Rail Accident Investigation Branch

Rail Accident Report

Derailment of two locomotives at East Somerset Junction 10 November 2008

Department for Transport

Report 28/2009
November 2009

This investigation was carried out in accordance with:

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

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Contents

Preface

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

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

Key Definitions

3 This accident occurred at East Somerset Junction, which is situated on the main line between Reading and Taunton, close to the village of Witham Friary in Somerset.

4 On the main line, all mileages are measured from a datum at Paddington (via Melksham); East Somerset Junction is at 120 miles 73 chains. The up line is used by trains travelling towards Reading and the down line by trains travelling towards Taunton.

5 There is a single track branch line from East Somerset Junction to Cranmore. All mileages on the branch are measured from a datum at East Somerset Junction.

6 Three appendices are provided at the rear of this report:

- abbreviations are in Appendix A;
- technical terms (shown in *italics* the first time they appear in the report) are in Appendix B;
- key standards current at the time are in Appendix C; and
- a paper on fatigue and the *Fatigue and Risk Index* is in Appendix D.

Summary of the Report

Key facts about the accident

7 At approximately 02:40 hrs on Monday 10 November 2008, the two locomotives hauling train 7A91, the delayed 22:31 hrs (Sunday) service from Merehead Quarry to Acton Yard, derailed on *trap points* at East Somerset Junction (Figure 1).

8 Nobody was injured in the accident.

9 The derailment caused damage to the track in the vicinity of the *points*. The position of the two locomotives made re-railing them difficult and it was not accomplished until 06:12 hrs on Tuesday 11 November 2008. The Merehead branch was reopened at 12:40 hrs the same day.

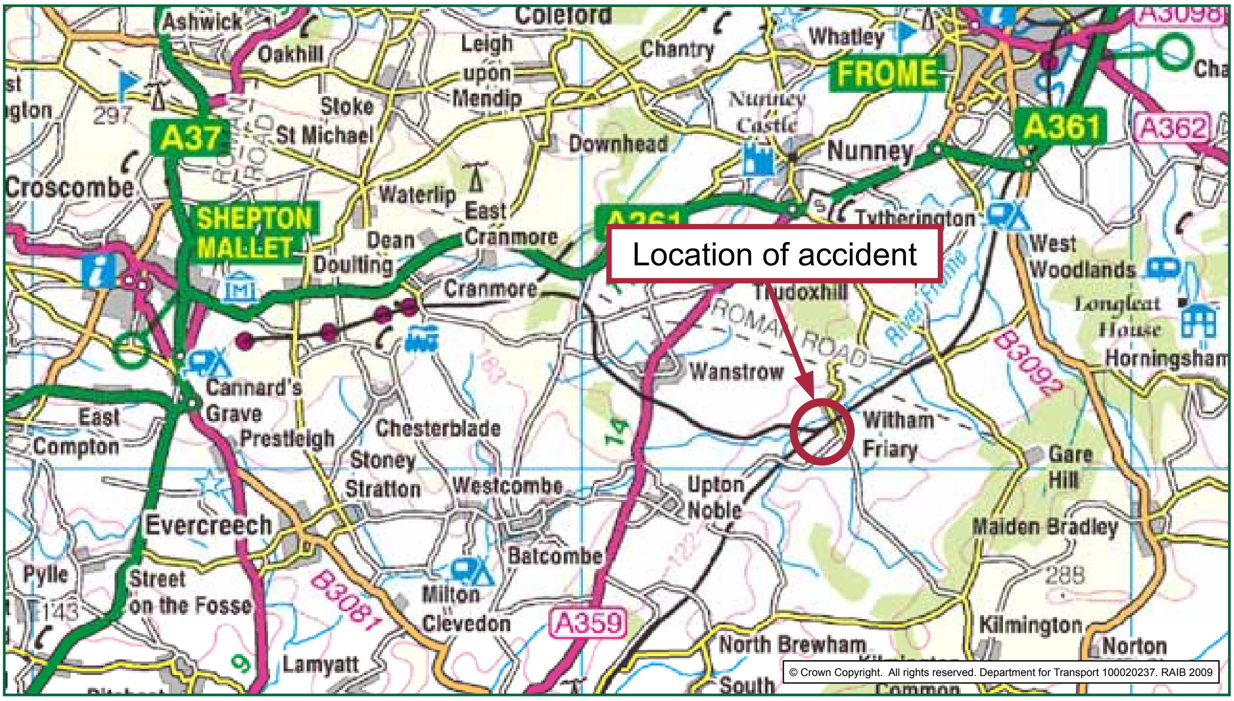


Figure 1: Extract from Ordnance Survey map showing location of accident

Management of fatigue by Network Rail

10 This investigation has found that signaller involved in the derailment at East Somerset Junction was probably suffering from fatigue. The RAIB and Network Rail have investigated other accidents and incidents where signaller fatigue was probably a causal factor (details are contained in paragraphs 127, 132 and 133 of this report). In some cases, recommendations were made which, had they been implemented, might have prevented the accident at East Somerset Junction. This report has examined why those recommendations were not implemented and has concluded that Network Rail considers that its current method of mandating a small number of working time limits and offering guidance to staff on good practice in avoiding fatigue is adequate to manage the overall risk. This report makes recommendations regarding Network Rail's management of fatigue.

Immediate cause, causal factors and underlying causes

11 The immediate cause of the accident was that the signaller did not operate a set of points (943 points) to the correct position for the safe movement of train 7A91 (Figure 2).

12 Causal factors were:

a. the failure of the signalling equipment on the Merehead branch;

b. the lack of a method over and above use of *route-setting cards* for helping the signaller to ensure that he had taken the correct actions in manually setting the route for train 7A91 at the time that pilot working was introduced; and

c. the signaller did not refer to his route-setting cards when setting a route for train 7A91 between two signals (signal W275 and signal W77; see Figures 2 and 3);

13 It is probable that the signaller's actions were affected by fatigue because of the number of hours and the nature of the shifts that he had worked in the period leading up to the accident. If this were the case, fatigue was a causal factor.

14 Underlying causes were:

a. the amended roster worked by the signaller was not subject to assessment using the Fatigue and Risk Index;

b. Network Rail's focus on a small number of working time limits as the principal mandated means for combating fatigue;

c. the absence of a suitable framework of controls to manage fatigue;

d. the absence of a human factors representative on Network Rail's Recommendations Review Panels; and

e. Network Rail did not have a formal monitoring system in place to identify recurring themes in accident and incident causation or the effectiveness of responses to previous relevant recommendations.

Recommendations

15 Recommendations can be found in paragraph 211. They relate to the following areas:

- assistance for signallers implementing procedures to address equipment failures while working alone;
- changes to the working arrangements at Westbury Power Signal Box;
- changes to the way Network Rail addresses fatigue in its safety-critical staff;
- improved processes for Network Rail to review recommendations from accident and incident investigations and identify common themes;
- the safety regulator's monitoring of changes in Network Rail's approach to fatigue management; and
- improved processes for Network Rail signallers, controllers and managers to prepare for, and deal with, incidents and accidents.

The Accident

Summary of the accident

16 At approximately 02:40 hrs on Monday 10 November 2008, the two locomotives hauling train 7A91, the delayed 22:31 hrs (Sunday) service from Merehead Quarry to Acton Yard, derailed on trap points at East Somerset Junction.

17 Nobody was injured in the accident.

18 The derailment caused damage to the track in the vicinity of the points. The position of the two locomotives made re-railing them difficult and it was not accomplished until 06:12 hrs on Tuesday 11 November 2008. The Merehead branch was reopened at 12:40 hrs the same day.

The parties involved

19 Train 7A91 was operated by English, Welsh and Scottish (EWS) Railways Ltd. This company has been owned by DB Schenker since June 2007, but continued to operate under the name of EWS Railways Ltd until January 2009. It was still branded as EWS Railways Ltd at the time of the accident at East Somerset Junction and is thus referred to as EWS in the remainder of this report.

20 The infrastructure was owned and operated by Network Rail; they also employed the signaller at Westbury *Power Signal Box* who controlled train movements at East Somerset Junction.

21 EWS (who employed the driver of train 7A91) and Network Rail freely co-operated with the RAIB's investigation.

Location

22 East Somerset Junction is the point at which the branch line from Cranmore joins the main line from Reading to Taunton (Figure 2). It is located approximately 11 miles (18 km) west of Westbury. The Merehead Quarry complex is located approximately four miles along the Cranmore branch, with two separate connections, one of which is normally used by trains arriving at the quarry and the other by trains departing from the quarry. The branch line is referred to as 'the Merehead Quarry branch' in the remainder of this report.

23 The main line comprises up and down lines and the maximum permitted speed is 100 mph (160 km/h) on both lines. They are referred to as the Up and Down Westbury lines.

24 The branch line approaches the area on the north side of the main line as a single track bidirectional line, but splits into a bidirectional branch line and a bidirectional branch loop line approximately 450 metres from the junction, thus providing two possible routes for trains running between the branch and the Up and Down Westbury lines (Figure 2). The maximum permitted speed for trains approaching the junction on the branch line is 25 mph (40 km/h).

25 There are two disused sidings located between the Up Westbury line and the branch line, designated as the 'up sidings'.

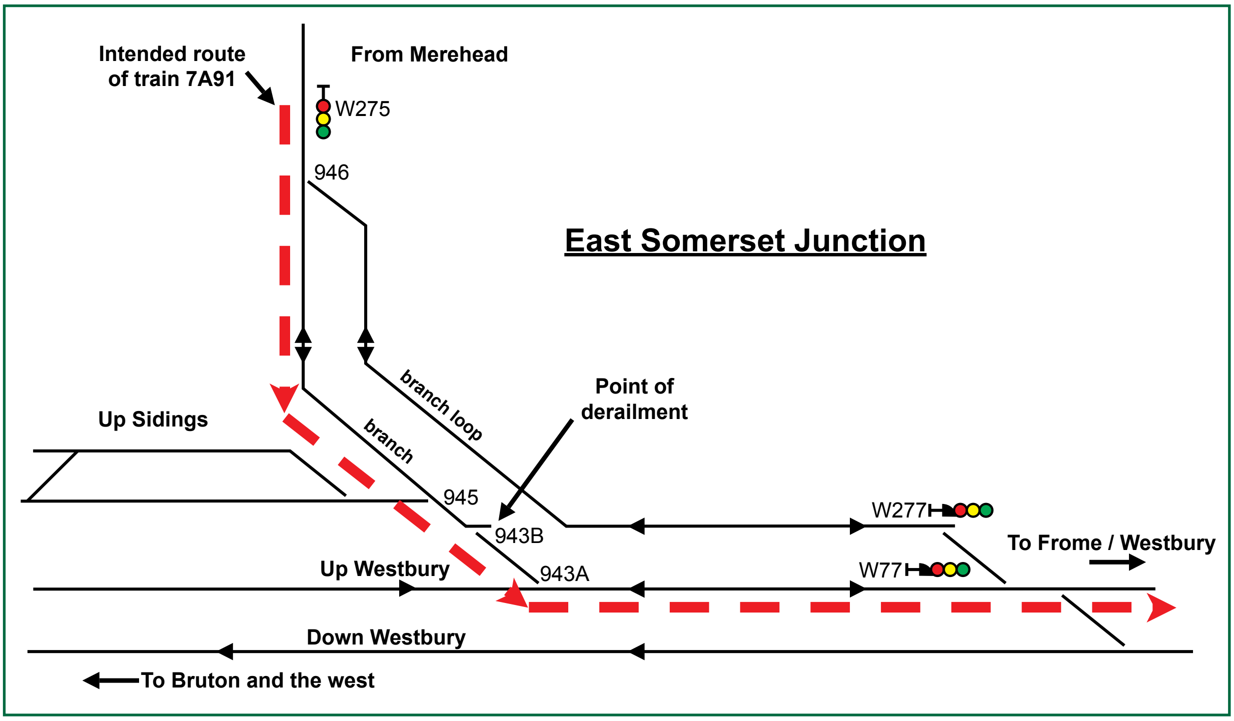


Figure 2: Track layout at East Somerset Junction

Train(s)/rail equipment

26 Train 7A91 comprised two class 59 *diesel electric locomotives* hauling 43 loaded wagons of types JHA and JNA. The JHA is a *hopper wagon* while the JNA is a *box wagon*. Both are designed to carry aggregates or coal and, when laden, each wagon can weigh up to 102 tonnes. The total weight of the train (including the locomotives) was 4505 tonnes.

