check track twist and gauge, take other appropriate measurements and to assess switches for more detailed inspections. They also would normally have taken with them a 'walk-out' report printed out from ELLIPSE; this was a list of all scheduled work listed for a particular length of line. This was done because the inspection was intended to check that the work was listed correctly and scheduled appropriately. Taking out this list was not a formal requirement at the time of the derailment, but Network Rail has subsequently mandated the practice.

147 The supervisor's visual inspection route which covered Marks Tey station and junction covered the line between Kelvedon and Marks Tey, up to 46 miles 60 chains. This meant that unlike the basic visual inspections, for which the diagrams split at the mid-point of the station platform, the supervisor's inspection covered the whole of the platform and the junction.

148 Relevant information from the supervisor's visual track inspection reports for the four months preceding the accident is:

- On 22 February 2008, Track Section Manager B undertook a supervisor's inspection between Kelvedon and Marks Tey. No relevant comment was made in the inspection report itself regarding the track at Marks Tey junction. The inspection report was signed off by Assistant Track Maintenance Engineer G. However, in the attached walk-out report there were multiple work tasks listed relating to the packing of the insulated rail joints and timbers on 2390B and 2392A points, scheduled for March and April 2008. There were also tasks requiring the replacement of timber bearers on 2390B points scheduled for May 2008.
- On 16 April 2008, Assistant Track Section Manager C undertook a supervisor's inspection between Kelvedon and Marks Tey. The inspection report stated that packing was required within 3 months at the insulated rail joints on the main line leg of 2392A points. The vertical and horizontal alignment of the line at 46 miles 60 chains was graded as 'good'. The inspection report was signed off by Assistant Track Maintenance Engineer G. No walk-out report was attached.

- On 11 June 2008 Assistant Track Section Manager D undertook a supervisor's inspection between Kelvedon and Marks Tey. The inspection report, which was signed off by Track Section Manager B, made no comment on the state of the line at Marks Tey. However in the attached walk-out report, the work tasks relating to the packing of the insulated rail joints and timbers on 2390B and 2392A points and the replacement of timber bearers on 2390B points were still present. The three month timescale laid down in the previous report was now almost over, and the work proposed had largely not been done. Accordingly, the majority of the packing work had been rescheduled to March 2009, although the renewal of the 9 ft timber bearers was rescheduled for October 2008 and that of the longer timber bearers for 2012. These scheduled dates were ticked off as being appropriate; however, in the case of the long timber renewal and the packing of the bearer a note had been added that these were completed on 6 June and 13 June respectively. The 13 June date indicates that these notes were added post-derailment; this is supported by the evidence of Assistant Track Section Manager D who stated that the notes were not made by him during or after the inspection. Assistant Track Section Manager D stated that he ticked off items on his reports if they still needed to be done.
- On 11 June 2008, Track Section Manager B undertook a supervisor's inspection between Marks Tey and Colchester starting from 46 miles 60 chains. Although this inspection was not intended to cover 2390B or 2392A points, they were visible from the start of the inspection route and examined at a distance by Track Section Manager B.

149 Regarding his inspection of the line through Marks Tey on 11 June, Assistant Track Section Manager D stated that, having walked the line from Kelvedon, he reached the up platform at Marks Tey station from the up main line, walked through the station and the road bridge at the Ipswich end, crossed over the lines outside the red zone prohibited limit and then walked back up the engineer's siding to the down platform (figure 3). From here and the cess adjacent to the down main, he visually inspected the points on the down main at Marks Tey junction. He was unable to get onto the track to apply his *track gauge*, as was required by NR/SP/TRK/001 Issue 2, but stated that he could see from his position in the cess that there were new bearers in place under 2390B points, that the packing around them looked '…*quite good…*' and that nothing else looked out of place. He was unaware before his inspection that these bearers had been replaced on 6 June. He considered that, given his experience in inspecting points, he would have spotted and addressed any problems that he could see although, as he did not observe the points under traffic (which he generally did not do unless he had a particular concern about a location), he was unable to check the points for voiding.

150 Assistant Track Section Manager D stated that his position observing 2390B from the cess may have led him to miss something. He was unaware of the T12 protection periods which had been arranged for Patrol 4 (paragraph 141) but commented that access to Marks Tey was generally very difficult to arrange and that, even when T2 protection was obtained, it was of insufficient duration to inspect the points properly or to undertake any work. Regardless of any effect on his observation of the points that his position in the cess may have had, this position certainly would have prevented him from carrying out some of the requirements of a supervisor's visual inspection that were required by NR/SP/TRK/001 Issue 2, such as measuring track twist and assessing the need to initiate detailed points inspections.

151 In relation to the inspections of 11 June, Track Section Manager B stated that he looked back from the start of his own inspection route at 46 miles 60 chains, and was satisfied with what he could see of the new bearer work. He could see that a few clips were missing but generally thought that the timber work looked '*pretty good … there was no twist or top fault*'. At this point he would have been some 3 chains (60 metres) from the site where the timbers were changed, and at a minimum the missing clips would have been clearly visible.

152 These on-foot inspections were supplemented by inspections undertaken from the cabs of trains. On 12 February 2008 a cab ride report submitted by Assistant Track Section Manager C noted that lifting and packing of the insulated rail joint at the heel of 2390B points was required within one month. This report was signed off by Track Section Manager B.

Track maintenance engineer's visual track inspection

153 Standard NR/SP/TRK/001 Issue 2 stated that the purpose of the track maintenance engineer's visual track inspections was to check the performance of those undertaking other visual inspections and to identify items which had a longer term potential to affect the safety of the railway.

154 In April 2006, Track Maintenance Engineer A undertook a visual track inspection through Marks Tey. He observed a '*poor line through S&C*' and graded the vertical and horizontal alignment as poor. He also commented '*requires design of S&C tamp*', indicating that a technical design of the layout's alignment would be necessary. In May 2007, Assistant Track Maintenance Engineer G undertook a visual track inspection through Marks Tey junction. No report was made as to any defect or observation.

155 On 11 February 2008, a cab ride inspection through Marks Tey was undertaken by Track Maintenance Engineer A. He reported that an S&C *tamper* was required, as was a proposal to renew the ballast through Marks Tey station. Track Section Manager B responded to this comment by noting that an 'S&C *tamper is planned*' (paragraphs 184 to 187).

156 On 23 April 2008, a cab ride inspection through Marks Tey was undertaken by Track Maintenance Engineer F. He reported a poor ride through Marks Tey station S&C. Track Section Manager B responded to this comment by noting '*S&C Marks Tey needs tamping*'.

Detailed points inspection

157 In addition to the inspections described previously, points are also subject to further more detailed inspections. Standard NR/L2/TRK/053 Issue 4 required that points have their switches inspected for conditions which would increase the risk of a facing point derailment at least every 13 weeks. Network Rail company standard NR/SP/TRK/054 Issue 2 'Inspection of cast crossings and cast vees in the track' requires that points also have their crossings inspected at least every six months.

158 The points at Marks Tey junction had their switches inspected every six weeks. These inspections were undertaken by a specialist team of track engineering and signalling staff known as the Joint Points Team (JPT). This six week interval was set because of the access problems at Marks Tey junction caused by its red zone prohibited status; it was envisaged that a six weekly interval would allow an inspection to be missed without infringing the 13 week maximum interval that was required by NR/L2/TRK/053 Issue 4. The inspections were usually undertaken under *T2D protection*, which gave the JPT around two hours to cover the four sets of points within the red zone prohibited area; this protection meant that traffic did not pass over the points in their presence. Because of the disruption caused to rail traffic, periods of T2D protection were only available at night, meaning that the point inspections were always carried out in the dark.

159 On 10 June 2008, two days before the derailment, the switches of both 2390B and 2392A were inspected by a member of the JPT, with a track engineering background. On 2390B points, they found that there was *lipping* on the cess stock rail and that both insulated rail joints at the heel of the switch were dipped, with the six-foot joint dip of 14 mm being the worst. They also found that the timbers under the toe of the switch (not those fitted on 6 June, which were nearer to the heel) needed to be packed by about 5 mm in order to reduce *hogging*. The sidewear measurements recorded required no action to be taken. Minor maintenance tasks (greasing the points and tightening bolts) were performed on these points and a Work Arising Identification Form (WAIF) was submitted, prioritising action to address the dipped joints within a month and the hogging timbers within three months. The degree of hogging present did not seem serious to the JPT member. They normally assigned a maintenance priority which reflected both the likely deterioration of the track and the time which it would take to organise a repair. The JPT member did not see that new timbers had been fitted elsewhere on the points; as they were undertaking an inspection of the switches, their focus would have been at opposite end of the points. It was also dark during the inspection, and they probably did not get within three to four metres of the new timbers. They did not observe that there were clips missing from the switch area of the points, although they were sure that this would have been noticeable, even in the dark. The inspection form and WAIF for this inspection were not submitted and signed off until after the derailment.

160 As the JPT were working under protection and in the dark, they were unable to observe traffic pass over either set of points. Because of this they would sometimes look for voiding by tapping the bearers with a metal spanner and assessing the resulting vibrations, a long-standing practice. On inspecting 2392A points, the JPT member noted from striking the timbers that the front three timbers of these points (i.e. those closest to 2390B points) were voiding. They were prioritised for action within four months.

161 None of the observations made on either set of points were repeats of those made in switch inspection forms in a three month period prior to the derailment.

Track geometry recording

162 As was required by NR/SP/TRK/001 Issue 2, track geometry recording runs on the down line were taking place approximately every three months. These recording runs aim to allow Network Rail to monitor the overall quality of the track and to find discrete track geometry faults. The runs are undertaken by specialist trains and the data which they collect is sent to track engineering staff in the form of a visual trace and an immediate action report, which lists the faults and the required period within which corrective action must be taken.

163 The last track geometry recording run through Marks Tey before the derailment was on 27 May 2008. Previous runs took place on 29 January and 29 April. Traces and immediate action reports for lines under the responsibility of the Track Maintenance Engineer Colchester were normally scrutinised by his technical team, lead by Assistant Track Maintenance Engineer G, before being passed onto the Track Section Managers.

164 The track recording run of 29 January 2008 detected a 3 metre twist fault of 1 in 179 at 46 miles 55 chains, which required correction within 14 days. This had been signed off as rectified on the immediate action report. It also detected a cyclic top fault between 46 miles 55 chains and 46 miles 58 chains, which was graded as 'Category C' and required correction within 60 days. This was not signed off on the immediate action report. The immediate action report as a whole had been signed off by Assistant Track Maintenance Engineer G.

165 The track recording run of 29 April 2008 showed no relevant faults.

166 The track recording run of 27 May 2008 detected a cyclic top fault between 46 miles 58 chains and 46 miles 59 chains, which was again graded as 'Category C' and required correction within 60 days. As with the 29 January run, this fault was not signed off on the immediate action report. The immediate action report as a whole was signed off by Assistant Track Maintenance Engineer G.

167 The track recording run's data was processed in order to allow comparison with the post-accident survey of the track (paragraph 71). The results showed the presence of cyclic top near the point of derailment similar to that found by the track recording train on 27 May 2008. It also highlighted a series of dips in the vertical alignment of the track on the approach to the nominal point of derailment, one of which corresponded to the position of the dipped insulated rail joints at the heel of 2390B points. Comparison with the post-accident survey showed that this dip had become significantly worse between 27 May and the condition it was found in after the derailment (paragraph 218).

168 Track recording runs also measure the ride quality of the track with respect to its vertical profile and alignment; this is expressed as a standard deviation value for every eighth of a mile. NR/SP/TRK/001 Issue 2 specified bands of standard deviation values against which measured track quality could be compared; this included maximum standard deviation values. No standard deviation values were produced for track twist or cant.

169 In respect of both vertical and lateral ride quality, Marks Tey junction had been graded as 'Very Poor' in all respects since November 2006. In August 2006 it had been graded as 'Very Poor' in all respects, except for 35 m vertical alignment for which it was graded 'Super Red' (i.e. it had exceeded the maximum value allowed). NR/SP/TRK/001 Issue 2 required that track graded as 'Very Poor' was to be inspected by a supervisor or track maintenance engineer within one month in order to decide on remedial action, with further inspections being undertaken at monthly intervals until actions were completed or a written action plan to improve track quality was approved by the track maintenance engineer. The standard also required that a track quality action plan be created if there were repeated 'Very Poor' or 'Super Red' values occurring at a location; once this was approved further inspections were not required unless the values worsened.

170 There is no evidence of these monthly inspections, or of a written track quality action plan existing for Marks Tey junction prior to 12 February 2008, when Assistant Track Maintenance Engineer C completed a report form for the site. This stated that the root cause was '*…Poor S&C, needs changing to welded in type…*'. Remedial action/control measures required were listed as measured shovel packing for 11 yards from 46 miles 54 chains, packing two insulated rail joints at the heel of 2390B points and measured shovel packing for 11 yards from 46 miles 55 chains, all of which were ticked off. A further entry, to change four timbers under a joint at 46 miles 55 chains, was crossed through and an additional comment added in different writing stating '*nothing done to line fault as needs tamper'*. It has not been possible to identify who wrote this comment. Permanent action to eradicate the problem was detailed as changing four timbers under a joint at 46 miles 55 chains and welding in new switches and crossings. This track quality action plan, which was a separate entity to the broken rail action plan created after the February 2008 rail break (paragraph 119), was approved on 20 February 2008 by Track Maintenance Engineer A.

171 Colchester Maintenance Delivery Unit used reports received directly from the track recording train to produced tabular reports to monitor track geometry faults. The first of these, a tabular report entitled 'Level 2 Repeats – Main Line HSTRC August 2007', shows that, by the time of a track geometry recording run undertaken on 31 July 2007 there were four cyclic top faults which were repeat (i.e. recurring) faults through Marks Tey junction (see table 1).