27 Signalling on all lines at East Somerset Junction is in accordance with the *track circuit block regulations.* Signals and points are controlled by the signaller at Westbury Power Signal Box using a communications link with a *relay interlocking* and a local *relay room* at Witham Friary (East Somerset Junction).

28 The Up Westbury line is protected from trains approaching from the branch line by a set of trap points designated 943B points. These points are designed deliberately to derail any train approaching from the branch if the route has not been set for it. Thus, if a train approaches East Somerset Junction from Merehead and passes signal W275 at danger, it would be derailed on 943B points before it encroached onto the Up Westbury line, with the aim of avoiding a collision at the junction (Figure 2).

Events preceding the accident

29 At around 23:00 hrs on Sunday 9 November 2008, multiple *track circuit* and signalling control/indication failures occurred in part of the area controlled by Westbury Power Signal Box. The failures affected the Up and Down Westbury lines between Bruton and East Somerset Junction, and the Merehead Quarry branch.

30 The failures meant that all the colour light signals in the affected area were showing no *aspect* and all track circuits were showing occupied (even when no train was present). The signaller at Westbury Power Signal Box was unable to control any of the signals or points in the affected area using the buttons and switches on his control panel.

31 The signaller contacted the Operations Control office at Swindon to report the problem and the *signalling fault team* based at Westbury went to site to investigate the failure of the equipment.

32 Two passenger trains were timetabled to operate on the Down Westbury line in the immediate aftermath of the power failure. They were moved safely through the affected area by the signaller giving verbal authority to each driver to move from signal to signal (one at a time) as permitted by Railway Group Standard GE/RT/8000 (the *Rule Book*).

33 At the time that the power failure occurred, train 7A91 was ready to depart from Merehead Quarry for Westbury. It was necessary to introduce *pilot working* following the power failure to enable train 7A91 to operate between Merehead Quarry and East Somerset Junction because the branch was a single bidirectional line. Additional safeguards over and above those described in paragraph 32 were necessary to ensure that two trains did not travel in different directions over the branch at the same time.

34 Network Rail's Route Control office at Swindon dispatched a *Mobile Operations Manager* (MOM) to Merehead Quarry to act as *pilotman* for train 7A91.

35 At 00:25 hrs, the signalling fault team restored normal signalling arrangements to the Up and Down Westbury lines by replacing a blown fuse in Witham Friary relay room. The area affected by the failure was then confined to the Merehead Quarry branch alone, up to and including 946 points (Figure 2).

36 Pilot working was established at 02:15 hrs and train 7A91 departed from Merehead Quarry at around 02:20 hrs. The pilotman did not travel with the train and was not required by the Rule Book to do so.

37 The signaller intended to route train 7A91 from signal W275 via the branch line to signal W77 (Figure 2), but had to use individual switches on his control panel to move 945 points and 943 points to the correct position (943 points has separate ends designated 'A' and 'B', but they are controlled to the correct position simultaneously by operation of a single switch). Although 945 points were already in the correct position for train 7A91, 943 points were not. They were set for a train approaching East Somerset Junction on the Up Westbury line from the Bruton direction. The signaller did not change the position of 943 points.

38 The signaller could not monitor the train's progress on the branch as all the track circuits were showing occupied because of the power supply failure. He waited for train 7A91 to appear on the track circuits beyond 946 points, which it did at around 02:38 hrs. It was at that point that he realised that 943 points were not in the correct position for the safe movement of train 7A91.

Events during the accident

39 The signaller had no means of communicating directly with the train, and he therefore telephoned the Route Control office at Swindon, requesting that an emergency *National Radio Network* (NRN) call was made to stop the train. The signaller identified the train as '1A91' and it was necessary for the controller at Swindon to make a return call to the signaller to confirm that it was train 7A91 that was the subject of the signaller's request.

40 In the meantime, the driver of train 7A91 had reduced the speed of the train to 10.5 mph (17 km/h) as he approached East Somerset Junction and was looking to see what aspect signal W77 was displaying.

41 As the train approached 943B points, the driver saw that they were incorrectly set and applied the emergency brake. The train was only approximately 20 metres from the points and there was no time for a reduction in speed before the derailment occurred.

Consequences of the accident

42 Although shaken by the accident, the driver was uninjured.

43 Both of the locomotives derailed and the second locomotive and the first wagon on the train became *buffer-locked*. The locomotives were foul of the branch loop line and the Up Westbury line.

44 Minor damage occurred to the track in the vicinity of 943 points.

Events following the accident

45 The driver contacted the signaller by mobile telephone from the cab of his locomotive to advise him of the derailment. The signaller confirmed that he had not set the route correctly for train 7A91.

46 While the driver and signaller were in conversation, the emergency NRN call from the Route Control office was broadcast, asking the driver of train 7A91 to stop immediately and contact the signaller.

47 The driver of train 7A91 answered the call and told the controller that the train was already derailed. The controller acknowledged the message and terminated the call.

48 The signaller used signals to ensure that no trains approached the site of the accident (there were no trains in the vicinity at the time) and asked the MOM who had been acting as pilotman to go to East Somerset Junction to assess the situation. On arrival, the MOM confirmed that the derailed locomotives were very close to the Up Westbury line, but that the Down Westbury line was clear.

49 The driver of train 7A91 was collected from East Somerset Junction by his manager and taken to Westbury depot. He was screened for drugs and alcohol in accordance with normal industry practice, the results of which were negative (clear).

50 The Route Control Manager at Swindon called Network Rail's on-call manager for the area to advise him of the derailment. The on-call manager contacted the signaller and then made his way to Westbury Power Signal Box. He arrived there at around 05:30 hrs. He also alerted his own manager (the Thames Valley Operations Manager) who lived closer to Westbury and the latter arrived at Westbury Power Signal Box at approximately 04:30 hrs.

51 The signaller was screened for drugs and alcohol in accordance with normal industry practice at around 06:10 hrs, the results of which were negative (clear).

52 Single line working was introduced over the Down Westbury line at East Somerset Junction while arrangements were made to re-rail the two locomotives. Two rail-borne cranes were sent from Margam and Toton, arriving on site at 21:05 hrs. Meanwhile, all the wagons had been moved back to Merehead by 17:00 hrs.

53 Signalling on the branch was restored by 20:45 hrs on 10 November 2008. A new power cable was installed to by-pass a defective cable at the Merehead end of the branch, which had caused the failure of the signalling equipment the previous evening.

54 Both locomotives were re-railed by 06:15 hrs on Tuesday 11 November 2008. Repairs then commenced to the track in the vicinity of 943 points. The line was re-opened at 12:40 hrs on 11 November 2008.

The Investigation

Sources of evidence

55 The principal sources of evidence were:

- recordings of voice communications between the driver and signaller and the driver and controller;
- on-train data recorder output from the leading locomotive of train 7A91;
- interviews with key witnesses;
- meetings with Network Rail and EWS staff;
- personal/competence records for key witnesses;
- documentation and procedures covering the management of signalling failures affecting single lines;
- documentation describing the competence management arrangements for signallers and controllers;
- documentation covering rostering arrangements at Westbury Power Signal Box and local working instructions at the same location;
- the 'Fatigue and Risk Index' available from the Health & Safety Executive website[1]; and
- a report commissioned by the RAIB from specialists in sleep patterns and fatigue.

[1] Guidance on the Fatigue and Risk Index can be found on the HSE's website at http://www.hse.gov.uk/research/rrpdf/rr446g.pdf and the fatigue and risk calculator at http://www.hse.gov.uk/research/rrpdf/rr446cal.xls

Key Information

The failure of the signalling equipment on the Merehead Quarry branch

56 The loss of control over signalling equipment and the false indications regarding its status (paragraph 30) were caused by a failure in a 650V power supply cable in the vicinity of Merehead West.

57 The failure of power supply cables causes the signalling system to 'fail safe'. Drivers are required to treat signals showing no aspect in the same way that they would treat a signal showing a red aspect. The signaller, in conjunction with each train driver, implements procedures designed to secure the safe passage of trains.

58 Network Rail has indicated that it monitors the conditions of cables on a periodic and frequent basis. The monitoring includes tests for earth leakage to identify incipient failures.

59 The RAIB has not investigated why the cable failed. It had been installed in the early 1980s as part of the re-signalling of the Merehead branch. Cabling on the branch is currently on a list for renewal, provisionally scheduled for 2013/2014.

Issues relating to the signaller

The actions of the signaller

60 The signaller who was on duty at the time of the accident had started his shift before the signalling equipment had failed. When the failure occurred, a second signaller was also on duty, but in accordance with the arrangements at Westbury Power Signal Box, he was rostered to complete his duty at midnight. The signaller who was rostered to work beyond midnight could have asked his colleague to stay on duty because of the additional workload caused by the failure of signalling equipment, but he considered that he would be able to cope on his own.

61 The procedure adopted for safe movement of trains on the Down Westbury line could not be applied on the Merehead Quarry branch (paragraphs 32 and 33). The signaller therefore implemented pilot working on the branch line in accordance with module P2 of the Rule Book, 'Working single and bi-directional lines by Pilotman'.

62 Under pilot working, a pilotman personally gives the driver of each train authority to enter the single line. The pilotman operates under the direction of the signaller, who maintains an overview of operations on the single line and decides in which order trains will pass. The Swindon MOM acted as pilotman (paragraph 34).

63 Module T5 of the Rule Book, 'Operating power-operated points by hand', requires that each set of points that a train is required to pass over that cannot be controlled in the normal manner by the signaller has to be hand wound to the correct position and secured by a *point clip* and *scotch*. The signaller instructs the pilotman on which points have to be secured and defines the correct position. As the failure was affecting the branch line up to and including 946 points at East Somerset Junction and the branch loop (see Figure 2), the MOM secured 946 points in the *normal* position to enable train 7A91 to approach the junction over the branch line.

64 The MOM then went to Merehead Quarry to facilitate the departure of train 7A91. Trains departing from Merehead Quarry are initially propelled into a siding (White's siding at Merehead West) and then hauled towards East Somerset Junction. These moves are normally controlled remotely by the signaller at Westbury. However, the signalling equipment failure on the branch meant that the correct position of points had to be obtained and secured by the MOM locally.

65 The MOM needed precise instructions from the signaller as to the position of various points for the movements described in paragraph 64. Some points had to be wound into one position and secured for the propelling move and then wound to a different position and secured again for the train's departure.

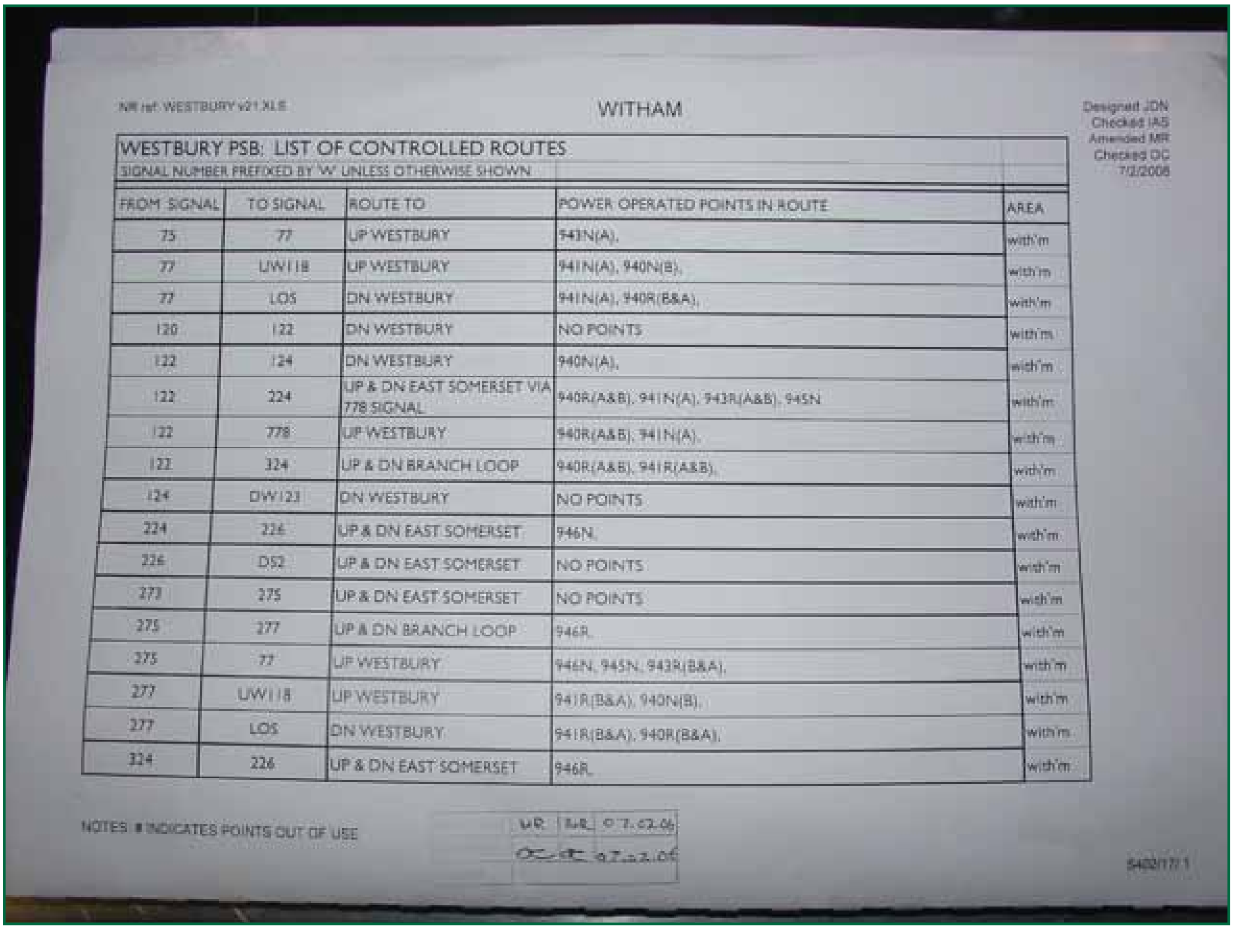
66 The signaller had decided that pilot working would extend from Merehead to signal W77 on the Up Westbury line (Figure 2) because signal W77 was the first signal outside of the area affected by the power failure and one that he could control normally. He gave instructions to the MOM on the completion of the pilotman's form (RT3154) and the driver's form (RT3156). The purpose of the forms is to provide the pilotman and the driver with a record of the arrangements that will apply. One of the requirements is that the signals to be ignored in the area affected by the failure are listed on form RT3156. The MOM did not do this, but identified only the signal to be passed at danger to enter the single line and the first signal to be obeyed at East Somerset Junction.

67 The driver of train 7A91 made his own note of the signals to be ignored on the back of the RT3156 form.

68 With no other trains in the vicinity, the signaller was able to clear signal W77 for the train to proceed towards Westbury. His expectation was that when the train arrived at East Somerset Junction, it would not stop.

69 Normally, the signaller would have set a route from signal W275 to signal W77 and the signalling equipment would have ensured that all points in that route (946, 945 and 943) were in the correct position for the safe movement of the train.

70 The signaller could not set a route from signal W275 to signal W77 because signal W275 was still affected by the failure. Under these circumstances, the signaller is expected to use route-setting cards (Figure 3) to ensure that points within the route are set for the safe movement of the train. The other signaller who was on duty in Westbury Power Signal Box until midnight had used them earlier in the evening for the movement of the two down trains through the area affected by the failure (paragraph 32).


NR ref: WESTBURY v21.XLS

WITHAM

Designed JDN
Checked IAS
Amended MR
Checked DC
7/2/2006

WESTBURY PSB: LIST OF CONTROLLED ROUTES
SIGNAL NUMBER PREFIXED BY 'W' UNLESS OTHERWISE SHOWN

FROM SIGNAL	TO SIGNAL	ROUTE TO	POWER OPERATED POINTS IN ROUTE	AREA
75	77	UP WESTBURY	943N(A),	with'm
77	UW118	UP WESTBURY	941N(A), 940N(B),	with'm
77	LOS	DN WESTBURY	941N(A), 940R(B&A),	with'm
120	122	DN WESTBURY	NO POINTS	with'm
122	124	DN WESTBURY	940N(A),	with'm
122	224	UP & DN EAST SOMERSET VIA 778 SIGNAL	940R(A&B), 941N(A), 943R(A&B), 945N	with'm
122	778	UP WESTBURY	940R(A&B), 941N(A),	with'm
122	324	UP & DN BRANCH LOOP	940R(A&B), 941R(A&B),	with'm
124	DW123	DN WESTBURY	NO POINTS	with'm
224	226	UP & DN EAST SOMERSET	946N,	with'm
226	DS2	UP & DN EAST SOMERSET	NO POINTS	with'm
273	275	UP & DN EAST SOMERSET	NO POINTS	with'm
275	277	UP & DN BRANCH LOOP	946R,	with'm
275	77	UP WESTBURY	946N, 945N, 943R(B&A),	with'm
277	UW118	UP WESTBURY	941R(B&A), 940N(B),	with'm
277	LOS	DN WESTBURY	941R(B&A), 940R(B&A),	with'm
324	226	UP & DN EAST SOMERSET	946R,	with'm

NOTES: # INDICATES POINTS OUT OF USE

MR | BR | 07.02.06

Figure 3: Route-setting card (the requirements for the route between signals W275 and W77 can be seen in the fourth row from the bottom)

71 The signaller would then use individual points switches on his panel to move each set of points to the correct position if he was able to control them remotely. This was the case for 943 and 945 points, which were now outside the area affected by the failure.

72 Module S5 of the Rule Book, 'Passing a signal at danger', is applicable because a signal showing no aspect is considered to be at danger, and the driver was required to pass signal W275 showing no aspect. The Rule Book states that when using route-setting cards to secure a safe route, the signaller should:

- operate the points to the position shown in the instructions;
- check that they have the correct indications; and
- ask a competent person, if present, to check the route setting.

73 The signaller did not undertake either of the first two actions and was unable to undertake the third because there was no other signaller present.

74 The signaller stated that he had located the relevant route-setting card, but for reasons that he was unable to explain, did not refer to it in order to set the route for train 7A91.

75 Once the train appeared on the track circuit beyond 946 points, the signaller was unable to move 943 points to the correct position because they were locked in place by the approaching train (a safety feature to ensure that a signaller cannot inadvertently change the position of points under a moving train). Hence, by the time that he realised 943 points were in the wrong position, the train was less than 500 metres from the points, and it was too late to change them.

76 The signaller called Swindon Route Control promptly to try to get train 7A91 stopped before it reached 943B points (paragraph 39).

77 In the aftermath of the derailment, the on-call manager contacted the signaller to ascertain his fitness to continue duty. On the basis of that discussion, the signaller remained on duty until relieved at 05:50 hrs, although accompanied by one of the on-call managers from 04:30 hrs. This is discussed further in paragraphs 119 and 120.

The medical fitness and competence of the signaller

78 The signaller involved in the accident had been in the signaller's grade since 1981 and had been a signaller at Westbury since 1984. He was taking medication, which had been checked by Network Rail's own occupational health specialists. The signaller was deemed fit to undertake his duties while using the medication. Neither the medication, nor the condition that it was treating, are considered to be causal or contributory to the accident.

79 The competence of Network Rail's signallers is assessed in a three-year cycle. The cycle for the signaller involved in the accident at East Somerset Junction commenced on 9 February 2007. During the three-year cycle, signallers are tested on the theory of different elements of the Rule Book relevant to their job by answering questions using a computer programme. The signaller involved in the accident at East Somerset Junction was tested on his knowledge of the theory of Module P2 of the Rule Book on 13 April 2007 and deemed competent.

80 In addition to this theory-based programme of testing, Network Rail company standard NR/L3/OCS/041, the O*perations Manual,* mandates how frequently signallers must be able to demonstrate practical experience of specific activities (e.g. degraded working because of equipment failure). Signallers maintain a record of all the incidents they have dealt with in a log book as evidence of their practical experience. In the absence of evidence of practical experience, the signaller's manager (the *Local Operations Manager* (LOM)) would use simulation to address the deficiency as part of the overall review of experience and competence towards the end of the three-year cycle.

81 The permissible methods of simulation according to the Operations Manual included discussions around paper-based scenarios, use of model railways and equipment simulators. For 'operating signalling equipment in degraded mode' (the situation that applied on the Merehead Quarry branch on the morning of 10 November 2008), the Operations Manual specified that simulation should be applied once in the three-year cycle if it did not naturally occur in that time.

82 The signaller involved in the accident at East Somerset Junction had not had recent experience of introducing pilot working. He had also not been exposed to any simulation exercises in the current three-year competence cycle. Such exercises would be unlikely to occur until early in 2010, i.e. towards the end of the three-year cycle if it became apparent that required competencies were not going to be met through experience.

83 The use of route-setting cards to ensure that points are set correctly is a Rule Book requirement that arises in a number of circumstances, such as:

- a failure that prevents the signaller from setting the route normally between two signals;
- a need to instruct a driver to pass a signal at danger; and
- arranging for a train to travel over a route for which there is no signalled move available, e.g. a wrong-direction move.

84 At the time of the accident, the signaller had had experience of three incidents where it had been necessary for him to use route-setting cards since his three-year assessment cycle started in February 2007.

The rostering of the signaller

85 Signalling staff are initially allocated work on a base roster. The base roster sets out how shifts will be covered when all staff allocated to a specific location (such as Westbury Power Signal Box) are available. The base roster is subject to amendment to take account of the planned non-availability of staff (such as for leave or training) and also to cover short-term contingencies (such as sickness).

86 The hours of duty on the base roster and the actual hours worked by the signaller in the four weeks before the accident are given in Table 1.

87 From 4 November 2008, the signaller started an alternating pattern of evening and night shifts, which meant that he completed his shift at midnight after one shift and 06:00 hrs after the next.

88 This shift pattern had been agreed between the signallers and their manager and had been in place since Westbury Power Signal Box had been single-manned between midnight and 06:00 hrs in 1996. The signallers at Westbury had agreed this roster pattern with local management as their preferred way of dealing with the need for two signallers between 06:00 hrs and midnight, but only one between midnight and 06:00 hrs in each 24 hour period.

89 The signallers' representative said that as a group, the staff at Westbury Power Signal Box preferred this arrangement because it meant that they did not have to undertake more than one night duty at a time.