Mileage	Location	Fault Size	Fault Type	Action Required	Repeats
46m 58ch - 46m 59ch	Marks Tey J/c	19.38	Cyclic – Top through 2390B and 2392A	Tamp	9
46m 58ch - 46m 60ch	Marks Tey J/c	24.38	Cyclic – Top through 2390B and 2392A	Tamp	25
46m 58ch - 46m 59ch	Marks Tey J/c	43.76	Cyclic – Top through 2390B and 2392A	Tamp	9
46m 58ch - 46m 61ch	Marks Tey J/c	19.4	Cyclic – Top through 2390B and 2392A	Tamp	22

Table 1: Extract from August 2007 report showing cyclic top faults at Marks Tey junction

172 This tabular report was not signed off and provided no record of whether the action required had been taken. Based on the required three monthly frequency of track recording vehicle runs, 25 repeats of a fault at Marks Tey junction would imply that it had existed for at least six years. By a similar reasoning, 9 repeats would imply that a fault had been in existence for over 2 years.

173 A second untitled tabular report which detailed faults recorded on 30 April 2008 listed a single instance of a Category C cyclic top fault at 46 miles 55 chains. This fault did not feature on the immediate action report for the run of 29 April; however it had been initialled as having been inspected by Track Section Manager B, who had noted the comments '*Joints*' and '*S&C*' and entered a completion date of 9 May 2008.

174 Dipped rail joints are measured in order to predict rail and fishplate breakages; although the measurement of vertical alignment by track recording trains may detect changes in the alignment of joints, the measurement of the dip angle is intended to give a greater understanding of the nature of the joint distortion and the likelihood of breakage.

175 The dip angle is measured in *millirads*. Network Rail's Letter of Instruction NR/BS/LI/033 Issue 4, 'Broken rail management: Use of dip angle outputs from track geometry recording', stated that a dip angle of 40 millirads is approximately equal to a static 10 mm dip measured over 1 m and 50 millirads is approximately equal to 12 mm dip measured over 1 m. These values did not take into account any voiding which may occur under the rail joints.

176 A third tabular report was dated 5 June 2008 and entitled '*Current Dip Angle Exceedences*'. It listed a dip in the right rail of the down main of 33.10 millirads at 46 miles 55 chains. This dip was recorded on 29 January 2008; the 'Action' column for this dip stated '*Inspect 14 days Repair 13 wks*', with a 13 week repair date of 29 April 2008. A dip of 33.00 millirads was also recorded at the right rail of the down main at 46 miles 60 chains; this had an identical recording date and actions proposed as for the previous dip.

177 A further tabular report, dated 4 June 2008 and entitled '*Current Repeat Exceedences – excluding dip angles*' listed a single instance of a Category C cyclic top fault at 46 miles 58 chains. This was the fault detailed in the immediate action report for the run of 25 May 2008. The fault has been initialled as having been inspected by Track Section Manager B, who had noted the comment '*S&C*'; he had also written a longer note on the bottom of the form which stated '*46.58 and 46.60 Poor top through S&C, spot timbering needed + weld in new switches + xing + need S&C machine to sort out line*'.

Drainage inspections

178 NR/SP/TRK/001 Issue 2 required that track drainage systems be inspected at sufficient frequencies '*… to enable any corrective measures to be instituted before the drains become ineffective…no less often than annually…checks shall be made that water is flowing freely…and that catchpits are not damaged… inspections may be carried out during the Supervisor visual track inspection'.*

179 The drainage at Marks Tey was the responsibility of the Service Delivery Manager Colchester, who reported to the Area Services Manager Anglia. As well as drainage, the Service Delivery Manager Colchester had responsibility for all off-track work within his area of responsibility; this included level crossings, fencing and vegetation management. The Service Delivery Manager Colchester had two general purpose teams of off-track staff, one each at Ipswich and Colchester. These teams could handle minor drainage works and would call on outside sub-contractors for assistance. Network Rail's view was that there was not sufficient expertise in these teams to undertake major drainage work, and there was no specific team or staff dedicated to drainage, although these had existed previously in other places, before Network Rail took maintenance 'in-house'. There was also no asset register of drains and so the location, linking and fall of drainage systems was undocumented.

180 Standard NR/SP/TRK/001 Issue 2, Section 20, required that drains were inspected on a frequency no less than annually, but gave no instruction as to how this was to be carried out, other than stating that '*these inspections may be carried out during the Supervisor visual track inspection'.* Witness evidence indicates that off-track staff relied upon track engineering staff to report any issues with drainage and did not themselves undertake regular inspections. They would expect any problems to be raised via a WAIF, which would then be entered into ELLIPSE and thereby enter the off-track team's work-bank. Once a defect had been corrected, the off-track team would close the defect in ELLIPSE, normally without referring back to track engineering. However, off-track staff stated that they rarely received reports of drainage defects from track engineering staff and their perception was that symptoms of possible poor drainage, such as wet beds, were often repeatedly corrected without any investigation of the underlying causes. There was also an ongoing issue regarding the routing of cable troughing over the top of catch pits which made their inspection and maintenance much more difficult.

181 Staff conducting supervisor's visual inspections of the track at Marks Tey stated that they checked the catch pits as part of these inspections; no discrete drainage inspection task was entered into the ELLIPSE workbank. They had noted that the catch pits did not seem to be flowing and that there was a recurring problem with wet beds on the up main line. Assistant Track Section Manager C stated that he had raised a WAIF requiring investigation of the drainage, although this had not been actioned prior to the derailment. The RAIB was unable to obtain a copy of this WAIF.

182 During interviews, the majority of track engineering staff based at Colchester Maintenance Delivery Unit stated that they did not find symptoms of drainage problems at Marks Tey junction itself, with any such problems generally being confined to the platform on the up line or the London end of the station.

Maintenance of the line

Renewal proposal by TME Colchester in February 2008

183 On 26 February 2008 Track Maintenance Engineer A, who was at that time Track Maintenance Engineer Colchester, raised two reports known as problem statements. A problem statement is a document which '*…highlights that a renewal may be the most cost-effective form of maintaining track asset integrity*'[14] and so is the first stage in arranging for a section of track to be renewed. Both the problem statements raised covered an identical section of the down main line through Marks Tey station between 46 miles 39 chains and 46 miles 53 chains. Neither statement covered Marks Tey junction. Track Maintenance Engineer A left the post of Track Maintenance Engineer Colchester shortly after this date. A problem statement should have been, at that time, submitted electronically to the Area Track Engineer, but neither statement was submitted, or made the subject of any other further action.

Tamping

184 Tamping records provided by Network Rail showed that the line around Marks Tey had been tamped on two occasions in the year prior to the derailment. On 16 June 2007 it had been planned that the down main line from 46 miles 40 chains to 46 miles 70 chains, including 2390B points, was to be tamped. However, the records show that only the portion of the line from 46 miles 41 chains to 46 miles 53 chains was actually tamped, apparently because the tamping machine had to leave the work site to refuel. Track recording data indicates that the vertical alignment of the track on the approach to the junction was improved as a result of this tamping.

185 On 1 March 2008 a further tamping run was undertaken. This was planned to cover the whole of the down main through Marks Tey station; however only the portion up to 46 miles 43 chains was actually tamped, because the tamper was unable to go past the worksite marker boards which had been placed on the approach to signal L827, situated at the end of the platform. Track recording data indicates the lateral alignment on the portion of the line which was tamped was improved as a result of this tamping.

186 The track engineering staff responsible for Marks Tey stated that they had wished to conduct more frequent tamping of the line through the station, including the junction, but a shortage of technical staff who were competent to produce designs and to supervise track quality work in the Assistant Track Maintenance Engineer's team, and the need to block both lines to tamp the junction (which could only be done at weekends, when renewal work elsewhere absorbed most of the available tamping resources), meant that tamping had been difficult to arrange successfully over a prolonged period.

187 Track Section Manager B stated that the joints on the heel of 2390B points were '*…always a problem...*' and that, in the absence of tamping, they were frequently packed manually under T2 protection.

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[14] Network Rail Standard NR/SP/TRK/6001 Issue 1 *Management of Problem Statements*.

The driving of the train

188 The OTDR evidence shows that the train was being driven at 77 mph (124 km/h). This was 2 mph (3.2 km/h) faster than the maximum permitted speed for this train. Railway Group Standard GM/RT2004, Issue 2 of October 1999, Requirements for Rail Vehicle Maintenance, specifies that train speed indicators can have a tolerance of +/- 2 mph (4 km/h) in their accuracy, so there is no evidence that the driver was knowingly breaking the speed limit. There is no evidence that being driven at a speed that was marginally over the maximum permitted speed of the train made any contribution to the derailment, or affected the consequences of it.

189 The actions which the driver took to protect the line after the derailment complied with the requirements of the Rule Book (Railway Group Standard GE/RT 8000).

Previous occurrences of a similar character

Derailment at Grayrigg 23 February 2007

190 On 23 February 2007, an express passenger train derailed at facing points, located near Grayrigg in Cumbria[15]. One passenger was fatally injured as a result of the derailment; 28 passengers, the train driver and one other crew member received serious injuries and 58 passengers received minor injuries.

191 The RAIB investigation into this derailment found that difficulties in obtaining access to these points in order to undertake inspection was a contributory factor to this accident. The RAIB made 22 safety recommendations in total to Network Rail, 10 of which relate to the issues of track inspection and the repair of track geometry faults which are relevant to Marks Tey. These were:

- Recommendation 2: Network Rail should implement processes to:

  a) capture, and record on a single national database, data about component failures, and interventions made during maintenance and inspection activities, for each set of S&C;

  b) use the data from a) above to monitor failure and intervention rates locally and nationally in the behaviour of S&C components;

  c) identify precursor faults that might lead to more serious failures; and

  d) identify those precursor faults where the failure and intervention rates indicate a need to reduce the risk of catastrophic failure.

  At the time of publication of this report, Network Rail has accepted this recommendation and has stated that it has carried out work to complete it. The ORR does not believe that sufficient work has been done for this recommendation to be closed.

- Recommendation 4: Network Rail should introduce processes that require the adoption of a structured risk based approach when reviewing and enhancing its standards for the inspection and maintenance of all existing types of S&C.

  At the time of publication of this report, Network Rail has accepted this recommendation and has stated that it has carried out work to complete it. The ORR does not believe that sufficient work has been done for this recommendation to be closed.

[15] RAIB report reference 20/2008, published October 2008.

- Recommendation 5: Network Rail should include in maintenance standards and instructions:
  - o the circumstances under which an investigation of a defect, fault or failure to S&C systems as a whole or its sub-components is required; and
  - o definition of the scope of the investigation and other immediate actions to be taken (e.g. temporary speed restrictions, special monitoring) for each situation.

At the time of publication of this report, Network Rail has accepted this recommendation and has stated that it is progressing work in order to meet it. The ORR is reviewing this work.

- Recommendation 10: Network Rail should review and amend its processes for basic visual track inspection so that the issues identified in this report are addressed. To achieve this Network Rail should consider issuing modified instructions to define:
  - a) the contents of task instructions issued to staff undertaking basic visual inspections;
  - b) the nature of defects that can occur and how to detect those that are difficult to readily observe;
  - c) job cards to advise the start and finish locations and the direction of the inspection for every occasion;
  - d) the information supplied to a patroller before an inspection in terms of clearly-presented intelligence on previously-reported defects;
  - e) the scope of information that is to be recorded during an inspection (including definition of the need to record or comment on previously reported defects);
  - f) the requirement to make positive statements about areas of the inspection where no defects have been found;
  - g) the checks for completeness that should be made within the track section manager's office, including verification that every inspection has been carried out;
  - h) the analysis and supervision that should be undertaken to confirm that inspections are being conscientiously completed; and
  - i) a suitable level of continuity that can be achieved by identifying individual patrollers with individual sections.

At the time of publication of this report, Network Rail has accepted this recommendation and has stated that it has carried out work to complete it. The ORR does not believe that sufficient work has been done for this recommendation to be closed.

- Recommendation 11: Network Rail should modify its processes to specify the following safeguards when a supervisor's visual track inspection is combined with a basic visual inspection:
  a) all the paperwork relevant to the basic visual inspection is supplied to the supervisor; and
  b) an assurance check is carried out by a person other than the relevant supervisor to confirm that both inspections have been completed and recorded appropriately.

At the time of publication of this report, Network Rail has accepted this recommendation and has stated that it has carried out work to complete it. The ORR does not believe that sufficient work has been done for this recommendation to be closed.

- Recommendation 12: Network Rail should review its processes for practical training, assessment and competence assurance for those undertaking S&C inspection and maintenance against current UK rail industry best practice (e.g. ORR's publication 'Developing and Maintaining Staff Competence'), and make relevant changes so that the requirements arising from Recommendations 6, 7, 8, 9, 10 and 11, as appropriate, and those from the more general observation about competence in this report, can be delivered.

At the time of publication of this report, Network Rail has proposed not to implement this recommendation. The ORR believes that the recommendation is valid and does not support Network Rail's proposal not to implement it. The RAIB also considers that the recommendation remains valid.

- Recommendation 13: Network Rail should conduct a review, focused on human factors, to develop an accurate understanding of the practicability of, and variability in, the performance and outcome of inspection and maintenance so that any issues identified can be taken into account in the design of S&C systems and the associated inspection and maintenance specification.

At the time of publication of this report, Network Rail has proposed not to implement this recommendation. The ORR believes that the recommendation is valid and does not support Network Rail's proposal not to implement it. The RAIB also considers that the recommendation remains valid.