90 However, it did lead to an irregular pattern of sleeping. Most signallers at Westbury tried to regulate their sleep by getting out of bed at a consistent time, around midday. Signallers would endeavour to sleep for up to 11 hours after working the shift that finished at midnight, but sleep for no more than 5 hours after working the shift that finished at 06:00 hrs.

91 The signaller involved in the accident at East Somerset Junction also followed this pattern, but could not always sleep for the whole time that he was in bed. On 9 November 2008, he had arrived home in the early hours of the morning (he lived close to his place of work) and had gone to bed between 01:30 hrs and 02:00 hrs. He had woken mid-morning and was unable to get back to sleep, although he remained in bed for a while. (On days when he finished work at 06:00 hrs, the signaller would not necessarily go to bed, but might take a few hours' sleep in a chair.)

92 This investigation has identified that the hours worked by the signaller in the days preceding the accident meant that it was probable that he was suffering from fatigue in the early hours of 10 November 2008 (see paragraphs 106 and 107).

Date (all 2008)	Base Roster (hours' duration)	Actual hours worked (duration)
12 October	18:00-24:00 (6)	18:00-24:00 (6)
13 October	18:00-06:00 (12)	18:00-06:00 (12)
14 October	18:00-06:00 (12)	18:00-06:00 (12)
15 October	18:00-24:00 (6)	18:00-06:00 (12)
16 October	Rest Day (0)	18:00-06:00 (12)
17 October	Rest Day (0)	18:00-06:00 (12)
18 October	Rest Day (0)	Rest Day (0)
19 October	Sunday Off Duty (0)	06:00-18:00 (12)
20 October	Rest Day (0)	18:00-24:00 (6)
21 October	Rest Day (0)	Rest Day (0)
22 October	06:00-18:00 (12)	06:00-18:00 (12)
23 October	06:00-18:00 (12)	06:00-18:00 (12)
24 October	06:00-18:00 (12)	06:00-18:00 (12)
25 October	18:00-06:00(12)	18:00-24:00 (6)
26 October	Sunday Off Duty (0)	Sunday Off Duty (0)
27 October	06:00-18:00 (12)	Leave (0)
28 October	06:00-18:00 (12)	06:00-18:00 (12)
29 October	06:00-18:00 (12)	06:00-18:00 (12)
30 October	Rest Day (0)	07:30-18:00 (10.5)
31 October	Rest Day (0)	06:00-18:00 (12)
1 November	Rest Day (0)	18:00-06:00 (12)
2 November	Sunday Off Duty (0)	Sunday Off Duty (0)
3 November	Rest Day (0)	Rest Day (0)
4 November	18:00-24:00 (6)	18:00-24:00 (6)
5 November	18:00-06:00 (12)	18:00-06:00 (12)
6 November	18:00-24:00 (6)	18:00-24:00 (6)
7 November	18:00-06:00 (12)	18:00-06:00 (12)
8 November	18:00-24:00 (6)	18:00-24:00 (6)
9 November	18:00-06:00 (12)	18:00-06:00 (12)
Total duration	**174 hours**	**238.5 hours**

Table 1: Comparison between base roster and actual hours worked by the signaller involved in the derailment at East Somerset Junction on 10 November 2008 (deviations from the base roster have been highlighted)

Legal requirements on working hours and the management of fatigue

93 The Working Time Regulations (1998) implement the European Working Time Directive into British law. The Regulations were amended, with effect from 1 August 2003, to extend working time measures in full to all workers in the railway industry.

94 The basic rights and protections that the Regulations provide include:

- a limit of an average of 48 hours a week which a worker can be required to work (though workers can choose to work more if they want to);
- a limit of an average of 8 hours work in 24 which nightworkers can be required to work;
- a right to 11 hours rest a day; and
- a right to a day off each week;

95 The Regulations do not apply in full to those workers in railway transport whose 'activities are linked to transport timetables and to ensuring the continuity and regularity of traffic' (such as signallers). In addition, workers in the United Kingdom are able to opt-out of the weekly working time limits and many in the railway industry do so. Where working time limits derived from the European Working Time Directive do not apply, or where workers have opted-out, limits on working time may still be defined by employers in individual industries. Paragraphs 101 and 102 describe the limits applied by Network Rail.

96 Legal requirements on railway operators relating to fatigue are contained in the Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS). Regulation 25 covers fatigue and states:

> 'Every controller of safety critical work shall have in place arrangements to ensure, so far as is reasonably practicable, that a safety critical worker under his management, supervision or control does not carry out safety critical work in circumstances where he is so fatigued or where he would be liable to become so fatigued that his health or safety or the health or safety of other persons on a transport system could be significantly affected.'

97 The Office of Rail Regulation (ORR) has issued guidance on the regulations[2]. It identifies the following factors that influence fatigue levels:

- how overtime is controlled;
- the nature of the work (for example, where workers have to carry out repetitive tasks or where a task requires a very high level of alertness);
- the workload and working environment;
- a roster design that prevents workers from getting enough sleep between shifts;
- workers' sleep being disturbed because they are 'on-call';
- how often workers have breaks;
- recovery time during periods of work; and
- how long it takes workers to travel to and from work.

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[2] The Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS): A guide to ROGS, Office of Rail Regulation. Available at http://www.rail-reg.gov.uk

98 The guidance advocates a nine-stage process for managing the risk arising from fatigue in safety-critical workers (signallers are classified as safety-critical workers). Those steps are:

- identify the safety-critical workers affected;
- identify, set and keep to appropriate standards and good practice for working hours and working patterns, observing any relevant working time limits;
- ensure that standards and limits are only exceeded with prior approval, infrequently and in exceptional circumstances;
- consult safety-critical workers by involving them and their safety representatives on arrangements for managing fatigue and when standards and limits are to be changed;
- record the arrangements;
- provide information to safety-critical workers on risks to health and safety arising from fatigue and arrangements made for managing fatigue;
- monitor the arrangements for managing fatigue to assess how effectively the risk is being managed;
- ensure, so far as is reasonably practicable, that workers who come to work while clearly affected by fatigue do not carry out safety-critical tasks and that workers who become affected by fatigue during a shift do not continue carrying out a safety-critical task; and
- review the arrangements if there is reason to doubt their effectiveness.

99 The ORR has not issued limits on working time for workers in the railway industry and currently has no specific work programme planned for addressing fatigue in signallers. The ORR advises that it focuses its regulatory efforts on the areas they believe to be of greatest risk. In terms of fatigue management, the ORR judges that the greatest risk is currently with maintenance depot staff, and they are focusing on this area. The ORR states that it would take formal action (which may comprise advice, a letter, improvement notice or prosecution) if they find significant risk resulting from failures to manage fatigue.

100 After the accident at East Somerset Junction, the ORR provided advice to Network Rail on the risk associated with the roster being worked by signallers at Westbury. The ORR states that Network Rail advised them that they intended to review and revise rosters in the Thames Valley area. Network Rail has not yet changed the Westbury signallers' roster on the basis that it is compliant with its own standards.

Network Rail's approach to the management of fatigue

101 Network Rail company standard NR/SP/ERG/003, 'Control of Excessive Working Hours for Persons Undertaking Safety Critical Work', contains Network Rail's mandated approach to those legal requirements. It has the objective of securing rostering arrangements for safety-critical staff that are 'designed to minimise the build up of fatigue and allow fatigue to dissipate by ensuring adequate rest between shifts and blocks of shifts'. The standard focuses on the need to comply with a set of rules on working time. The rules applied by Network Rail relevant to signallers are:

- no more than 12 hours to be worked per shift;
- no more than 72 hours to be worked per week;
- a minimum rest period of 12 hours between booking off from one duty and booking on for the next (can be reduced to eight hours at weekly shift changeover); and
- no more than 13 turns of duty to be worked in a 14-day period.

102 The hours defined are those that were generally adopted by the railway industry after the publication of Sir Anthony Hidden's inquiry report into the collision that occurred at Clapham Junction on 12 December 1988, which identified excessive overtime as one of the factors in the causal chain of the accident. They are often referred to in the railway industry as the 'Hidden limits'. The rostering process employed at Westbury Power Signal Box took into account the Hidden limits.

The Fatigue and Risk Index and its use by Network Rail

103 Appendix D defines fatigue and describes the Fatigue and Risk Index (FRI) which is used by Network Rail to evaluate the risk of fatigue in signallers' base rosters.

104 The FRI has some limitations in that it deals with averages only and takes no account of individual factors such as age, fitness, etc. It also takes no account of an individual's lifestyle outside work, including the amount or quality of sleep obtained preceding a shift. The FRI does, however, enable effective comparisons to be made between different shift roster patterns.

105 Network Rail uses the FRI when determining the likely impact of fatigue on base rosters, focusing on the fatigue element of the index rather than the risk element. Network Rail does not use the FRI to determine the likely impact of fatigue on amended rosters. It is necessary to amend rosters when staff are unavailable, for example because of sickness, training, leave, etc. In order to provide cover for unavailable staff, general practice within Network Rail is to allocate enough staff to locations such as Westbury Power Signal Box to provide a level of cover for the contingencies described. Spare resources provided in this way will be used, if available. In the absence of spare resources, staff will be asked to work additional hours or on their rest days. The arrangements that apply to asking staff to work such additional duties are often agreed at local level and designed to ensure that all staff have an approximately equal opportunity to work overtime.

106 Westbury Power Signal Box is allocated ten signallers to cover its base roster. At the time of the accident, there was one vacancy and a further member of staff had been unavailable for signalling duties for several weeks. It was therefore necessary to amend the base roster to address the shortfall. In the 28 days leading up to the accident, the signaller involved in the accident at East Somerset Junction had deviated from the base roster pattern, working an additional 64.5 hours (Table 1). During that period, he should have had twelve days off duty, but in practice only had six, the equivalent of 1.5 additional duties per week. When the actual hours that he worked are entered into the FRI, the output is a fatigue score of 48.5 for the shift in which the accident occurred. This is above the benchmark value of 45 (see Appendix D). The base roster value was also high at 43, but below the benchmark. The risk index figure for the shift in which the accident occurred was 1.86. At other times in the preceding 28 days, the fatigue index reached a peak of 51.1 (during a fourth consecutive 12-hour night shift) and the risk index reached a peak of 1.98. Figures 4 and 5 show the fluctuations in the fatigue and risk indices in the 28 days leading up to the accident.

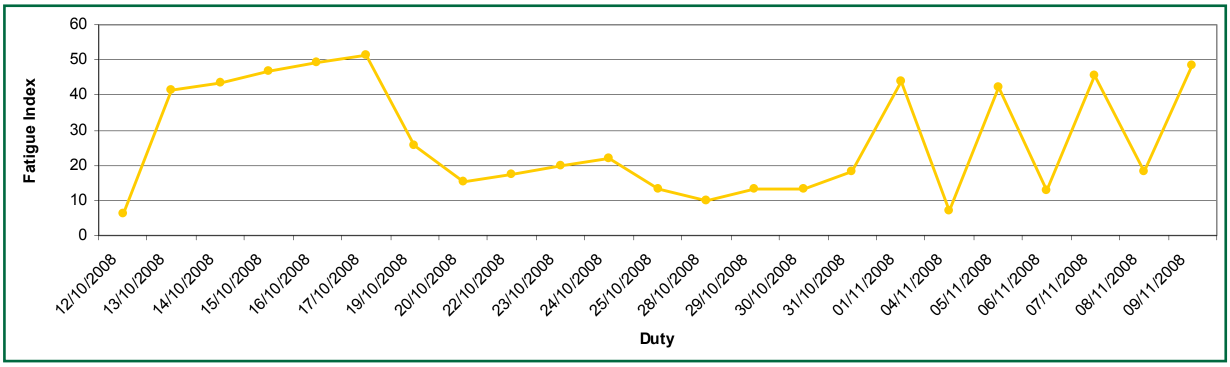


Figure 4: Fatigue index for the shifts worked by the signaller in the four weeks leading up to the accident

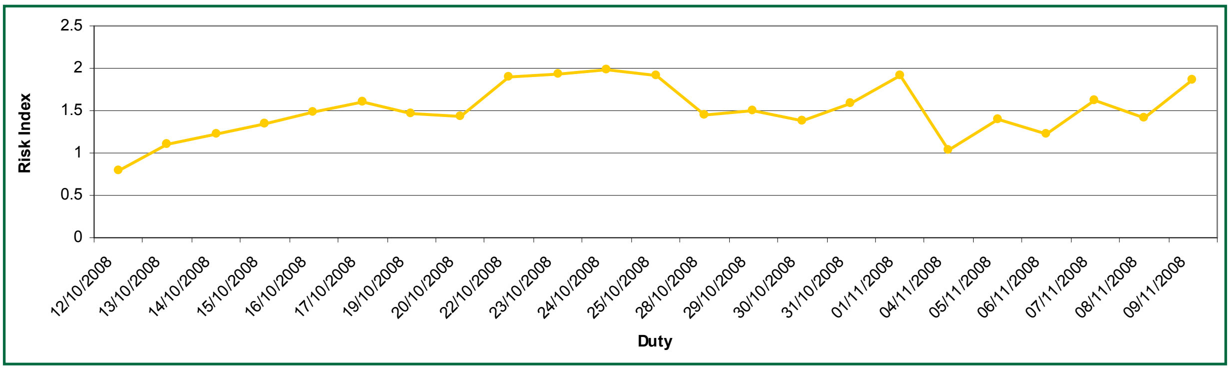


Figure 5: Risk index for the shifts worked by the signaller in the four weeks leading up to the accident

107 Paragraph 106 and Figures 4 and 5 indicate that it was probable that the signaller involved in the accident at East Somerset Junction was suffering from fatigue at the time.

The actions of the controller

108 When the signaller placed the emergency call to the controller in Swindon Route Control (paragraph 39), it was answered by the incident controller for the area that included East Somerset Junction. There are six controllers on duty in the Control office: an incident controller (responsible for managing Network Rail's response to incidents) and a train running controller (responsible for managing the effects of an incident on train services) for each of three geographical areas of the route.

109 The train running controller for the same area listened-in to the call. This arrangement allowed him to start taking action while his colleague dealt with the initial call. The train running controller assumed responsibility for calling the driver of train 7A91, but had first to call back the signaller at Westbury Power Signal Box to confirm that it was train 7A91 that needed to be stopped (paragraph 39).

110 Once the train running controller had received confirmation, he made the emergency call. When the driver responded and stated that his train had already derailed, the controller acknowledged the message and ended the call. He did not use the facility available within the NRN system to alert other drivers in the area of the derailment or speak to the signaller at Westbury Power Signal Box to advise him of the derailment as required by Network Rail company standard, NR/L3/OCS/043/2.1, National Control Instructions. He did not ask whether the driver needed assistance, establish which lines were affected or confirm whether the driver was in contact with the signaller. Controllers' managers were in general agreement that this was information that a controller should try to obtain when advised of an accident, but it is not formalised in any procedure and no reference is made to it in the National Control Instructions. It was, however, potentially important information that could have been secured while the controller was in contact with the driver.

111 The train running controller had worked in that position with Network Rail since March 2006. He had received specific NRN training when he joined Network Rail and had undertaken job-specific competence assessments before being rostered as a controller.

112 However, he had limited experience of making emergency NRN calls. He had only occasionally stopped a train at the request of a signaller, and only once had he taken a call from the driver of a train that required him to stop other trains in the area. The train running controller's training included situations where a train had been involved in an incident or accident, and it is the controller's responsibility to alert all other drivers in the area to stop. On the morning of 10 November 2008, having asked the driver of train 7A91 to stop, he was advised that it had already derailed. This took the train running controller out of his learned routine for responding immediately to incidents, as the situation changed from warning a driver to take action, to handling a derailment.

113 The arrangements for maintaining the competence of both train running and incident controllers are contained in Network Rail's Operations Manual (procedure 4-09, 'control centre competence standard'). This includes a breakdown of the controller's role into individual elements, and identifies the competence required for each one. It specifies how often the controller needs to have actual experience of each element and how that competence can be maintained in the absence of specific experience.

114 The element most relevant to the accident on 10 November 2008 was 'train radio communication systems' (element 2.2). The performance criteria associated with this element were that controllers must ensure that they can:

- make emergency broadcasts using NRN;
- use correct communication protocols;
- make a general call to a specific train;
- answer NRN calls; and
- deal with emergency calls appropriately.

115 The controller's competence cycle lasts three years and started in September 2007. The standard specifies that the controller's knowledge of element 2.2 should be tested once in the assessment cycle, i.e. once between September 2007 and September 2010. The Operations Manual states that simulation is 'not applicable' as a means of maintaining competence for element 2.2.

116 There is little documentary information on giving and receiving emergency NRN messages in Network Rail's procedures. The National Control Instructions provide only limited guidance, focused on the mechanics of making such calls rather than the content of them. Material given to controllers during training is similar. There is no specific documented information that provides guidance to a controller on the key items of information to obtain when advised of an emergency (paragraph 110).

The response of Network Rail's managers to the accident

117 Network Rail operates a two-line on call system. In the Thames Valley area, first-line on-call is provided by the LOMs. There are six of them, each with a geographical area of responsibility. At any one time only one of the six LOMs is on-call to respond to incidents or accidents throughout the whole of the Thames Valley area.

118 At the time of the derailment, second-line on-call was provided by senior managers in the Thames Valley area. Second line involvement happens when a major incident or accident occurs which might have a serious effect on train services.

119 On the night of the accident, the LOM on-call was located at the London end of the Thames Valley Area. He had an initial conversation with the signaller at Westbury to establish the circumstances of the accident. Although the LOM intended to go to Westbury, he was approximately 80 miles away. He discussed the accident with the second line on-call manager who decided to go to Westbury as well because he lived closer than the LOM. Before setting off, he asked the LOM to see if the signaller could find another signaller to take charge of Westbury Power Signal Box.

120 The signaller had no recollection of the request to find his own relief and did not do so. The on-call managers took the decision to allow the signaller to continue working on his own until one of them was able to get to Westbury Power Signal Box. In taking that decision, the second-line on-call manager stated that they were guided by four factors:

- no replacement could be found (although it is unlikely that one was sought);
- the immediate cause of the accident had already been established;
- the signaller had said that he was happy to continue and they judged that he was fit to do so; and
- it would be for a limited period because the second-line on-call manager could reach Westbury within 90 minutes.

121 Network Rail's guidance to managers on dealing with staff involved in an incident or accident is contained within Procedure 2-05 of the Operations Manual, 'Action to be taken with employees following an incident'. Section 8 states:

> '…an assessment must be made as to whether (the staff involved) are likely to have been affected by the nature of the incident and if so, whether they should be allowed to continue their duty or should be relieved as soon as possible. The assessment should include the severity and possible trauma of the incident, complexity of any degraded mode operation to be worked, and whether the employee is already subject to the Additional Monitoring and Support regime. During the initial interview with the employee following the incident, which should preferably be conducted face to face but for remote locations where no Duty/Shift Manager is employed may be conducted by telephone, the local manager must ask them whether they feel fit to continue duty.

122 The second-line on-call manager reached Westbury Power Signal Box at around 04:30 hrs and remained with the signaller until the latter was relieved by a colleague at 05:50 hrs.

Network Rail's process for reviewing recommendations from investigations into accidents and incidents

123 Paragraph 106 and Figures 3 and 4 provide evidence that the signaller involved in the accident at East Somerset Junction was probably suffering from fatigue at the time that the accident occurred. The following section of this report contains details of a selection of accidents and incidents occurring on Network Rail infrastructure where fatigue was an issue in the causal chain, including a number involving signallers. It also refers to actions taken by Network Rail's Recommendations Review Panel in relation to recommendations on fatigue arising from the investigations into those accidents and incidents.

124 The Recommendations Review Panels have changed in structure in the period between 2002 and 2008 (the period in which the incidents and accidents referred to in the following section occurred). As a general rule, Recommendations Review Panels have existed at national and local level during that period. The National Recommendations Review Panel considers recommendations which have national significance, while route-based Recommendations Review Panels consider recommendations relevant only to the locality in which the accident or incident occurred.

125 The Recommendations Review Panels are constituted from specialists in engineering and operating disciplines from within Network Rail. A specialist with a human factors background attends the National Recommendations Review Panel as an observer.

126 Network Rail does not currently have a formal process in place to monitor recurring themes in accident and incident causation. The Recommendations Review Panels rely on the memories of individual members to identify common themes in accident causation.

Previous occurrences of a similar character

Previous incident in the Westbury area

127 On 4 May 2005, a derailment occurred at Westbury North Junction in the early hours of the morning when points were moved under a *tamping machine.* It happened during an *engineers' possession* when the tamping machine was making a movement which was not a normal signalled move. Network Rail investigated the accident and concluded, on the balance of probability, that the signaller in Westbury Power Signal Box had moved the points under the train. One contributory factor identified in the investigation was that at the time of the accident, the signaller was working his seventh consecutive shift in an alternating 6- and 12-hour roster pattern.

128 Network Rail's investigator identified this shift pattern (which was the same as that being worked by the signaller involved in the accident at East Somerset Junction on 10 November 2008) as causing a lack of continuity with regard to taking rest and said that this might lead to fatigue. The investigator recommended that Network Rail should consider reviewing the number of consecutive shifts involving late evening and night work that signallers undertake in order to reduce the risk of fatigue.

129 Network Rail's National Recommendations Review Panel rejected the recommendation on the basis that a number of fatigue studies had been undertaken (these were not specified by the Panel) and standard rostering principles (not identified by the Panel) had been introduced. It also referred to the investigation report identifying 'that the signaller was not considered to be fatigued at the time of the incident'. The report did not do this, although it did identify that the signaller involved in the accident did not consider that he was suffering from fatigue.

Previous incidents involving signaller fatigue investigated by Network Rail

130 Since 2001, the Rail Safety & Standards Board (RSSB) has maintained a library of accident and investigation reports compiled by the railway industry. Fatigue has been referred to in nearly 200 investigations in that period, although it was only considered a possible causal or contributory factor in 74 investigations. Of those 74 investigations, the vast majority (67) relate to fatigue possibly affecting drivers. Many of the incidents involve a signal being passed at danger and in most cases, safety systems intervened to prevent an accident occurring. One further incident involved fatigue possibly affecting a member of staff involved in supervising the safety of a work group undertaking engineering activity on the railway.

131 The 68 incidents provide an illustration that some of the factors that affect fatigue are external to the work place. In a number of cases, individuals involved had experienced insufficient or poor quality sleep in the day or days leading up to the incident caused by factors such as hot weather, health problems, noise from adjacent building work or neighbours and disturbance by young children. Many of these issues have a potentially significant impact on an individual's propensity to fatigue, particularly for those who work at night and need to sleep during the day or immediately before reporting for duty. Such factors are outside the scope of the FRI, which focuses on working hours and shift patterns only (paragraph 104).