- Recommendation 17: Network Rail should review and, if necessary, revise its access arrangements and plans (including Rules of the Route) for its main-line routes. This should be done to provide for the needs of maintenance and inspection of existing infrastructure, given current and planned traffic levels.

At the time of publication of this report, Network Rail has accepted this recommendation and has stated that it has carried out work to complete it. The ORR is reviewing this work.

- Recommendation 18: Network Rail should review and, if necessary, revise its management organisation to provide effective stewardship of S&C assets. The review should include consideration of the creation of a single professional department (design authority) responsible to the chief engineer for all aspects of S&C, including specifying design, procurement, installation, set-up, commissioning, inspection, maintenance and performance.

At the time of publication of this report, Network Rail has accepted this recommendation and has stated that it has carried out work to complete it. The ORR is reviewing this work with a view to closing the recommendation.

- Recommendation 19: Network Rail should re-assess the differing requirements of plain line and S&C track inspections with regard to:
  - the amount that is appropriate to be done by human intervention, and the amount by automated data capture, for both types of track;
  - the different relative frequencies that may be appropriate for both types of track; and
  - what protection arrangements should be provided.

  Consideration should be given to separate processes for plain line and S&C inspections to recognise the different requirements of each.

At the time of publication of this report, Network Rail has accepted this recommendation and has stated that it has carried out work to complete it. The ORR is considering Network Rails' response.

Derailment at Santon 25 January 2008

192 In January 2008, there was a derailment of a freight train loaded with coal on plain line at Santon, situated between Wrawby Junction and Foreign Ore Branch Junction, Scunthorpe[16]. The RAIB investigation into this derailment found the causes to include a failure of the local Network Rail inspection and maintenance regime to detect and repair track geometry faults, and that local maintenance staff did not prevent those faults that were repaired from quickly appearing again. Two safety recommendations were made in relation to track inspection and the repair of track geometry faults:

- Recommendation 5: Network Rail should provide their inspection and maintenance staff with a single source of information that allows the identification of localised areas where track quality is poor, and is repeatedly deteriorating, due to discrete track geometry faults. In particular, information about the detection, measurement, repair and post-repair inspection of discrete track geometry faults should be recorded, together with references to related work orders that are recorded on ELLIPSE.

Network Rail accepted this recommendation and stated in response that a geometry fault management system similar to the rail defect management system is under consideration. At the time of publication of this report, the recommendation remains open.

[16] RAIB report reference 10/2009, published April 2009.

- Recommendation 7: Network Rail should implement processes to investigate and monitor the effectiveness of repairs to repetitive track geometry faults, so that when a track geometry fault recurs, the reason for it coming back can be established, an appropriate repair method can be chosen and monitoring can be carried out to determine whether the second attempt to repair it has been successful.

  Network Rail accepted this recommendation and stated in response that the present track geometry report already contains an operational repeats report and that more use should be made of it. It will review processes and expectations and restate them as competence and training issues. At the time of publication of this report, the recommendation remains open.

At the time of publication of this report, the ORR is monitoring Network Rail's progress on Recommendations 5 and 7 to an agreed timescale.

Other incidents involving FSA/FTA wagons

193 Industry data show there to have been three previous derailments of FSA/FTA wagons, all of which occurred in the part-laden state[17]. The industry joint investigations concluded that in two of these cases the cause was the presence of cyclic top, with excessive track twist also found to be present during one incident. The remaining derailment was found to relate to a severe dip in the track, combined with some twist and misalignment. These derailments all took place between 1997 and 2000.

[17] Rail Safety and Standards Board, *Risk Assessment of Ride Performance and Dynamic Derailment of Bogie Freight Vehicles*, Report RSSB 1258, October 2007.

Analysis

Identification of the immediate cause[18]

194 Marks on the rail head of the cess rail on the section of plain line between trailing points 2390B and facing points 2392A (paragraph 60) and damage to the wheelsets on the trailing bogie of wagon 608440 (paragraph 77) showed that the immediate cause of the derailment was the rearmost left-hand wheel of this wagon running over the rail head and derailing as train 4L41 traversed Marks Tey junction.

Identification of causal[19] and contributory[20] and underlying factors[21]

The derailment mechanism

195 The wheel unloading for a part-laden FSA wagon in the Marks Tey condition (paragraph 97) was modelled dynamically as it passed over the track geometry recorded during the post-accident survey. The model calculated that all four axles of the wagon would completely unload on the approach to the nominal point of derailment, with the effect being most sustained on the trailing bogie.

196 On this trailing bogie, wheel unloading started to occur shortly before the wheelsets passed over the dipped joint at the heel of 2390B points (figure 18). There were then periods of wheel unloading between 11 and 6 metres before the nominal point of derailment, which presented a significant risk of derailment for both wheels of the rear axle. This wheel unloading was a causal factor in the derailment.

197 The model showed that, for a wagon in the Marks Tey condition, the vertical body accelerations over the leading and trailing bogie pivots were out of phase, indicating that the wagon was pitching. The level of accelerations was high, with a peak between 11 and 6 metres before the nominal point of derailment. These vehicle oscillations corresponded with the wheel unloading events and were therefore causal factors in the derailment.

198 Dynamic modelling studies calculated sustained Y/Q force ratios (paragraph 94) of 1.8 where the train derailed. This is greatly in excess of that required by GM/RT 2141, and is consistent with the train derailing at the point where it actually did. However, the calculated DQ/Q (paragraph 95) force ratios were also large, at 0.8, indicating that there was significant unloading of the wheels present. This indicates that wheel unloading was the primary cause of the high Y/Q ratio, and it is this, rather than a high lateral force, that led to the derailment condition. This finding from the modelling is supported by the large number of wheels that did mount onto the rail head, but then returned to normal running, with only one wheel crossing the rail head to fully derail.

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

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

[20] 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.

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

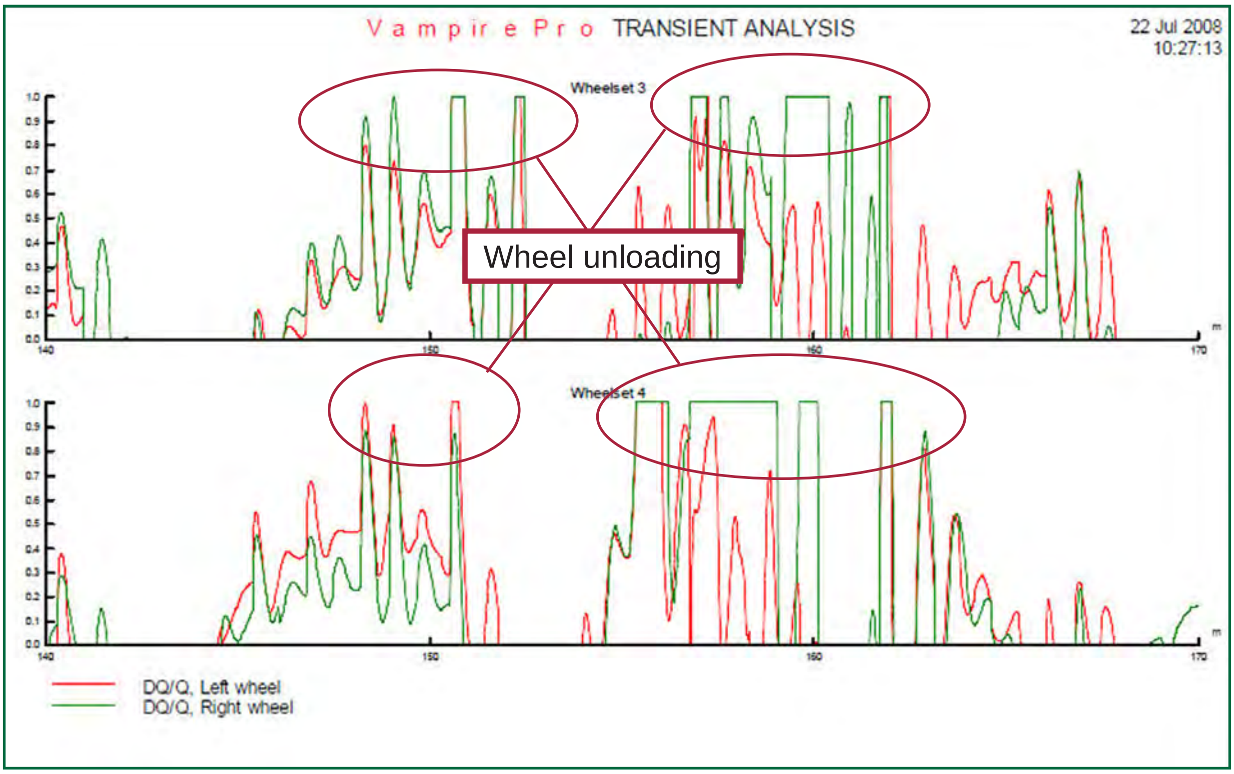

Figure 18: Cycle of wheel unloading on trailing bogie on approach to nominal POD (image courtesy of Delta Rail)

199 The modelling was able to confirm that the measured cant, curvature, horizontal alignment and gauge of the track contributed little to creating the wheel unloading events, and that the dominant mechanism was the vehicle's response to changes in vertical track alignment.

200 The modelling also examined how the Marks Tey condition wagon would have reacted running at 75 mph (121 km/h) over the track geometry as it was recorded on 27 May 2008 (paragraph 166). While cyclic wheel unloading was still apparent, the dynamic wheel unloading ratio limit was not exceeded; this confirms that the derailment could not have taken place without a deterioration in track geometry taking place after this date. A comparison between the post-accident survey and the data recorded on 27 May showed that a dip at the heel of 2390B points had become significantly worse (figure 19). This dip was the site of an insulated rail joint under which the four new timber bearers had been fitted. The post-accident survey found voiding present under these new timbers (paragraph 71).

201 The track geometry data was then changed to simulate perfect and typical[22] vertical alignment and cant on the approach to, and the exit from, the dip at the heel of 2390B points. The results demonstrated that, if the track on the approach to the defect at 2390B points was a perfect or typical track profile and the track geometry after the defect was left in the state measured post-accident, then there would still be a significant risk of derailment (paragraph 94). The model also showed that there would not be a significant risk of derailment if the track geometry after the defect was a perfect or typical profile.

[22] A model of 100 mph track that was close to, but complied with, Network Rail's standard deviation limits in the vertical dimension was used.

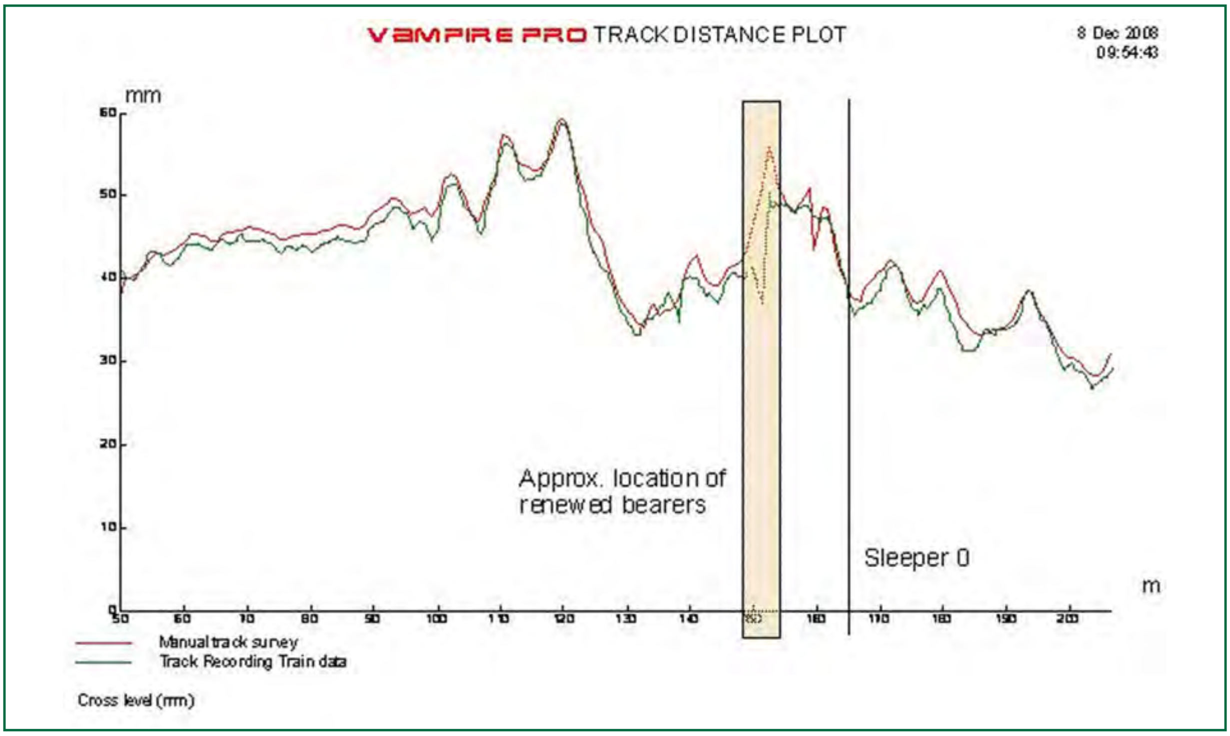

Figure 19: Comparison between the post-accident survey and the data recorded on 27 May 2008 (image courtesy of Delta Rail)

202 This meant that the geometry of the track on the approach to the defect (i.e. the down main through Marks Tey station platform) was not causal to the derailment. It also meant that, although the dip at the heel of 2390B points found following the accident was necessary for the derailment to take place, it was not on its own sufficient for the wagons to pose a derailment risk. For such a derailment risk to exist, it was also necessary for the track beyond this dip to have the presence of the cyclic top that was measured post-accident and which matched well with that recorded on 27 May 2008 (paragraph 167).

203 The derailment risk at Marks Tey junction was therefore caused by the response of the wagon to both the dip at the heel of 2390B points (created after 27 May 2008) and the cyclic top present shortly beyond these points (which was consistent with that recorded on 27 May 2008).

Response of the FSA/FTA design of wagon

204 The modelling compared the performance of a part-laden FSA/FTA wagon in both the nominal and Marks Tey conditions against the requirements of Railway Group Standard GM/RT 2141 Issue 2 ‘Resistance of Railway Vehicles to Derailment and Roll-Over’ in respect of new vehicle vertical dynamic performance. This was achieved by modelling the vertical dynamic performance of these wagons on a length of jointed track that had been frequently used by a *Vehicle Acceptance Body* (VAB) for ride acceptance testing vehicles.

205 The model showed that, over jointed track, a part-laden FSA/FTA wagon did not satisfy the requirements of GM/RT 2141 Issue 2. In the nominal condition at 60 mph, it exceeded these requirements only slightly; however, in both the nominal and Marks Tey conditions at 75 mph, its performance fell significantly outside that required. The Marks Tey condition was the worst performing of all, which reflected the effect of reduced friction damping (caused as a result of the worn Lenoir links) on vertical dynamic behaviour (figure 20).

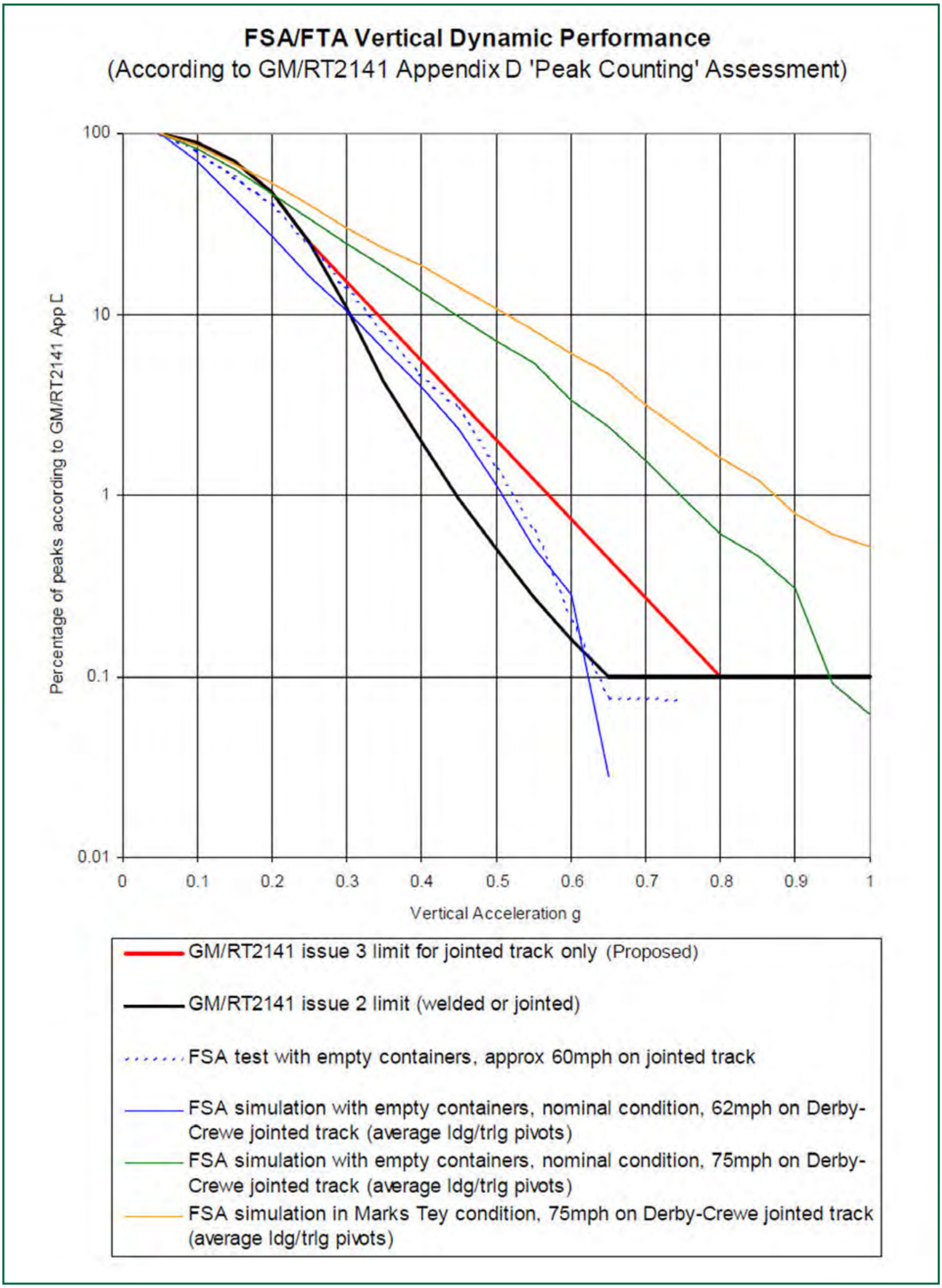

Figure 20: FSA/FTA Vertical Dynamic Performance comparison (image courtesy of Delta Rail)

206 The limits in GM/RT 2141 Issue 2 applied only to new vehicles and were created in the knowledge that vertical dynamic performance would deteriorate as suspension components wore in service. Although the model's performance over jointed track was worst in the Marks Tey condition, a comparison with the performance of the wagon in the nominal condition over the post-accident surveyed track geometry (which was over welded track) showed very similar results. This demonstrates that the wear in the suspension did not, in this case, have a significant influence on the wagon's response and therefore did not contribute to the derailment.

207 FSA/FTA wagons were introduced into service prior to the issuing of GM/RT 2141, and so are not required to comply with its requirements. The 1991 British Rail testing report[23] which detailed their performance during ride acceptance tests stated that:

'*…the vertical ride at tare and with empty containers was acceptable on welded track at 75 mph but exceeded the freight acceptance curve at 60 mph on jointed tracks. After a bedding-in period, although improved, the vertical ride was still non-compliant on jointed track. Vertical ride parameters…were satisfactory and acceptable for all of the required operating speeds on welded and jointed track…. for the tare + empty container condition*[24] *an improvement was…seen after the bedding-in period, however the ride was still inferior to the tare condition and a retest is recommended after in service running….the wagons are acceptable for a maximum of 75 mph*'.

208 The wagon design was subject to further scrutiny by a VAB in 2000, when its maximum gross laden weight was increased from 82 to 87 tonnes. The calculations submitted to the VAB considered primarily the effect of the increase in maximum gross laden weight. Of interest within these calculations were notes that the maximum speed for the new weight would be 65 mph, that the vertical ride was not influenced greatly by variations in wheel profile and that vertical ride was not greatly changed by the laden load increase. On this basis the wagons were approved for service at the higher maximum gross laden weight. The report noted that wheel unloading tests carried out around three years after the wagons entered service found the worst case of wheel unloading occurred when they were in the tare condition.

209 The RAIB undertook further dynamic modelling to examine the reaction of a part-laden FSA/FTA wagon which complied with the vehicle vertical dynamic performance requirements of GM/RT 2141 Issue 2; this was done by changing the Marks Tey condition model solely in respect of its vertical dynamic performance. This model demonstrated that, although wheel unloading behaviour was still present in the compliant wagon model, the trailing bogie's rear right wheel only briefly exceeded the derailment limit for a sufficiently large distance (i.e. more than two metres) to be considered a derailment risk (figure 21). The risk of derailment was therefore reduced compared with the previous modelling of the non-compliant Marks Tey condition wagon. The FSA/FTA wagon design in the part-laden condition not meeting the requirements of GM/RT 2141 Issue 2 in respect of vertical dynamic performance was therefore a contributory factor in the derailment.

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[23] British Railways Board Headquarters, Mechanical and Electrical Engineering Testing Section Report No. 1274, October 1991.

[24] 'Tare + empty containers' corresponds with the part-laden configuration of FSA/FTA wagons.

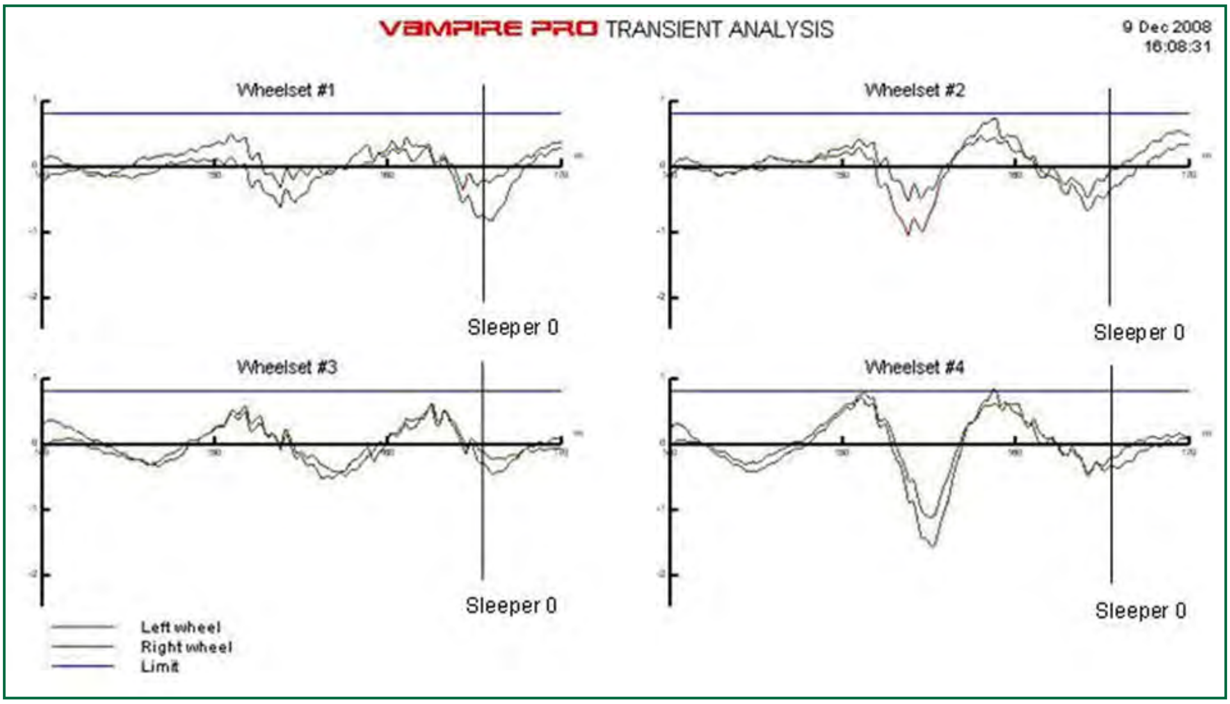

Figure 21: Filtered cycle of wheel unloading on compliant wagon on approach to nominal POD (image courtesy of Delta Rail)

210 The effect of speed on the behaviour of a wagon in the Marks Tey condition over the accident track geometry was also modelled. Speeds ranging from 60 mph to 75 mph were examined in 5 mph increments and the results showed that cyclic wheel unloading was still present at all speeds (figure 22); however the dynamic wheel unloading was not sustained for a large enough distance to present a significant risk of derailment at speeds of 70 mph or below. The permitted speed of the train was 75 mph; this was a causal factor in the derailment.

211 In October 2007 the *Rail Safety and Standards Board* (RSSB) produced a report 'Risk Assessment of Ride Performance and Dynamic Derailment of Bogie Freight Vehicles'[25]. This found that, at 75 mph, the FSA/FTA wagon design exceeded the vertical dynamic performance requirements of GM/RT 2141 Issue 2 in the tare, part-laden and laden conditions. At 75 mph in the part-laden condition the vertical dynamic performance lay closer to that required by the standard than in either the tare or laden conditions; as before these results and the requirements of the standard considered performance over jointed track.

212 The modelling demonstrated that the worse vertical dynamic performance over jointed track of the Marks Tey condition model, when compared to the nominal condition model, was not significant when the post-accident surveyed track geometry was considered (paragraph 206). It is possible therefore that the differences in performance between the tare, laden and part-laden conditions which the RSSB report highlights would not have been repeated had they been assessed over the post-accident surveyed track geometry.

[25] Rail Safety and Standards Board, *Risk Assessment of Ride Performance and Dynamic Derailment of Bogie Freight Vehicles*, Report RSSB 1258, October 2007.