132 The remaining six incidents[3] on the RSSB database involved signallers:

- On 18 September 2002, a freight train passed a signal at danger at Aylesbury. An underlying cause of the incident was that the signaller gave ambiguous information and failed to ensure a clear understanding had been reached in respect of the movement of the train. The investigation found that because of staff shortages, the signaller had been working long hours in the weeks leading up to the incident and that the Fatigue Index 'thresholds' had been exceeded throughout that period. The investigation team concluded that there was a 'high potential for a fatigue-based concentration lapse to have contributed to this incident'. They recommended that Network Rail review its procedures for monitoring excessive hours to incorporate assessments for potential fatigue in roster patterns and to cater for exceptional circumstances such as in the event of staff shortages. Network Rail's Recommendations Review Panel rejected the recommendation in March 2003 on the basis that its standard on control of excessive working hours for persons undertaking safety-critical work 'already covered the situation'. The standard referred to was the forerunner to NR/SP/ERG/003 (paragraph 101), with similar content.

[3] All of these incidents and the derailment at Westbury North occurred in the period September 2002 to May 2005. The RAIB became operational in October 2005 and only investigated incidents occurring after that date.

- On 25 February 2003, a passenger train was derailed at Hemel Hempstead on the West Coast Main Line when a signaller incorrectly operated points which were under his manual control as the train was passing over them. The signaller had worked 11 consecutive night shifts, some of which had been of 12 hours' duration. The Fatigue Index score was above the 'threshold' at which there is a high probability of an individual's actions being affected by fatigue for nine consecutive shifts, although it was slightly below the 'threshold' for the shift in which the accident occurred. The investigation team recommended that Network Rail should arrange the signaller's roster to minimise fatigue. This recommendation was later rejected by Network Rail's Recommendations Review Panel because it believed that a fatigue index was in existence and should be applied.
- On 25 June 2003, a locomotive passed a signal at danger at Thornton Fields in east London. Although not deemed causal or contributory to the incident, the investigation found that it was likely that the signal was not cleared because of an error on the part of the signaller. The investigation found that both the driver and the signaller involved in the incident had 'elevated values' in the Fatigue Index. The investigation team recommended that Network Rail should review its arrangements for the management of working hours for signallers, with the intention of ensuring that shift patterns worked by signallers are designed to minimise the risk of fatigue (a similar recommendation was made to EWS in respect of the driver). This recommendation was rejected by Network Rail's National Recommendations Review Panel in June 2004. The reason for its rejection was not recorded in the notes of the meeting.
- On 12 October 2003, a freight train derailed at Wigston North Junction after running through points. There was a misunderstanding between the driver and the signaller over a shunting movement to be made. In this case, the scores from the Fatigue Index for the signaller and the driver were below the 'threshold' where there is a high probability that an individual's actions will be affected by fatigue. However, the signaller had not slept well in the preceding week and was feeling tired. The investigation team concluded that the 'signaller's omissions could be aligned to the effects of tiredness and fatigue', citing the signaller's tiredness as an underlying cause of the accident. They recommended that the signaller receive a 'lifestyle brief' in order to provide him with guidance on how he could increase the quality and quantity of sleep obtained between shifts. This was a 'local' action and not therefore subject to review by a Recommendations Review Panel.

- On 25 November 2003, a signaller at Lostwithiel authorised the driver of a passenger train to pass a signal at danger and proceed through a single line section during pilot working (because of equipment failure). The signaller did not move one set of points to the correct position for the safe movement of the train, but the driver saw this as he approached the points and stopped before reaching them. The signaller had worked 72 hours in seven days: four twelve-hour night turns and two twelve-hour day turns separated by a rest day. The period of rest was only 24 hours between the last night turn and the first day turn. The Fatigue Index 'threshold' was exceeded for the night turns and for the day turn when the incident happened. The signaller stated that he felt tired. The investigation team concluded that fatigue 'could have been an issue' and recommended that Network Rail should introduce a minimum rest period for signallers if they have worked for a period of four or more consecutive night shifts of 12 hours' duration. Network Rail considered this recommendation to be 'local' in nature and it was not considered by the National Recommendations Review Panel. Instead, it was considered by Western Route's Recommendations Review Panel in May 2004 and rejected because 'guidelines were adhered to' (a reference to standard NR/SP/ERG/003 (paragraph 101)).
- On 21 August 2004, a tamping machine passed a signal at danger at Stafford. The Fatigue Index scores for both the signaller and the tamper driver involved were above the 'threshold' where there is a high probability of actions being affected by fatigue. The signaller had worked seven consecutive night shifts and the tamper driver only worked night shifts. Both stated that they were adequately rested for their shifts. The investigation team concluded that although it could not be established that fatigue was a factor in the incident, it was 'considered a safety related issue'. They recommended that Network Rail should ensure that monitoring of the signallers' roster is carried out to reduce fatigue levels for signallers. Network Rail considered this to be a local issue and it was discussed at North Western Route's Recommendations Review Panel in May 2005. The Panel closed the recommendation on the basis that rosters had been adjusted locally to reduce the probability of fatigue.

Previous incidents involving fatigue investigated by the RAIB

133 On 28 June 2006, a derailment occurred in the early hours of the morning at Maltby North in Yorkshire as a result of points moving under a freight train. The RAIB investigated the accident (RAIB report No. 24/2007[4]) and concluded that it was likely that the signaller had moved the points under the train. One of the contributory factors identified was that the length of the shifts worked by the signallers at Maltby Signal Box may have made them liable to fatigue.

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

134 The RAIB recommended that Network Rail should design roster patterns for signal boxes that are manned by a single person such that the signaller is not subjected to undue fatigue. Network Rail responded to this recommendation by indicating that all base rosters for signallers were assessed using the FRI. The ORR is required by the Railways (Accident Investigation and Reporting) Regulations 2005 to ensure that recommendations are duly taken into consideration and, where appropriate, acted upon. The ORR is also required to report to the RAIB within twelve months, giving full details of any measures taken to implement the recommendation, or a proposed timetable for implementation, or a full explanation of why measures are not being taken to implement it. The ORR reported Network Rail's response and closed the recommendation.

135 Fatigue can affect many different grades of staff. The RAIB's investigation into a freight train derailment at Brentingby Junction (RAIB report No. 01/2007) found that the driver had fallen asleep as the train approached the junction, passing a signal at danger and subsequently derailing on trap points. The driver had been awake for 22 hours at the time of the accident and had not obtained sufficient sleep before the turn of duty in which the accident occurred. Recommendations made as a result of this investigation were specific to train drivers and not relevant for signallers.

136 The RAIB investigated a collision between two *on-track machines* at Badminton on 31 October 2006 (RAIB report No. 30/2007). The investigation concluded that fatigue was a possible causal factor, based on the erratic way that the machine was being driven before the collision occurred. The driver's roster pattern would have enabled him to take sufficient rest before the shift in which the accident occurred, but the RAIB was unable to establish for how much of that time he had actually been asleep.

137 Fatigue was identified as a factor that was probably causal in an incident involving a driver passing a signal at danger at Purley on 18 August 2006 (RAIB report No. 27/2007). The driver was working his sixth turn of duty that was either a night shift or an early shift with a very early start. The driver had not slept well during the night before the incident because his sleep had been interrupted by a thunderstorm. No recommendation was made because the driver's fatigue had arisen from a disturbed night's sleep rather than from a work-related cause. Processes exist for drivers to advise their supervisor if they do not consider that they are fit for duty because of insufficient rest.

138 The RAIB investigated an incident involving an unsecured load being conveyed on wagons despatched from Basford Hall Yard in Crewe, which occurred on 21 February 2008 (RAIB report No. 06/2007). The RAIB concluded that dispatch procedures had not been followed correctly and that the shifts worked by the member of staff at Basford Hall who was responsible for dispatching the train may have increased his susceptibility to error (in conjunction with his off-duty activities). The Fatigue Index for the shift that he worked was 46.8. The RAIB recommended that Freightliner (who employed the member of staff concerned) put in place a company process to assess and take account of fatigue arising from the shifts that members of staff work, together with any disclosed off-duty factors so as to reduce the likelihood of staff making errors due to fatigue. Freightliner responded to the recommendation by using the FRI to review base rosters for shunting staff at Basford Hall. The ORR closed the recommendation (paragraph 134).

139 In its report into the derailment on defective points at Grayrigg that occurred on 23 February 2007 (RAIB report No. 20/2008), the RAIB found that the local track section manager did not undertake a scheduled inspection of those points on the Sunday before the accident. The RAIB's investigation showed that the track section manager had worked extended hours in the weeks before the accident and the investigation report noted previous work which suggests that there may be a link between long hours and performance. The RAIB recommended that:

- Network Rail should carry out research to establish if there is a link between working long hours over extended periods, including the number and distribution of rest days, and the propensity for human errors during safety-critical tasks. The study should include, but not be limited to, those staff who have ordinary office-based duties interspersed with safety-critical tasks, such as inspections. The output of the research should be a set of threshold levels of hours for differing roles.
- Using the output of the research, Network Rail should establish procedures to deliver compliance with the thresholds identified.

140 Network Rail considers that it has already completed relevant human factors studies and that company standard NR/SP/ERG/003 (paragraph 101) addresses the monitoring and control of excessive working hours and associated fatigue (although Network Rail does intend to revise this standard). It is the RAIB's view that this response does not satisfy the intent of the recommendation or bring about the intended changes.

141 The ORR's position is that it will not require Network Rail to consider this recommendation. The ORR believes that requiring Network Rail to carry out research to enable it to understand the link between working hours and degraded performance in safety-critical areas would divert Network Rail from improving the management of its employees' working hours. However, the RAIB considers that the research required is limited by the extent to which it needs to be done. The intent of the recommendation is to identify possible links between working hours and performance in order to define a set of working time thresholds for differing roles.

Analysis

Identification of the immediate cause[5]

142 The immediate cause of the accident was that the signaller did not operate 943 points to the correct position for the safe movement of train 7A91.

Identification of causal[6] factors

The failure of signalling equipment on the Merehead Quarry branch

143 The failure of the signalling equipment on the Merehead branch resulted in the need for the signaller to set the route manually between signal W275 and signal W77, including operating 943 points to the correct position, and was a causal factor in this accident.

The actions of the signaller

144 With the knowledge that the signalling equipment failure was affecting the Up and Down Westbury lines in the vicinity of East Somerset Junction and on the Merehead branch, the signaller could have requested that a second signaller be provided for the duration of the failure. This would have been a reasonable request under Network Rail's 'work safe' procedure, which allows an employee to question the safety of working systems and the cessation or modification of those systems as appropriate. However, the signaller did not consider that it was unsafe to work on his own between midnight and 06:00 hrs because there were only a limited number of train movements scheduled to take place in the area during that time and he felt he could cope on his own.

145 The normal workload in Westbury Power Signal Box was not heavy between midnight and 06:00 hrs on a Monday morning. For the area affected by the failure, only the down and up sleeping car trains were due to operate over the Westbury lines after midnight and there were three scheduled movements over the Merehead branch (either from or to the Westbury lines). The signaller was able to provide detailed guidance to the pilotman on the actions required to move and secure points at Merehead, and this was done correctly.

146 For most of the period between midnight and 06:00 hrs, the only other work the signaller was involved with was movement of trains in and around Westbury station while they were being cleaned.

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

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

147 However, had a second signaller been present after midnight, there would have been another person in Westbury Power Signal Box to check the actions of the signaller as he introduced pilot working over the branch and set the route manually between signal W275 and signal W77. It is likely that this process of checking would have identified the mistake made by the signaller in not reversing 943 points. Module S5 of the Rule Book (paragraph 72) mandates that a competent person, if present, should check the route setting arrangements. This implies that such checking is desirable, but recognises that it is not always possible.

148 There are many locations where signallers work on their own and it would not be practical to roster a second person to provide support during degraded working. In the absence of another person, no other method is currently mandated to help the signaller to ensure that he has carried out the correct actions in setting a route for a train when using route-setting cards and individual points switches. There is also no risk-based guidance on whether there are circumstances under which it should be mandatory for a second competent person to check the actions of a signaller during degraded working.

149 The lack of a method over and above use of the route-setting card for helping the signaller to check that he had taken the correct actions in setting the route for train 7A91 at the time that pilot working was introduced was a causal factor in this accident.

150 It has not been possible to establish why the signaller did not consult the route-setting card (having obtained it). The fact that he obtained the card in the first place demonstrated a willingness to use it and suggests that he was not complacent about the requirements for moving train 7A91 safely through the East Somerset Junction area. His workload after he gave permission for the train to depart from Merehead was light and is unlikely to have caused him to overlook the requirement to refer to the route-setting card. It is, however, possible that he suffered a lapse in concentration, which may have been caused by fatigue (see paragraph 155). The fact that he did not refer to the route-setting card was a causal factor in this accident.

151 It is likely that the signaller's state of anxiety when he realised that the route was not set correctly for the passage of train 7A91 through 943 points is the explanation for his mistake in identifying the train to Swindon Route Control as '1A91' (paragraph 39). Given the close proximity of train 7A91 to the points at the time that the signaller realised that they were not set correctly (paragraph 75) and the length of time it would take to stop a train of 4505 tonnes, this mistake had no bearing on the occurrence of the accident.

The rostering of the signaller

152 The FRI (see Appendix D) provides an overall assessment of the effect of the hours worked and the actual shift pattern on an individual's propensity to fatigue. The score obtained for the hours worked by the signaller involved in the accident at East Somerset Junction was above the 'good practice threshold' and at a level where the risk from fatigue was high (paragraph 106).

153 Network Rail had applied the FRI to the Westbury signallers' base roster. Although the FRI was capable of assessing the hours worked by the signaller and took into account the likely impact of trying to sleep at different times of day, it did not consider any possible compounding effects of the alternating shift finishing times. The RAIB commissioned consultants with expertise in fatigue and sleep to examine this specific issue and to offer some guidance on good rostering practice.

154 The consultants provided the following general observations on the roster pattern:

- Working twelve-hour night shifts will almost certainly result in the progressive accumulation of 'sleep debt' – the difference between the optimum amount of sleep required and the actual amount of sleep obtained.
- A roster pattern that intersperses six-hour evening turns between twelve-hour night turns may help an individual to recover some of that sleep debt, but there will still be an accumulation as the roster progresses, i.e. a long sequence of alternating evening and night turns will result in significant sleep debt.
- Switching between evening shifts and night shifts and the consequent advancing and delaying of sleep may lead to difficulties in obtaining sufficient sleep.
- The rostering of signallers for 18:00-06:00 hrs shifts at Westbury Power Signal Box means that there is a coincidence between the time that they are likely to be most tired and the time that they are on their own in the signal box.

155 The consultants offered the following observations on the circumstances of the accident:

- The pattern of shifts in the period leading up to the shift on Sunday night (9 November 2008) could have contributed to fatigue because it was the sixth successive shift in the alternating pattern that included three 12-hour night shifts.
- The accident occurred when the signaller had been on duty for eight to nine hours, which would coincide with a time when levels of alertness are naturally low.
- The increased level of activity associated with the need to provide detailed instructions to the MOM at Merehead (paragraphs 64 and 65) could have contributed to lower levels of alertness later in the night.
- The signaller's omission in not using the route-setting card, having initially obtained it, was behaviour that might have been due to fatigue (or its early signs). The mistake in describing the train to Route Control as '1A91' might also have been caused by fatigue, although it could equally be attributable to anxiety or stress about the possibility of an impending derailment.

156 In the 28 days leading up to the accident (see Table 1), the signaller had only six days off duty, of which two days had been individually and the other four as two periods of two consecutive days. The consultant advised that two days' rest is normally sufficient to mitigate the effects of a number of consecutive days on duty and this is reflected in the construction of and output from the FRI (Figure 4). However, the extent to which this is true will also be dependent on what the individual does during the two days off duty.

157 It is not possible to establish with certainty a causal link between fatigue and the signaller's actions on 10 November 2008. However, taking into account the consultant's report, the accident in almost identical circumstances that occurred at Westbury North Junction in May 2005 (paragraphs 127 and 128) and the circumstances of the derailment at East Somerset Junction on 10 November 2008, it is considered probable that fatigue affected the signaller's actions. If this was the case, fatigue was a causal factor in this accident.

158 The consultants have offered the following advice for reducing the likelihood of fatigue:

- It is preferable to limit night shifts to a maximum of 10 hours (this increases the time available for rest between shifts and reduces the amount of time at work overnight). Research into the relative risk of accidents or injuries has shown that in comparison with an 8-hour shift, there is an increased risk of 13% for 10-hour shifts and an increased risk of 27% for 12-hour shifts. A limit of 10 hours for day shifts and 9.5 hours for night shifts is imposed on the hours worked by air traffic controllers.
- Guidance should be offered to staff on managing sleep and fatigue countermeasures during and outside the period on-shift. While some of this advice can be general in nature, it should also be tailored to the specific roster pattern. (Network Rail offers guidance to staff on balancing the demands of their work and home lives to take account of the demands of shift work, especially night shifts. This guidance is available on Network Rail's intranet, and the human factors team has also undertaken a programme of briefing to safety-critical staff including signallers and their managers.)
- After a twelve-hour night shift, staff should be encouraged to go to bed as soon as possible to limit the exposure to daylight (depending on the actual hours worked, this would only be effective for a proportion of the year, i.e. the sun rises after 06:30 hrs for about six months) and to sleep for at least four hours. Any deficit could be made up by taking a nap in the afternoon.
- Staff involved in compiling rosters should be provided with guidance on roster design and best practice to reduce the risk of fatigue, including the preference for forward rotation of shifts, the maximum number of consecutive night shifts to be worked and the rest periods to be applied after each block of night shifts.

Identification of underlying factors[7]

The rostering of the signaller

159 The hours worked by the signaller in the four weeks leading up to the accident deviated from the base roster (Table 1, following paragraph 85) and were significantly (37%) in excess of it. For this reason, it would have been prudent to review the effects of the change on the signaller's propensity to fatigue, by using the FRI to assess the amended roster (paragraph 105). Had this been done, Network Rail would have identified that the amended roster was above the 'good practice threshold' on five occasions and may, despite the temporary non-availability of two signallers at Westbury (paragraph 106) have been able to make alternative arrangements to reduce the number of hours worked by the signaller. The non-application of the FRI to the amended roster for the signaller involved in the derailment on 10 November was an underlying factor in this accident.

160 Network Rail's focus on the fatigue element of the FRI means that it overlooks the information provided by the risk element (paragraph 105). Given that the focus of the two indices is different, valuable information on the likely consequences of fatigue could be reflected in base rosters by taking greater account of the output from the risk index.

Network Rail's approach to the management of fatigue

161 Paragraph 101 describes how Network Rail company standard NR/SP/ERG/003 mandates limits on the numbers of hours that safety-critical staff can work. The mandated limits were respected in the roster being worked by the signaller involved in the accident at East Somerset Junction, but were insufficient to prevent signaller fatigue from being a probable cause of the accident. Although the intention of the standard is to minimise the build-up of fatigue, it does this primarily by focusing on a small number of working time limits (paragraph 101). The standard does not explicitly take account of the issues that are considered within the FRI, such as the sequencing of shifts and the time of day that people are working. It also does not reflect all of the guidance on good practice in managing fatigue contained within the ROGS regulations (paragraph 96), although this is partly attributable to it having been prepared when the guidance was in draft form only.

162 Network Rail's use of the FRI to evaluate base rosters is a starting point for exercising control over the issue of fatigue. However, while the FRI is a valuable tool, it should not be the only means of ensuring that risk from fatigue is minimised. The RAIB considers that limits on working hours can be used as another means to reduce the probability of fatigue by mandating requirements that address its underlying causes in the work place.

163 Fatigue also arises from causes outside the workplace as shown by the review of incidents included within RSSB's accident report database (paragraphs 130 to 132) and needs to be addressed as well. Network Rail's Human Factors team has undertaken extensive work in identifying good practice in this area (see paragraph 207) and the output from this work needs to be understood and acted upon by all managers of safety-critical staff within Network Rail.

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

164 Network Rail does offer guidance to staff on managing fatigue and this is currently in the process of being updated (see paragraph 207). Overall, Network Rail's approach to fatigue management is biased towards guidance rather than the imposition of mandatory requirements. Network Rail's focus on a small number of working time limits as the principal mandated means for combating fatigue was an underlying factor in this accident.

165 There are no limits on working time applied by the safety regulator for the railways (the ORR) through its safety certification/authorisation process for railway operators (including infrastructure controllers such as Network Rail). The Civil Aviation Authority, the safety regulator for the air industry in the UK, takes a different approach to working time limits for air traffic controllers. Under the Air Navigation Order 2005, the Civil Aviation Authority approves air traffic control units. Approval is contingent on the Civil Aviation Authority being satisfied that the applicant is competent to provide a service which is safe for use by aircraft, having regard to his organisation, staffing (including fatigue risk management), equipment, maintenance and other arrangements. The Civil Aviation Authority has defined a set of working time limits for air traffic controllers (Scheme for Regulation of Air Traffic Controllers' Hours), which constitute an acceptable means of compliance for those aspects of CAA's requirements that address fatigue.

166 In the absence of working time limits applied by the ORR, the limits used by Network Rail are those that it has self-mandated in standard NR/SP/ERG/003. Table 2 shows a comparison between Network Rail's working time limits and the Civil Aviation Authority's working time limits for air traffic controllers.

167 While the tasks performed by air traffic controllers and signallers have similarities, and both enjoy the protection of safety systems to mitigate or eliminate mistakes, the consequences of unprotected errors by air traffic controllers are likely to be much more serious than would be the case on the railway. However, errors by signallers during degraded working can result in accidents such as train derailments collisions. Two of the incidents referred to in paragraph 132 involved passenger trains and one of them resulted in a derailment. The Civil Aviation Authority's limits on working time for air traffic controllers recognise the potential seriousness of the consequences of fatigue. They do not necessarily constitute a model that should be adopted in its entirety for signallers.

168 The approach taken by the Civil Aviation Authority for air traffic controllers' working hours recognises the effect that working at night and insufficient time to recover from shift working can have on an individual's propensity to fatigue. In particular, the stipulation that no more than two consecutive night turns can be worked, that they should be of no more than 9.5 hours' duration and that they should be followed by 54 hours off-duty help to ensure that working hours alone cannot contribute to fatigue. Any employer of air traffic controllers must apply for permission if they wish to deviate from these requirements and the Civil Aviation Authority will take a number of factors including risk into account in making its decision.

Parameter	Network Rail's requirement for signallers[8]	Civil Aviation Authority's requirement for air traffic controllers[9]
Maximum hours per shift (day turns)	12	10
Maximum hours per shift (night turns)	12	9.5
Minimum rest period (hours) between shifts	12 (but 8 at weekly shift changeover)	12 (one incidence of 11 hours permitted in any 30-day period, but only with controller's approval)
Maximum number of consecutive shifts	13 (implicit)	6
Minimum rest period after six consecutive shifts	N/A	60 hours
Maximum working period in any shift	N/A	2 hours on then at least 30 minutes off
Maximum number of consecutive night shifts	13 (implicit)	2
Minimum rest period (hours) after working night shifts	12 (but 8 at weekly changeover)	54 (exceptionally, 48 permitted if a single night shift has been worked to cover short-term contingency, but only with controller's approval)
Maximum number of on-duty hours permitted in 30-day cycle	312 (26 shifts of 12 hours, with 1 rest day at the end of each 72-hour week)	200

Table 2: Comparison between working time limits for signallers and air traffic controllers

169 It is not necessarily the case that adopting new working time limits would involve any additional cost for the railway industry. Paragraph 158 describes the disproportionate increase in risk associated with 12-hour night turns. If night turns were restricted to ten hours or less, then the risk would diminish. It need have no impact on base cost, because signallers are normally contracted to work a set number of hours a week. Limiting night shifts to ten hours would increase the number of shifts that signallers worked, but not the number of hours that they worked. Although they would have fewer rest days, they would spend less time at work each day.