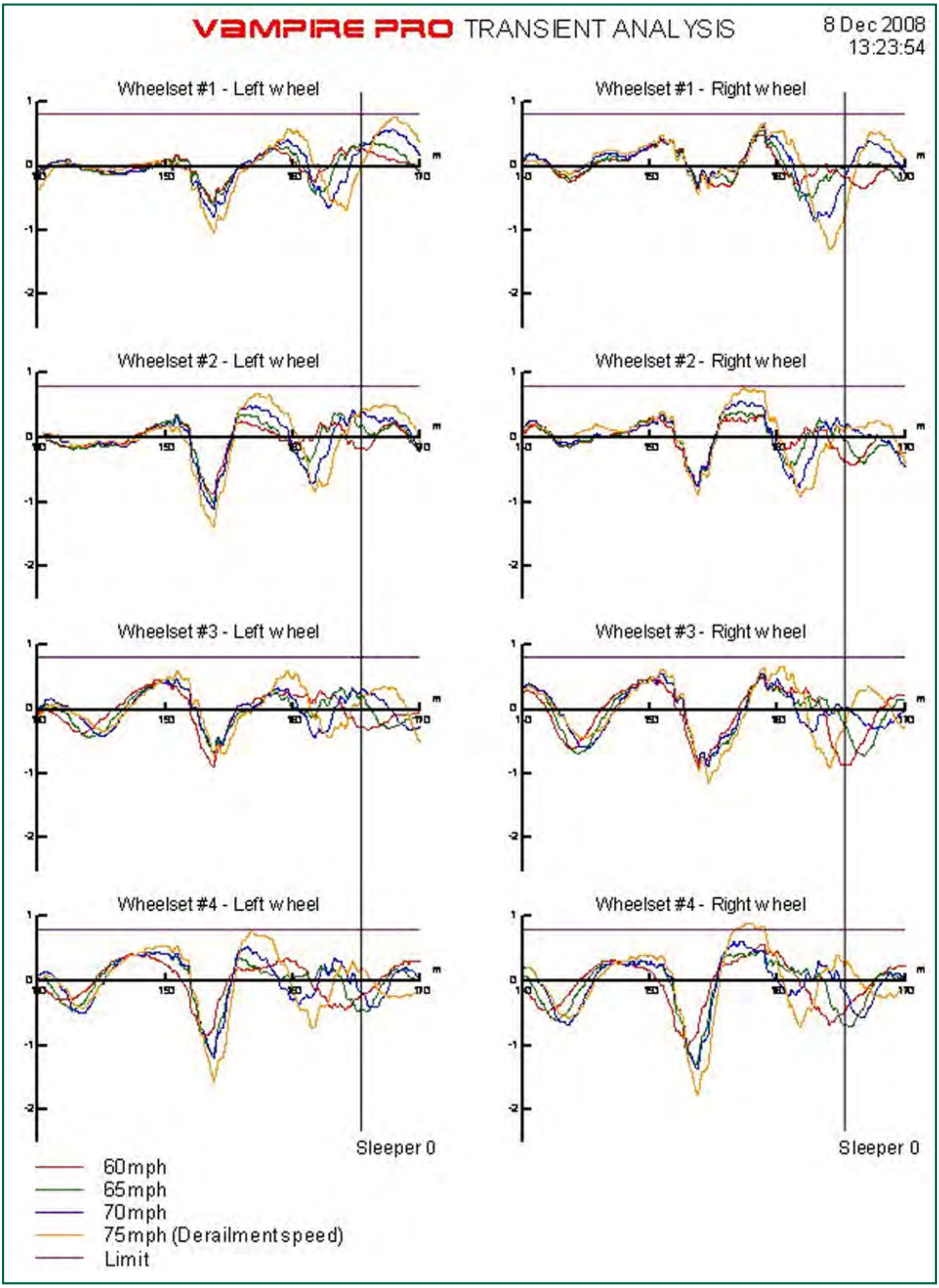

Figure 22: Filtered cycle of wheel unloading on Marks Tey condition wagon at various speeds (image courtesy of Delta Rail)

213 Modelling has also previously shown that a wagon meeting the vertical dynamic performance requirements of GM/RT 2141 Issue 2 for jointed track would have had a reduced chance of derailment (paragraph 209); it is possible therefore that a better vertical dynamic performance generally would have resulted in a reduced chance of derailment. However, testing undertaken after three years service found that the tare condition saw the worst wheel unloading (paragraph 208).

214 There is, therefore, no evidence to suggest that the part-laden condition would have a worse vertical dynamic performance over the post-accident surveyed track geometry than either the tare or laden conditions. This means therefore that the part-laden condition of wagon 608440 probably did not contribute to the derailment.

215 As well as examining the risks associated with dynamic derailments of bogie freight vehicles, the October 2007 RSSB report considered whether it would be acceptable for the acceptance limits for vertical dynamic performance of rail vehicles to be relaxed. The intention of this revision would be to incorporate existing vehicles which currently fell outside the limits but which in practice had, in the opinion of the report, a good safety record. The report ultimately proposed a revised limit curve for vertical dynamic performance, subject to further confirmatory study. The report noted that the FSA/FTA design of wagon remained outside the revised limit in the tare condition at 75 mph. As part of the modelling work undertaken following this derailment, the Marks Tey condition wagon was compared against the proposed revised limit at 75 mph and was found to be non-compliant[26].

216 The RSSB report compared the risk represented by the derailment of a bogie freight vehicle with the RSSB Safety Risk Model Issue 5 and concluded that the risk from such derailments was very low as the probability of a derailment was decreasing. This decrease was due to improved vehicle design, the reduction in jointed track mileage, the improved monitoring of cyclic track defects and of train speeds, and improved track maintenance techniques.

217 There have been previous derailments of partially laden FSA and FTA wagons when faced with track geometry defects (paragraph 193). None of these derailments or known non-compliances in vertical dynamic performance (paragraph 207) have led the successive owners of these wagons to make any modification to the design or the maximum permitted speed of these vehicles. The absence of action to address these factors is probably because the risk associated with such derailments is seen as very low and decreasing, and the recorded occurrence of such derailments is considered as relatively infrequent in the light of the very high fleet mileage. The absence of action to address previous derailments or the vertical dynamic performance of the FSA/FTA wagon design was an underlying factor in the derailment.

Factors relating to the defect present at the heel of 2390B points

218 The dip in vertical alignment found during the post-accident survey (paragraph 71) that was partly causal to the derailment (paragraph 203) was located at the heel of 2390B points. A dip had been present at this point on 27 May 2008 during the track recording train run; it had, however, not been of sufficient magnitude to cause the derailment (paragraph 203). The increase in magnitude of the dip at the heel of 2390B points after 27 May 2008 was therefore a causal factor in the derailment.

[26] These revised limits have now been incorporated into GM/RT 2141 Issue 3.

219 This dip in vertical alignment was caused by significant voiding found at the heel of 2390B points (paragraph 71), under four timber bearers which had been replaced on the night of 6/7 June 2008 (paragraph 117). The extent of voiding found post-accident provides substantial evidence that the replacement timber bearers were not correctly packed during installation. The absence of track clips, either because of the action of traffic passing over voiding timbers or because they were not fitted at all, and the failure to fit new insulating rail pads (paragraph 68) were also good evidence that the work had not been completed correctly. Not carrying out the bearer installation correctly was therefore a causal factor in the derailment.

Factors relating to the installation of the timber bearers at 2390B points

220 It is not possible from the evidence to conclusively determine why faults existed in the bearer replacement work. However, as the task was arranged with limited notice and needed to be undertaken within existing possession arrangements, this meant that it was necessary to use staff who had volunteered to work overtime and who had been drawn from different sections. These elements may have diminished the cohesion of the team and thus the effectiveness of the work. The lack of time available in which to arrange the task was therefore a possible contributory factor in the derailment.

221 This lack of time also meant that the task was treated as 'arising work' and not subject in advance to a formal work plan; no such plan was required by NR/L3/TRK/002 Issue 4. Although there was a pre-work site visit and briefing, this was given to an inexperienced staff member who had not undertaken this particular task before, and not to the team leader responsible for the work. This person was of a relatively junior grade (Leading Trackman) and had only experienced timber changing on site, and had not been formally instructed in the precautions that might be needed, such as adequate packing or inspection for voids. The quality of the work may have been affected by this lack of formal planning and briefing. This again identifies that the lack of planning of the task was a possible contributory factor in the derailment. It also identifies the absence of a requirement for preventative maintenance tasks to be planned in advance within NR/L3/TRK/002 Issue 4 as having been a possible underlying factor in the derailment.

222 The replacement of the bearers was undertaken with little notice, despite being identified as a medium term action within the February 2008 broken rail action plan, and having subsequently been entered into the ELLIPSE work bank. Evidence from witnesses was that there was no knowledge of the broken rail action plan by the track engineering staff responsible for Marks Tey. It was only when the Territory Engineer (Track) requested a progress report on the broken rail action plan that they became aware of it. It was this lack of knowledge of the broken rail action plan, and the sudden and unexpected need to progress its requirements, which led to the need for action to be taken immediately, i.e. the replacement of the timber bearers. This lack of knowledge by track engineering staff of the broken rail action plan was therefore a possible contributory factor in the derailment.

223 This lack of knowledge of the broken rail action plan is possibly rooted in the change over of the Track Maintenance Engineer Colchester post, after which point visibility of the plan appears to have become 'lost' at delivery unit level. This was probably caused by the lack of a either a formal or an informal hand-over of the post between Track Maintenance Engineer A and Track Maintenance Engineer F (paragraph 109). The lack of a hand-over between Track Maintenance Engineer A and Track Maintenance Engineer F was therefore a possible contributory factor in the derailment.

224 The lack of knowledge of the broken rail action plan may also be related to the documentation of the plan itself. The documents relating to the broken rail consisted of a standard broken rail incident form[27], completed by Assistant Track Section Manager C and a broken rail action plan in the form of a 'PowerPoint' presentation, created by Track Maintenance Engineer A[28].

225 The broken rail incident form recorded the nature of the break and very briefly described the actions immediately undertaken and those which would prevent reoccurrence; it identified that the new switches and selected timbers should be replaced prior to the end of the financial year. It did not provide detail of any medium or longer term actions, which were described within the 'PowerPoint' broken rail action plan. Other than the completion of the relevant sections of the broken rail incident form, there is no requirement within Network Rail standard RT/CE/S/057 Issue 4 'Rail Failure Handbook' for a broken rail action plan to be created or a standard format for such plans. Although the broken rail incident form was signed off, there appears to be no provision to review progress; such reviews are not required by RT/CE/S/057 Issue 4. This is in contrast to the requirements which were included in NR/SP/TRK/001 Issue 2 for regular monthly reviews of track needing remedial work, until the formal approval of a track quality action plan (paragraph 169).

226 Although this lack of a requirement to review the progress did not prevent the Territory Engineer (Track) from being aware of the plan and calling for a review of progress after some months, an absence of any formal arrangements to review the plan probably contributed to the lack of knowledge of it by track engineering staff at Colchester. The lack of a requirement within Network Rail's procedures and processes for reviewing medium or long term actions intended to prevent the reoccurrence of broken rails was therefore a possible underlying factor in the derailment.

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[27] Network Rail document TEF/3039 *Broken Rail Incident Form*.

[28] The broken rail and its subsequent repair would have also been entered into Network Rail's Rail Failure Database system as is required by standard RT/CE/S/057 Issue 4.

227 The remainder of the main line at Marks Tey was considerably newer than 2390B points (paragraph 58). The investigation into the broken rail incident (paragraph 117) identified that this was the second incident of this type at these points. Although the timbers were graded as 'fair' by Assistant Track Section Manager C during this incident they were, along with the switches, identified as needing replacement before the end of the financial year (paragraph 118). This investigation also noted that replacement switches and a crossing which had been scheduled to be fitted in February 2008 had been diverted elsewhere (paragraph 118). Had they been replaced as scheduled, then the need to replace the bearers on 6/7 June 2008 would probably not have arisen. The failure to replace 2390B switches as scheduled, which would probably have led to the timbers being replaced at the same time, was therefore a probable underlying factor in this derailment.

228 Had the voiding present been measured dynamically by a track recording train, then it would have been recorded as a 'Level 2' vertical alignment (top) geometry defect which would have required correction within 14 days of detection. This means that, had a track recording unit run through Marks Tey junction immediately after the installation of the bearers and detected the voiding, then the repair could possibly have been outstanding at the time of the derailment, even though the requirements of NR/SP/TRK/001 Issue 2 would have been complied with.

229 NR/SP/TRK/001 Issue 2 stated that '*…these actions assume no significant associated irregularities. If other irregularities exist the action may need to be more stringent…*'. According to the immediate action report resulting from the track recording run of 27 May 2008, the presence of the cyclic top fault beyond the bearers was of a magnitude which required repair within 60 days (paragraph 166). It seems unlikely that it would have been seen as significant enough to demand more stringent action within the context of NR/SP/TRK/001 Issue 2.

Factors relating to the inspection of the timber bearers following their installation

230 Although the output from the track recording train would have designated this as a 14 day repair, witness evidence from track supervisory staff has indicated that the state of the points and the extent of the voiding, once detected by track engineering staff, would probably have been addressed more quickly than this 14 day period, most likely by the immediate implementation of an emergency speed restriction across the junction. It has been shown (paragraph 210) that a reduction in speed would have prevented the derailment. Track engineering staff not detecting the defects in the points and applying an appropriate emergency speed restriction was therefore a probable causal factor in the derailment.

231 The following opportunities existed for track engineering staff to detect the defects after the bearer installation:

- the immediate post-installation inspection undertaken by Leading Trackman H on the night of 6/7 June 2008;
- the post-consolidation inspection which was planned to be undertaken by Assistant Track Section Manager C in the days which followed the installation;
- the inspection of the switches of 2390B and 2392A points undertaken by a member of the JPT on 10 June 2008; and
- the supervisor's visual inspection between Kelvedon and Marks Tey undertaken by Assistant Track Section Manager D on 11 June 2008.

232 None of the faults in the bearer installation were detected by the immediate post-installation inspection undertaken by Leading Trackman H on the night of 6/7 June. The inspection was not effective in detecting the faults in the installation; this was a probable causal factor in the derailment.

233 Although the manner in which the WAIF relating to the work was completed and the absence of any records of the inspection (paragraph 129) may indicate deficiencies in the post-installation inspection, there is no clear reason as to why this was not effective. It is possible that the passage of traffic over the replacement timbers would have assisted in the detection of voiding. However, the protection under which the work was undertaken meant that this was not possible, and such an observation is in any case not required by Network Rail work instruction NR/L3/TRK/002/G06. Even had protection arrangements allowed observation under traffic to take place, it seems unlikely that Leading Trackman H would have chosen to undertake it, given the doubts he expressed about its effectiveness at night (paragraph 131).

234 The failure of team leaders to observe traffic passing over repairs in areas where access was difficult, and a lack of inspection of repairs by Assistant Track Section Managers were similar issues to those raised by the investigation into the November 2007 track fault at Colchester station (paragraph 106), which can be seen as a precursor event.

235 Although a post-consolidation inspection was not formally required by the relevant work instruction, witness evidence indicated that it was accepted practice within Colchester Maintenance Delivery Unit to revisit bearer replacements after a period of days, in order to conduct such inspections (paragraph 132). The responsibility for undertaking this inspection fell to Assistant Track Section Manager C, who did not undertake it. The absence of this inspection was a probable causal factor in the derailment.

236 Although he had accepted responsibility for it, Assistant Track Section Manager C did not undertake the post-consolidation inspection because he prioritised other work tasks ahead of it (paragraph 133); this was due to his workload and probably also because he knew that he would be undertaking a scheduled inspection on 11 June. Assistant Track Section Manager C's workload was a probable causal factor in the derailment.

237 When the 11 June supervisor's visual inspection was allocated to Assistant Track Section Manager D in lieu of Assistant Track Section Manager C, the latter did not inform him of the need to conduct a post-consolidation inspection of the bearers. It is feasible that Assistant Track Section Manager D may have conducted a more effective inspection of 2390B points had he been told in advance of the bearer replacement. The lack of briefing between the two Assistant Track Section Managers was therefore a potential causal factor in the derailment.

238 During this inspection, Assistant Track Section Manager D inspected 2390B points from the cess. Although he noticed that new bearers had been fitted, he did not find any deficiency in the points which required action (paragraph 149). Given the state of the points as they were found the next day, it is likely that missing clips and voiding could have been detected during this inspection. Assistant Track Section Manager D not detecting the faults in 2390B during this inspection was therefore a probable causal factor in the derailment.

239 Assistant Track Section Manager D's position in the cess prevented him from completing all the requirements of NR/SP/TRK/001 Issue 2 for supervisor's visual track inspections, and probably reduced his ability to detect the defects that had resulted from the installation of the timbers at 2390B points. He inspected the points from the cess because of the red zone prohibited status of the line at this location; he did not attempt to arrange for protection to allow him to get onto the track as this was seen by him, and other witnesses, as being difficult to obtain. Assistant Track Section Manager D was unaware of the protection that had already been arranged for Patrol 4, and this may have contributed to him forming this opinion. Assistant Track Section Manager D not arranging protection which would allow him to inspect 2390B points effectively was a probable contributory factor in the derailment.

240 The inspection of the switches at 2390B and 2392A points undertaken on 10 June by the JPT failed to detect any defects relating to the timber bearer replacement. This is probably because, although the JPT had access to examine the points in detail, the switch inspection would have correctly been focused on the opposite end of the points to that under which the new bearers had been installed. In addition, the red zone prohibited status of Marks Tey junction meant that these inspections took place under at least a perceived time pressure and always at night; it seems likely that these elements combined to limit the ability of the JPT member to observe any faults which lay outside of the direct focus of the switch inspection. The conducting of switch inspections within protection of limited duration and at night was therefore a probable contributory factor in the derailment.

241 The effectiveness of the inspections undertaken by both Assistant Track Section Manager D and the JPT were probably adversely affected, although in different ways, by the arrangements put in place to access the red zone prohibited Marks Tey junction. This led to a sustained period where Marks Tey junction was inspected principally from the cess during visual inspections and only inspected in detail at night. Although regular T12 protection was put in place for Patrol 4 by Track Maintenance Engineer A, this protection did not cover the junction and the availability of this protection was only known to some track engineering staff, mainly within the patrol team. Others, including those in supervisory and managerial positions, had no knowledge of it. Apart from this, no action was taken at any stage to facilitate direct access to the red zone prohibited area of the junction in order to allow for its effective visual inspection and to allow the requirements of NR/SP/TRK/001 Issue 2 to be met. This was a probable underlying factor in the derailment.

Factors relating to the presence of the cyclic top fault at Marks Tey junction

242 The dip found at the heel of 2390B points was not on its own sufficient for the wagons to pose a derailment risk. It was also necessary for this dip to be combined with the cyclic top fault which was measured post-accident and which closely matched that measured by the track recording train on 27 May 2008 (paragraph 166). Its presence on this date means that it clearly was not related to the replacement of the timber bearers on 2390B points on 6/7 June.

243 At the time of the derailment, the cyclic top fault detected on 27 May 2008 had been reported as requiring correction within the 60 day rectification window specified in NR/SP/TRK/001 Issue 2 (paragraph 166). Because of the high priority which was placed on detecting twist faults within NR/SP/TRK/001 Issue 2, the presence of cyclic top in both rails simultaneously (which would create a dip as opposed to a twist (paragraph 71)) required a greater magnitude of fault before being reported. Scrutiny of the track recording trace indicates that the track geometry at Marks Tey was actually within this 'both rails' limit. It appears that regardless of this, the fault was reported as the right rail was detected as exceeding the 'single rail' limit.

244 The July 2007 report summarising track recorder run outputs (paragraph 171) highlighted that the cyclic top faults at Marks Tey junction had existed for a period of at least six years. The proposed solution at this point was to arrange tamping, a response which was also given to the Track Maintenance Engineer's inspections in 2006 and 2008 (paragraphs 153 and 154). Despite this, for the reasons detailed in paragraphs 184 and 185, tamping was not carried out through Marks Tey junction in the year prior to the derailment. Witness evidence stated that, in the absence of tamping, manual packing was used to address any cyclic top faults which arose at this location (paragraph 186).

245 Later track recorder runs in January 2008 and May 2008 detected the reappearance of cyclic top at Marks Tey junction; in neither case was the action proposed detailed on the immediate action report.

246 Prior to the derailment there had been a period of at least two years where the track geometry quality over the junction had been measured as 'Very Poor' (paragraph 169). Despite this, it was only at the end of February 2008 that the requirements of NR/SP/TRK/001 Issue 2 to create an action plan to improve track quality were satisfied. Within this track quality action plan, the proposed actions largely matched those already proposed in the broken rail action plan, with an additional requirement for tamping to be arranged. As was detailed in paragraph 221, none of these actions, other than the replacement of the timber bearers at the heel of 2390B points, was undertaken prior to the derailment.

247 The preceding paragraphs highlight that a cyclic top defect and problems with the general quality of track geometry at Marks Tey junction had existed intermittently for a period of years. They were being addressed only by the use of manual packing and there had apparently been no attempt to investigate or to resolve any underlying issues. This created an ongoing cycle of repair and deterioration in the track. Other actions identified to try and improve matters, such as tamping or the replacement of components, were planned but not carried out prior to the derailment. No 'problem statements' (paragraph 183), which may have led to the consideration of the renewal of the line through the junction, had been prepared or submitted.

248 Although the magnitude of the cyclic top fault at the time of the derailment was within the limits laid down in NR/SP/TRK/001 Issue 2, it is probable that a more effective treatment of this long standing problem area would have resulted in a track vertical alignment profile which would have prevented the derailment (paragraph 201). The RAIB has not been able to establish why local staff did not elevate the repeated unavailability of tampers and possessions to a higher level, given the repeated recurrence of defects that they were documenting. The absence of an effective investigation into, and resolution of, the track geometry defects by the track engineering staff with responsibility for Marks Tey junction over a prolonged period was a probable causal factor in the derailment.

249 Not renewing 2390B points in the 1990s, at the same time as the remainder of the line at Marks Tey, had left variations in the track formation, and thus possibly also variations in track stiffness between these sections of the line. This may have led to difficulties in maintaining vertical and lateral track alignment across the junction and so was therefore a potential underlying factor in the derailment.

250 The drainage in the Marks Tey area was in a poor state (paragraph 72). The layout and features of the track drainage system were not documented (paragraph 179). Although track engineering staff seemed to be aware that there were issues with the flow of water in the drains, this had not been reported to the off-track section for investigation, despite the fact that there were ongoing problems with wet beds on the up line and at the London end of the station. This meant that the missing components and blockages in the drainage system were not discovered until after the derailment.

251 Although there was no reported problem of wet beds or other symptoms of poor drainage at Marks Tey junction itself, it is possible that the absence of effective drainage, and its effect on the stability of the underlying formation, may have led to difficulties in maintaining vertical and lateral track alignment across the junction. The absence of effective drainage, drainage records and drainage inspection at Marks Tey junction were potential underlying factors in the derailment.

252 The ambiguous requirements of NR/SP/TRK/001 Issue 2 as to when drainage should be inspected, and within which inspection, may have led to confusion on the part of track engineering staff as to their responsibilities for drainage inspection (paragraph 180). This was a potential underlying factor in the derailment.

253 In the vicinity of Marks Tey, cable troughing was routed over catch pits with only minimal clearance (paragraph 180). This may also have made effective inspection of drainage more difficult, and was a potential underlying factor in the derailment.

254 Following the re-organisation of track engineering staff (paragraph 112) it is evident that there was confusion as to who was responsible for the maintenance and inspection of Marks Tey junction. From witness evidence and the way that he accepted and organised work, it appears that Assistant Track Section Manager C did eventually accept responsibility for the junction; however, the confusion as to ownership of it may have contributed to the general failure to address the condition of the track with anything other than short term actions. This was a potential contributory factor in the derailment.

Factors relating to other matters

255 The investigations into the Colchester station incident and the broken rail at Marks Tey junction highlighted some months prior to the derailment that there was a back-log in undertaking key tasks relating to track quality, caused by staff absence and a lack of qualified deputies (paragraph 105). The technical audit in February 2008 also highlighted that the Track Maintenance Engineer Colchester's organisation was non-compliant in other important respects (paragraph 108).

256 The RAIB found substantial evidence (paragraph 116) that, in the months immediately prior to the derailment and despite the efforts of the new Track Maintenance Engineer, the legacy from this earlier period was still adversely affecting the working relationships between some track engineering staff at Colchester. The poor communication and working relationships between these staff was a probable underlying factor in the derailment.

Conclusions

Immediate cause

257 The immediate cause of the derailment was the left-hand wheel of the trailing wheelset of the rear bogie of wagon 608440 running over the cess rail head and derailing as train 4L41 traversed a section of plain line between trailing points 2390B and facing points 2392A at Marks Tey junction.

Causal factors

258 Causal factors were:

a. the unloading of the wheels of the rear axle of the trailing bogie of wagon 608440 (paragraph 195, Recommendation 1);

b. the dip in vertical alignment of the track caused by the incorrect replacement of the bearers at the heel of 2390B points (paragraphs 218 and 219, recommendations 2 and 5);

c. the cyclic top present shortly after these points (paragraph 203, Recommendation 1); and

d. the permitted speed of the train (paragraph 210, Recommendation 1).

259 Probable causal factors were:

a. the absence of an effective post-installation inspection of 2390B points by Leading Trackman H on the night of 6/7 June (paragraph 232, Recommendations 2 and 7);

b. the absence of an effective post-consolidation inspection of 2390B points by Assistant Track Section Manager C (paragraph 235, Recommendations 2 and 7);

c. the workload of Assistant Track Section Manager C (paragraph 236, no recommendation);

d. the absence of briefing between Assistant Track Section Manager C and Assistant Track Section Manager D prior to the supervisor's visual inspection on 11 June (paragraph 237, no recommendation);

e. the absence of an effective supervisor's visual inspection of 2390B points by Assistant Track Section Manager D on 11 June (paragraph 238, Recommendation 2); and

f. the absence of an effective investigation and resolution of the track geometry defects at Marks Tey junction over a prolonged period (paragraph 248, Recommendations 2 and 3).

Contributory factors

260 Contributory factors were:

a. the FTA/FSA wagon in the part-laden condition did not meet the vertical dynamic performance requirements of GM/RT 2141 Issue 2, having been introduced into service by British Rail prior to the issuing of this standard (paragraph 209, Recommendation 1).

261 Probable contributory factors were:

a. Assistant Track Section Manager D did not arrange suitable protection to allow him to inspect 2390B points in line with the requirements of NR/SP/TRK/001 Issue 2 (paragraph 239, Recommendation 4); and

b. detailed points inspections were only undertaken at Marks Tey junction at night and within protection of limited duration (paragraph 241, Recommendation 4).

262 Possible contributory factors were:

a. the lack of formal planning of the bearer replacement at the heel of 2390B points (paragraphs 220 and 221, Recommendation 5);

b. the lack of knowledge by track engineering staff of the broken rail action plan (paragraph 223, Recommendation 6);

c. the lack of a hand-over between Track Maintenance Engineer A and Track Maintenance Engineer F, resulting in the loss of the broken-rail action plan (paragraph 223, no recommendation); and

d. in the months prior to the derailment, there was confusion as to who was responsible for track engineering at Marks Tey junction (paragraph 254, no recommendation as the issue has now been clarified).

Underlying factors

263 Underlying factors were:

a. the absence of action to address the vertical dynamic performance or previous derailments of the FSA/FTA wagon design (paragraph 217, Recommendation 1).

264 Probable underlying factors were:

a. not replacing 2390B switches as scheduled in February 2009 (paragraph 227, Recommendation 3); and

b. the poor communication and working relationships between some staff at Colchester Maintenance Delivery Unit (paragraph 256, no recommendations).

265 Possible underlying factors were:

a. the absence of a requirement for preventative maintenance tasks to be planned and briefed in advance within NR/L3/TRK/002 Issue 4 (paragraph 221, Recommendation 5);

b. the lack of a requirement within Network Rail's procedures and processes for reviewing medium or long term actions intended to prevent the reoccurrence of broken rails (paragraph 226, Recommendation 6);

c. the lack of action to allow access to the red zone prohibited area of Marks Tey junction to allow for its effective visual inspection (paragraph 241, Recommendations 3 and 4);

d. Network Rail's work instruction for changing timber bearers including neither a requirement for a post-consolidation inspection nor a timeframe for such an inspection[29] (paragraph 132, Recommendation 7);

e. the non-renewal of 2390B points with the remainder of the line in the 1990s (paragraph 249, no recommendation);

f. the absence of effective drainage, drainage records and drainage inspection at Marks Tey junction (paragraphs 251 and 273 - 277, Recommendation 2);

g. the ambiguous requirements of NR/SP/TRK/001 Issue 2 as to when drainage should be inspected, and by whom (paragraphs 252 and 278 - 281, no recommendation); and

h. cable troughing being routed over catch pits with only minimal clearance, making effective inspection of drainage more difficult (paragraph 253, Recommendation 2).

Additional observations[30]

266 The incorrect correct maximum gross laden weight was displayed on the side of wagon 608440 (paragraph 40, no recommendation);

267 Some of the basic visual inspection routes for the area for which the Track Section Manager Colchester was responsible were being unofficially altered by track engineering staff within the patrol team. This was due in part to their length, but also to perceived access difficulties. This meant that patrols were often sub-divided between patrol team staff and, on some occasions, were being extended or not being fully undertaken (paragraphs 140 and 141, no recommendation, but see paragraphs 269 and 270);

268 Both 2390B and 2392 points were fitted with the incorrect type of fishplates for strengthened points, which would have led to a loss of strengthening and a requirement for more frequent inspection (paragraph 67, no recommendation).

[29] As the staff did not refer to the work instructions, there is no certainty as to whether the omission of this requirement would have affected the derailment.

[30] An element discovered as part of the investigation that did not have a direct or indirect effect on the outcome of the accident but does deserve scrutiny.

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

269 In December 2008 Network Rail issued procedure NR/L3/TRK/1015 Issue 1 'Management of Track Patrolling Activity'. This requires that basic visual inspections be allocated to patrollers based on their competency, familiarity with a location and the ownership of a section of track. Under this procedure, each patrol's diagram is allocated a regular patroller who should conduct at least two of any four sequential patrols over that diagram.

270 This procedure also requires that patrollers overlap their patrol boundaries by 25 sleepers and that defects be marked on site to allow for effective review by Supervisor's inspections. Patrollers are also required to be accompanied by a Section Manager (Track)[31] or Assistant Section Manager (Track)[32] at least annually. The patroller is also to report any incomplete patrols immediately to the Section Manager (Track) who is then to arrange for immediate mitigation and the re-planning of the patrol.

271 In March 2008 Network Rail issued procedure NR/L3/TRK/7002 Issue 1 'Reporting of Permanent Way failures and incidents'[33]. This requires that failures identified other than by normal inspection be assigned a hazard rating, with items scoring a rating of 50 or more being notified within one day to identified posts including the Director of Maintenance and Head of Track Engineering. They are also notified to the Chief Engineer and the Board of Network Rail as part of the broader safety, environment and assurance report.

272 The broken rail action plan (paragraph 118) noted several risk factors relating to the broken rail which occurred at Marks Tey in February 2008, such as the presence of an overbridge and facing points. This means that the February 2008 rail break, if it were to occur now, would probably be considered as a high risk permanent way failure within NR/L3/TRK/7002. As such it would be notified to the senior management post-holders mentioned above and this would probably result in it receiving a higher degree of attention and follow-up action.

[31] Formerly known as the Track Section Manager.

[32] Formerly known as the Assistant Track Section Manager.

[33] At the time of publication, this standard has been revised to Issue 2.

Completed actions which address causal factors

273 On 21 January 2009, following a further broken rail incident which took place at Marks Tey station in December 2008, the Office of Rail Regulation (ORR) issued an *improvement notice* to Network Rail's Anglia territory[34] relating to the drainage of the track at Marks Tey.

274 This improvement notice stated that an inspection of the track at Marks Tey by the ORR on 16 December 2008 had found '*…clogged ballast, wet spots, standing water, voided sleepers and poor vertical track alignment…investigations confirmed that the track drainage through this site was ineffective due to blockages….Subsequent investigations confirmed that* [within the Anglia territory] *your Maintenance Delivery Units do not have adequate arrangements in place for ensuring, so far as is reasonably practicable, that lineside collector drains and outfalls are adequately inspected and maintained*'.

275 The improvement notice required that Network Rail's Anglia territory *'…produce diagrams showing the locations of lineside collector drain catchpits, direction of water flow and location of outfalls; AND produce an annual plan for inspection of these lineside collector drains and outfalls, at a frequency sufficient to enable any corrective measures to be implemented before the drains become ineffective; AND record details of these inspections; OR Comply by any other equally effective means*'. These items were required to be completed by 21 March 2009, although this compliance deadline was later extended to 30 September 2009.

276 On 14 September 2009, the ORR confirmed that the improvement notice of 16 December 2008 had been fully complied with. In addition to the requirements of the notice the Colchester Maintenance Delivery Unit had established criteria for prioritising drainage defects, using track geometry quality results and was attempting to spread this as best practice nationwide.

277 In the light of this action addressing the factor identified in paragraph 265f, the RAIB has decided not to issue a recommendation relating to drainage.

278 On 5 December 2009 Network Rail superseded standard NR/SP/TRK/001 with a set of new standards, including NR/L2/TRK/001/A01 Issue 4 'Inspection and maintenance of permanent way – Inspection'. This retains the previous requirements of NR/SP/TRK/001 Issue 2 (paragraph 178) that track drainage systems are inspected at a frequency '*…to enable any corrective measures to be instituted before the drains become ineffective'* and that '*…inspections may be carried out during the Supervisor's routine visual track inspection'*.

279 However, NR/L2/TRK/001/A01 Issue 4 also introduces additional requirements in respect of drainage. Ensuring that drainage inspections are undertaken at a sufficient frequency is made the clear responsibility of the Track Maintenance Engineer, who is required to develop a risk-based inspection plan of drainage systems which must take account of any history of drainage problems and those locations known to be at risk of water-logging or flooding. The minimum routine inspection interval is set at 52 weeks, with more detailed inspections of the less accessible parts of the system being undertaken in the event that drainage problems arise, or at least every 5 years.

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[34] This was the Network Rail territory with responsibility for Marks Tey.

280 NR/L2/TRK/001/A01 Issue 4 also requires that the Track Maintenance Engineer keep a register of drainage systems for the area for which he is responsible. The date and findings of all drainage inspections, and any remedial action taken, are to be recorded and used to update this register.

281 In the light of this action addressing the factor identified in paragraph 265g, the RAIB has decided not to issue a recommendation relating to drainage inspection.

Recommendations

282 The following safety recommendations are made[35]:

Recommendations to address causal, contributory and underlying factors

1 *The intention of this recommendation is to reduce the risk of derailment of FSA/FTA wagons (paragraphs 258a, 258b, 258c, 258d, 260a and 263).*

Freightliner should examine if appropriate mitigation action can be taken that will reduce the risk of derailment of FSA/FTA wagons when travelling over the track vertical alignment profiles which could reasonably be encountered in service. This should take into account the full range of load conditions and train speeds permitted for the wagons. Freightliner should implement any appropriate mitigation found during this examination.

2 *The intention of this recommendation is to address omissions in inspections identified within the Colchester Maintenance Delivery Unit (paragraphs 258b, 259a, 259b, 259e, 259f, 265f and 265h).*

Network Rail should carry out a review to assure itself that staff at Colchester Maintenance Delivery Unit are correctly undertaking the following tasks:

- supervisor's visual inspections, particularly the inspection of drainage, and the reporting of drainage defects; and
- the inspection of the line following the completion of work and the re-opening of the line to traffic.

continued

[35] Those 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 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 (paragraph 167 to 171) can be found on RAIB's web site at www.raib.gov.uk.

3 *The intention of this recommendation is to ensure the correct management of repeated defects from track recording train outputs within Colchester Maintenance Delivery Unit (paragraphs 259f, 261a, 261b, 264a and 265c).*

Network Rail should review the arrangements by which Colchester Maintenance Delivery Unit manages:

- repeated track geometry defects;
- repeated eighth-mile sections where the track geometry exceeds maximum and target standard deviation values;

and implement any necessary improvements.

4 *The intention of this recommendation is to ensure that there is sufficient provision of access to the line within the area managed by Colchester Maintenance Delivery Unit to carry out all required inspections of the track (paragraphs 261a, 261b and 265c).*

Network Rail should:

- review the arrangements within Colchester Maintenance Delivery Unit that allow staff to undertake inspections of the line within areas;
- identify where there are difficulties of access, such as red-zone prohibited areas;

and implement any necessary improvements.

5 *The intention of this recommendation is that preventative maintenance tasks are appropriately planned and briefed (paragraphs 258b, 262a, 265a and 265b).*

Network Rail should revise 'Track Maintenance Handbook' NR/L3/TRK/002 Issue 4 to add a requirement to undertake appropriate formal planning and briefing of staff prior to undertaking preventative maintenance tasks within its remit.

6 *The intention of this recommendation is that actions intended to prevent the reoccurrence of broken rails are identified and undertaken (paragraph 262b).*

Network Rail should revise its procedures relating to the reporting of broken rails to require:

- the production of formal action plans which will identify the actions proposed to prevent reoccurrence;
- a formal approval process for such action plans; and
- formal periodic review of progress against the action plans by an appropriate competent person.

continued

7 *The intention of this recommendation is that timber bearer replacements are subjected to post-installation inspection to confirm adequate consolidation (paragraphs 259a, 259b and 265d).*

Network Rail should revise work instruction NR/L3/TRK/002/G06 Issue 2.0 relating to the replacement of timber bearers, in order to add a requirement for an appropriate post-installation check of the work-site for ballast consolidation.

Appendices

Appendix A - Glossary of abbreviations and acronyms

CCTV	Closed circuit television
COSS	Controller of site safety
ERIC	Enhanced Railfreight Distribution Intermodal Control
IECC	Integrated Electronic Control Centre
JPT	Joint points team
ORR	Office of Rail Regulation
OTDR	On Train Data Recorder
RSSB	Rail Safety and Standards Board
TOPS	Total Operating Processing System
TRUST	Train Running System on TOPS
WAIF	Work arising identification form

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

Bearer	A term used to describe a wooden or concrete beam used to support the track, generally in switch and crossings.*
Bogie	A metal frame equipped with two or three wheelsets and able to rotate freely in plan, used in pairs under rail vehicles to improve ride quality and better distribute forces to the track.*
Cast crossing	A crossing (see below) made of cast manganese steel.
Catch pit	A sump fitted in track drains at regular intervals, to allow access to the pipes for cleaning.*
Cess	The part of the track bed outside the ballast shoulder that is deliberately maintained lower than the sleeper bottom.*
Cess rail	The rail adjacent to the cess.
Chain	A unit of length equal to 66 feet or 22 yards (approximately 20117mm). There are 80 chains in one standard mile.*
Closure rail	A short length of running rail used to complete a track assembly, particularly between two switch and crossing units.*
Continuous welded rail	A rail of length greater than 37m (120'), (or 55m (180') in certain tunnels).*
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 turnouts connected to permit movements between parallel tracks.*
Cyclic top	Regular vertical, medium wavelength variations from design level.*
Down	In a direction away from London.*
Drawgear	The collective term for all the equipment used to connect a rail vehicle to another rail vehicle for haulage purposes.*
Emergency protection	The emergency action carried to protect a mishap or failed train.*
Enhanced Railfreight Distribution Intermodal Control (ERIC)	The Enhanced Railfreight Distribution Intermodal Control system is a computerised system used to record the movement of containers.

Facing points	A Set of Points or Set of Switches installed so that two or more Routes diverge in the direction of travel.*
Field side	Describing the side of a Line or Track nearest the Cess, and so nearest the fields.*
Flat-bottom	A rail section with a flat based rail foot or flange.*
Four-foot	The area between the two running rails of a standard gauge railway.*
Gauge corner	The curved profile of the rail head between running surface and running edge.*
GEOGIS	Geography and Infrastructure System. A British Railways (BR) database holding information such as age, construction and responsibility for structures and track nationally.*
Green zone	A site of work which is on or near the line but within which there are no train movements (except for possibly engineering trains or on-track plant moving at no faster than walking pace). Green zone working is the preferred method of working on or near the line.
Headstock	The horizontal beam forming the end of a rail vehicle, used to attach couplings and buffers.*
Heel	The end of a crossing furthest from the crossing nose.*
Hogging	Hogging is a condition where the forces acting on an item cause the centre to rise in relation to the ends, thus causing the item to bend upwards. The opposite condition is known as sagging.
Improvement notice	When an ORR Inspector is of the opinion that a railway undertaking is contravening or has contravened and is likely to continue to contravene a relevant statutory provision, then they may issue an improvement notice to them under section 21 of the Health and Safety at Work Act 1974. An improvement notice will detail the nature of the contravention and the date by which it must be remedied. An improvement notice may or may not require specific remedial measures to be undertaken. Appeals against improvement notices may be made to an Employment Tribunal within 21 days of them being served. The entering of an appeal suspends an improvement notice until the appeal has been determined, but does not automatically alter the date by which the contravention must be remedied.
Insulated rail joint	A fish-plated rail joint in which one rail is electrically insulated from the abutting rail for signalling or electrification purposes, normally utilising insulated fishplates.*
Lipping	A description of the effect on a running edge being subjected to the rolling action by passing wheelsets, causing plastic deformation of the rail head.*

Millirad	An angle of one thousandth of a radian.
Non-strengthened fishplates	Fishplates that are not reinforced for carrying thermal stresses in continuously welded rail.
On Train Data Recorder	A data recorder fitted to traction units collecting information about the performance of the train.*
Pandrol clip	The colloquial term for types of sprung clips for flat bottom rails.*
Patrol diagram	A diagram indicating the extent and track layout of a basic track inspection, as specified in NRSP/TRK/001.
Patrol team	A team of track staff whose work is focused on carrying out inspection activities.
Production team	A team of track staff whose work is focused on carrying out maintenance activities.
Protect (a train)	The action of placing track circuit clips and detonators on the track to prevent a train running into a failed train, an obstruction, or a potential obstruction, on the track.
Protect (staff)	Systems to allow staff to work on the line without the risk of being struck by a moving train.
Rail clamp	Used to join 2 rail ends where there are no bolt holes. The fishplates are secured by adjustable clamps instead of fish bolts.
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. Network Rail produces Network Rail Company Standards that detail how the requirements of the Railway Group Standards are to be achieved on its system.*
Rail Safety and Standards Board	An independent rail industry body which manages the creation and revision of certain mandatory and technical standards, including Railway Group Standards, as well as leading a programme of research and development on behalf of government and the railway industry.
Red zone prohibited	A length of track on which work cannot be carried out safely if trains are running.*
Shallow depth	A switch assembly in which the switch rail is produced from a rail section of shallower depth than that used for the stock rail, allowing the switch rail to pass over the un-machined foot of the stock rail when the switch is in the closed position.*
Sidewear	A progressive removal of rail metal generally afflicting the high rail on curves, due to the high lateral forces produced when a train negotiates a curve with insufficient cant or high cant deficiency.*

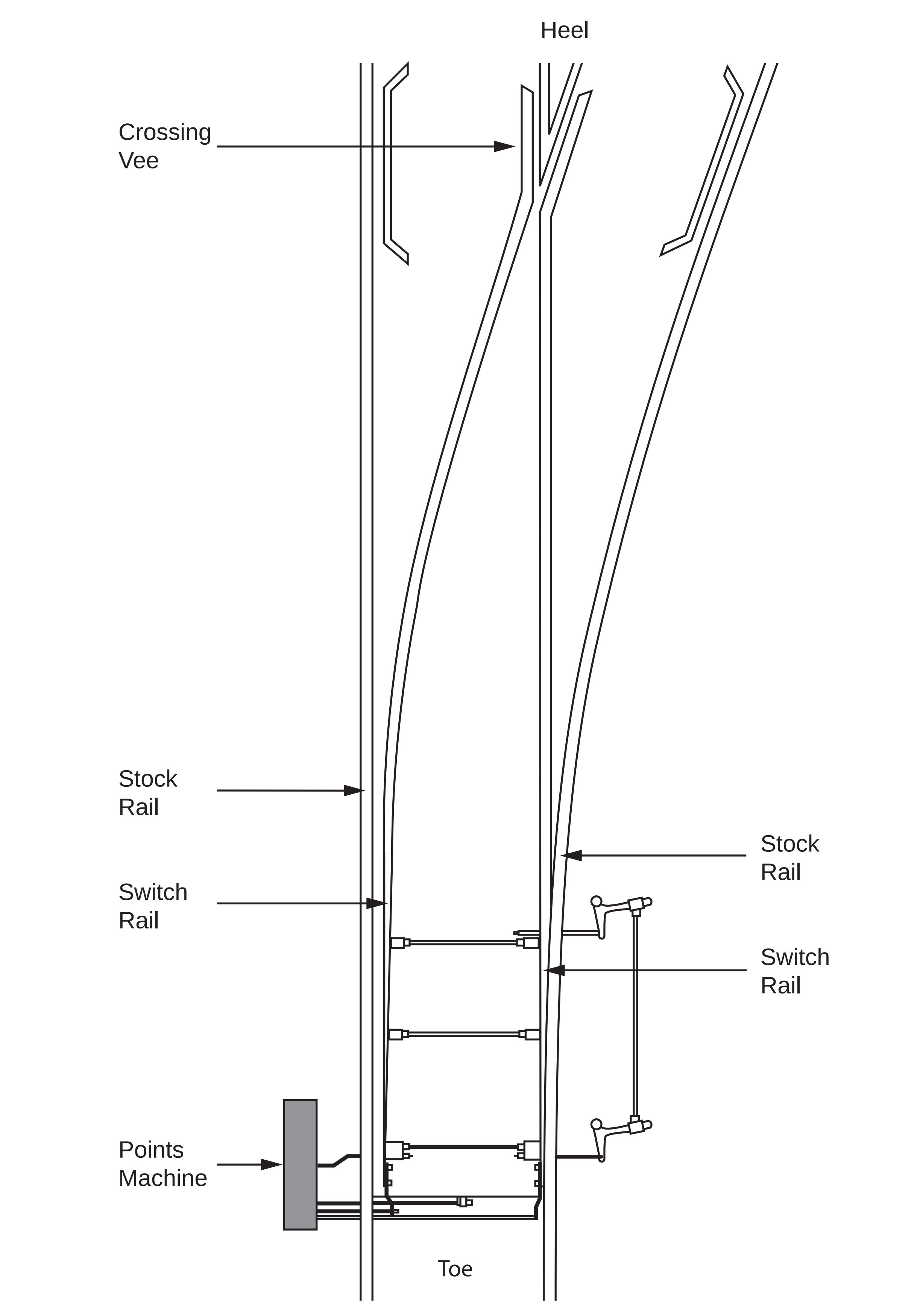
Single line working	The temporary use of one track for traffic working in both directions.*
Stock rail	The fixed rail in a switch half set. The other rail is the switch rail.*
Strengthened points	A prefix added to descriptions of Switch and Crossing Layouts to indicate that they are reinforced for welding into continuously welded rail.
Switches	An assembly of two movable rails (the switch rails) and two fixed rails (the stock rails) and other components (base plates, bolts, distance blocks, soleplates, stress transfer blocks and stretcher bars) used to divert vehicles from one track to another.*
T2D/T2H protection	A standard arrangement where the working party are only permitted to work until the next train is due to pass. This time is agreed with the Signaller prior to starting work.
T3 possession	The rules applying to Possessions of Running Lines, also known as Absolute Possession. Under these arrangements the times and extents are agreed in advance, but the engineer decides when the possession is given up, not the Signaller.*
T12 protection	A method of blocking a line for periods of less than 60 minutes, where the safety of the line will not be affected, to allow a small workgroup to work.*
Tamper	An On Track Machine that can lift and slew the track and simultaneously compact the ballast under the sleepers.*
Total Operating Processing System (TOPS)	Total Operating Processing System, a mainframe based computer system used to track rail vehicles. It deals with destination, load, location and maintenance information for all vehicles on the network.*
Track circuit block system	A signalling system where the line beyond is proved clear to the end of the overlap beyond the next signal using track circuits.*
Track gauge	A gauge that measures the horizontal distance between the rails (gauge), and the vertical difference between the rails (cant). Track gauges can also be used to measure check rail clearances, or to replicate wheel profiles at any point on the track.
Track twist	The change of cross level along a track measured over a specific distance.
Trailing points	A set of points where two routes converge in the normal direction of traffic.*
Trailing junction	A junction where two routes converge in the normal direction of traffic.*

Train Running System on TOPS (TRUST)	A computer system that processes reports of train running and compares them with the timetable.*
Up	Moving in a direction towards London.*
Vehicle Acceptance Body	A body given authority by the Rail Safety and Standards Board to exclusively undertake engineering acceptance for rail vehicles.
Voiding	The formation of spaces below sleepers in the packing area because of displacement of the supporting ballast.
WheelChex	WheelChex is a type of Wheel Impact Load Detector system. Both rails on a section of straight and level track are instrumented and measure the load imparted by a moving wheel. The primary function of WheelChex is to identify vehicles with wheels that are generating excessive dynamic loads on the rail head, so that these vehicles can be stopped before they damage the infrastructure.
Wheel flange	The extended portion of a rail vehicle's wheel that contacts the rail head and thus provides the wheelset with directional guidance.*
Wheelset	Two rail wheels mounted on their joining axle.*

Appendix C - Key standards current at the time

GE/RT 8000	The Rule Book for operations on Network Rail's infrastructure
GM/RT 2004 Issue 2	Requirements for Rail Vehicle Maintenance
GM/RT 2141 Issue 2	Resistance of Railway vehicles to Derailment and Roll-Over
NR/BS/LI/033 Issue 4	Letter of Instruction - Broken rail management: Use of dip angle outputs from track geometry recording
NR/PRC/MTC/PLC0159	Short-term work planning in maintenance
NR/SP/TRK/001 Issue 2	Inspection and Maintenance of Permanent Way
NR/L3/TRK/002 Issue 4	Track Maintenance Handbook
NR/L3/TRK/002/G06 Issue 2.0	S&C Change Timber Bearer
NR/L2/TRK/053 Issue 4	Inspection and repair to reduce the risk of derailment at switches
NR/SP/TRK/054 Issue 2	Inspection of cast crossings and cast vees in the track
NR/SP/TRK/6001 Issue 1	Management of Problem Statements
RT/CE/S/057 Issue 4	Rail Failure Handbook

Appendix D - Terms used in points



Appendix E - Chronology of events leading to derailment

Date	Event	Paragraph (s)
Mid 1970s	2390B points installed.	58
Late 1990s	2392A points installed.	59
April 2006	Track Maintenance Engineer A inspects Marks Tey visually – poor line and top recorded with a requirement for design of S&C tamp.	154
May 2007	Assistant Track Maintenance Engineer G visually inspects Marks Tey – no defects or observations recorded.	154
16 June 2007	Tamping at Marks Tey – did not cover 2390B points.	184
November 2007	Line through Colchester blocked to traffic after twist fault – local investigation by Track Maintenance Engineer A (then in post as Track Maintenance Engineer Colchester).	105
29 January 2008	Track recording run - detects a 3 metre twist fault of 1 in 179 at 46 miles 55 chains requiring correction within 14 days and a Category C cyclic top fault between 46 miles 55 chains and 46 miles 58 chains which required correction within 60 days.	164
6 February 2008	Broken rail at Marks Tey junction. Broken rail incident form subsequently completed by Assistant Track Section Manager C.	117
9 February 2008	The original planned replacement date for the switches in 2390B points; subsequently deferred as the switches had been used elsewhere.	118
11 February 2008	Track Maintenance Engineer A cab rides through Marks Tey. States S&C tamper required – Track Section Manager B responds that this tamping is planned.	155
12 February 2008	Assistant Track Section Manager C undertakes a cab ride through Marks Tey – reports that IRJ at heel of 2390B points needed lifting and packing within one month. Report signed off by Track Section Manager B.	152
February 2008	Track Maintenance Engineer A investigates broken rail and develops action plan.	117
22 February 2008	Track Section Manager B inspects track at Marks Tey. No comment on 2390B in inspection report, but accompanying walk-out report identifies multiple work tasks of lifting and packing, along with replacement of bearers, scheduled for March and April 2008. Report signed off by Assistant Track Maintenance Engineer G.	148
February 2008	Network Rail undertake a technical audit of Colchester Track Maintenance Engineer Organisation.	108
March 2008	Track Maintenance Engineer A leaves Track Maintenance Engineer Colchester post. Track Maintenance Engineer F takes over. No handover takes place.	109
1 March 2008	Tamping at Marks Tey – did not cover 2390B points.	185

Date	Event	Paragraph (s)
16 April 2008	Assistant Track Section Manager C undertakes supervisor's inspection. Vertical and horizontal alignment at 46 miles 60 chains graded as 'good', no comments made regarding 2390B points. Report signed off by Assistant Track Maintenance Engineer G.	148
23 April 2008	Track Maintenance Engineer F cab rides through Marks Tey – records poor ride. Track Section Manager B responds that it needs tamping.	156
29 April 2008	Track recording run, recorded no relevant faults.	165
May 2008	Reorganisation of Track Supervisory organisation carried out by Track Maintenance Engineer F.	112
16 May 2008	Area Track Engineer requests a progress report on behalf of Territory Engineer (Track), in respect of the broken rail action plan created in February.	121
27 May 2008	Track recording run detects: a Category C cyclic top fault between 46 miles 58 chains and 46 miles 59 chains, which required correction within 60 days.	166
31 May / 1 June 2008	Planned date to renew timbers in 2390B points. Cancelled due to staff shortages, re-planned for 6/7 June.	123
5 June 2008	Assistant Track Section Manager C briefs Trackman J on work to be carried out on 6/7 June (brief intended for Leading Trackman H, but he was not available).	125
6/7 June 2008	Four timbers changed near the heel of 2390B switches on down line. No-one observes train running over timbers at end of possession.	46, 131
9 June 2008	Assistant Track Section Manager C intended to carry out inspection of work. Due to other work, decides to postpone until 11 June, when he was scheduled to undertake supervisor's visual inspection of this location.	133
9 June 2008	Date of Trackman J's signature on form recording work. Form actually completed by Leading Trackman H.	129
10 June 2008	NR/L2/TRK/053 inspection of 2390B and 2392A switches– carried out in darkness by JPT.	159
10 June 2008	Track Maintenance Engineer F asks Assistant Track Section Manager C to carry out other duties on 11 June. Assistant Track Section Manager D carries out supervisor's visual track inspection of the line including Marks Tey junction in his place. No mention is made to Assistant Track Section Manager D of the bearers at 2390B points needing inspection.	134
11 June 2008	Assistant Track Section Manager D undertakes supervisor's visual track inspection of the line including Marks Tey junction – observes 2390B points from the cess and does not observe traffic pass over them.	149
12 June 2008	Derailment of 4L41.	23

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