[8] Network Rail Company Standard NR/SP/ERG/003, 'Control of Excessive Working Hours for Persons Undertaking Safety Critical Work', Issue 4, April 2006.

[9] CAP670, Air Traffic Services Safety Requirements, Part D, Section 2, Scheme for Regulation of Air Traffic Controllers' Hours. Civil Aviation Authority, Safety Regulation Group, May 2009.

170 The approach taken by the Civil Aviation Authority to limiting the working time of air traffic controllers contrasts with the approach taken by the ORR for safety-critical staff on the railway. The ORR has issued guidance on the management of fatigue, but has not developed a set of working time limits as a method of influencing how fatigue is managed.

171 The ORR's preference is to continue to use a mixture of guidance and persuasion to encourage Network Rail to improve its approach to fatigue management. The approach adopted by the ORR has not yielded a change in fatigue management within Network Rail (paragraph 99). Overall, the absence of a suitable framework of controls to manage fatigue for safety-critical staff working within Network Rail was an underlying factor in this accident.

The functioning and constitution of Network Rail's Recommendations Review Panels

172 Paragraphs 129 and 132 refer to a total of five specific accidents or incidents where recommendations on fatigue management were made by Network Rail's own investigators, but rejected by either the local or national Recommendations Review Panel. The reasons given for rejection include the belief that standard NR/SP/ERG/003 addressed the problem of fatigue and that application of the Fatigue Index or the FRI was adequate for the purposes of minimising the risk from fatigue.

173 Eight accidents or incidents involving signallers where fatigue was likely to have been a possible or probable factor (including the derailment at East Somerset Junction) have occurred in the six years between September 2002 and November 2008. In most cases, the railway was operating with the normal protection offered by the signalling system degraded in one way or another. Had the signalling system been functioning normally, the accidents or incidents would not have occurred, although the signallers concerned would still have been suffering from fatigue. It is likely, therefore, that the incidence of signallers suffering from fatigue is higher than implied by the number of accidents and incidents that have occurred.

174 Although management of fatigue is handled at local level, expertise in fatigue management resides with Network Rail's human factors team. The accidents and incidents that were reviewed by the Recommendations Review Panels identified practices that were inconsistent with good fatigue management. Human factors representation on the National Recommendations Review Panel did not start until March 2008, and the representative only attends as an observer. If the human factors representative had been present on the National Recommendations Review Panel earlier, and with full membership status, it is likely that the fatigue issues identified would have achieved a higher profile within Network Rail and action might have been taken to address them.

175 The absence of a human factors representative on Recommendations Review Panels is an underlying factor in this accident.

176 Network Rail does not formally monitor recurring themes from accident and incident investigations and relies on the memories of those present to identify links between recommendations from different investigations (paragraph 126). Had Network Rail identified fatigue as a recurring theme, it is possible that action might have been taken which would have prevented the accident at East Somerset Junction on 10 November 2008. The review of arrangements for fatigue management was required as part of the ORR's guidance on the subject (paragraph 98, last bullet point).

177 The absence of a formal monitoring system to identify recurring themes in accident and incident causation was an underlying factor in this accident.

Other factors for consideration

The competence of the signaller

178 The arrangements for competence assessment of signallers within Network Rail are described in paragraphs 78 to 82.

179 Signallers will have variable exposure to different types of incident and the attendant requirement to implement procedures during the three-year competence cycle. By their nature, the types of incident that require the implementation of such procedures are comparatively rare.

180 This means that when called upon to implement such a procedure, a signaller may have limited recent experience upon which to draw. One way in which this inexperience can be mitigated is by using simulators to replicate emergency conditions and allowing the signaller to respond to the incident in a practical manner.

181 The signaller involved in the accident at East Somerset Junction had rarely introduced pilot working. Western Route has simulators available at Reading and Bristol to enable signallers to practise rarely-experienced scenarios such as the introduction of pilot working. Despite this, the signaller involved in the accident at East Somerset Junction had never had a session on the simulator. The use of a three-year competence cycle means that it is only towards the end of the third year that simulation might be considered for competencies that had not been tested 'naturally'. The RAIB considers that there would be merit in using simulators more frequently and spreading their use throughout the three-year cycle.

182 The lack of use of simulators for signallers was noted as a factor in a signaller's response to an incident involving a train that was unable to stop as it approached a red signal at a junction at Lewes on 30 November 2005. This incident was the subject of a RAIB investigation (RAIB report 25/2006 (Part 2)) published in January 2007. In that incident, the signaller did not use the correct button to send a radio message to all trains in the locality to warn them of the approaching train, with the result that another train also approached the junction, stopping as the errant train passed and narrowly avoiding a collision.

183 In its report into the Lewes incident, the RAIB recommended that Network Rail should review and modify its current practice on all routes to exploit the availability of simulators for testing signallers periodically on their response to rarely-experienced scenarios such as the need to stop all trains and specific trains in an emergency.

184 Network Rail responded to this recommendation by identifying in the Operations Manual where simulation could be included as a means for maintaining competence (paragraph 81). However, a number of methods of simulation are identified in the Operations Manual, of which the use of simulators is only one. The report was published almost three years ago. The ORR is still considering Network Rail's response to this recommendation and it remains open.

185 The RAIB also investigated an incident involving two wagons becoming detached from an engineers' train and running away in Camden Road tunnel in 2007 (RAIB report No. 12/2008, published in May 2008). One of the contributory factors identified in the investigation was that the competence management system applied to the signaller did not include the opportunity to be familiar with degraded working (such as by use of a simulator).

186 The RAIB recommended that Network Rail should review the competence management system applied to signallers with the aim of improving the way that signallers' actions in response to accidents and incidents are practised and assessed.

187 Network Rail has responded to this recommendation by stating that it regularly reviews the competence management system applied to signallers and that it would consider the recommendation when the next review is undertaken. The report was published 18 months ago. The ORR is still considering Network Rail's response to this recommendation and it remains open.

The actions of the controller

188 The actions of the controller are described in paragraphs 108 to 116. The task of a controller is to respond to situations that affect the normal running of the railway. The majority of those situations are not classified as emergencies, for example, making arrangements to deal with the failure of a train, which affects the passengers on board, train crew, rolling stock and the timetable.

189 A controller will only rarely have to deal with an emergency, but by their very nature, there is no forewarning. This means that controllers need to be ready to deal with an emergency as soon as it happens.

190 Once qualified, controllers are not systematically exposed to simulated emergencies and they have little opportunity to practise their skills. For the elements of the job that were relevant to the accident that occurred on 10 November 2008, simulation is, in any case, deemed not applicable by Network Rail (paragraph 115).

191 In addition, it was not Network Rail's practice to define for controllers key questions to be asked when a driver advises them that an accident has occurred (paragraph 110). It is not formalised in any procedure and no reference is made to it in the National Control Instructions. On 10 November 2008, the controller who spoke to the driver of train 7A91 had never had to deal with such an incident before, and he did not have any relevant training or reference material to prompt him on the questions that needed to be asked.

192 The exchange of information between the driver and the controller is potentially important for the safety of the railway and the safety of the person or people involved in the accident.

The response of Network Rail's managers to the accident

193 The response of Network Rail's managers to the accident is described in paragraphs 117 to 122.

194 Despite the signaller having been involved in a serious accident, he remained on duty on his own for almost two hours.

195 The basis for the decision to allow the signaller to continue is described in paragraph 120. Procedure 2-05 in the Operations Manual does not include any consideration of factors such as the number of train movements to be managed, whether the member of staff is working on their own and how long they will have to do so before relief or support can be obtained.

196 There is conflicting evidence as to whether the signaller was asked to find someone to relieve him from duty (paragraphs 119 and 120). However, the request to the first-line on-call manager to see if relief could be found for the signaller implies that it was the preferred approach.

197 Other options could have been considered such as asking the MOM who had been acting as pilotman on the Merehead branch to go to Westbury Power Signal Box or calling the Local Operations Manager based in Westbury. However, Network Rail's on-call managers decided that it was acceptable, given the circumstances of the accident, for the signaller to continue on duty on his own based on the limited range of parameters contained in the Operations Manual.

198 It is important that Network Rail managers have clear guidelines they can follow in determining whether a member of staff should be allowed to continue duty after an accident in which their own actions have been implicated.

Conclusions

Immediate cause

199 The immediate cause of the accident was that the signaller did not operate 943 points to the correct position for the safe movement of train 7A91 (paragraph 142).

Causal factors

200 Causal factors were:

a. the failure of the signalling equipment on the Merehead branch (paragraph 143, no recommendation is made);

b. the lack of a method over and above use of the route-setting card for helping the signaller to ensure that he had taken the correct actions in manually setting the route for train 7A91 at the time that pilot working was introduced (paragraph 149, Recommendation 1); and

c. the signaller did not refer to his route-setting cards when setting a route for train 7A91 from signal W275 to signal W77 (paragraph 150, no recommendation is made).

201 It is probable that the signaller's actions were affected by fatigue, as a result of the number of hours and the nature of the shifts that he had worked in the period leading up to the accident. If this was the case, fatigue was a causal factor (paragraph 157, Recommendation 2).

Underlying causes

202 Underlying causes were:

a. the amended roster worked by the signaller was not subject to assessment using the Fatigue and Risk Index (paragraph 159, Recommendation 3);

b. Network Rail's focus on a small number of working time limits as the principal mandated means for combating fatigue (paragraph 164, Recommendation 4);

c. the absence of a suitable framework of controls to manage fatigue for safety-critical staff working within Network Rail (paragraph 171, Recommendation 5);

d. the absence of a human factors representative on Network Rail's Recommendations Review Panels (paragraph 175, Recommendation 6); and

e. Network Rail did not have a formal monitoring system in place to identify recurring themes in accident and incident causation or the effectiveness of responses to previous relevant recommendations (paragraph 176, Recommendation 7).

Additional observations[10]

203 The use of simulators to enable signallers to practise all aspects of complex scenarios is currently limited on Western Route and only takes place towards the end of the three-year competence cycle (paragraph 181, Recommendation 8).

204 The train running controller who made the emergency call to the driver of train 7A91 had not had the opportunity to practise his skills in simulated emergency exercises (paragraph 190, Recommendation 9).

205 The train running controller's response to the driver of train 7A91 when he was advised of the derailment did not establish key items of information, because he had not dealt with this type of emergency before and had no specific training or reference material to guide his actions (paragraph 191, Recommendation 10).

206 Network Rail's managers who responded to the incident did not have clear guidelines on the circumstances under which a signaller involved in a serious accident can be permitted to continue duty, including how long they can continue to work on their own (paragraphs 193 to 198, Recommendation 11).

[10] 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

207 Network Rail is currently developing an 'e-learning' package on fatigue management, which will be briefed to LOMs and managers responsible for infrastructure maintenance teams. It describes the causes of fatigue, how it can be managed, good practice in rostering, and appropriate lifestyles for staff involved in safety-critical work.

208 Network Rail, Western Route, has introduced a set of prompt cards which describe the actions to be undertaken by controllers in the overall handling of emergencies such as train collisions, derailments and fires. The actions defined relate to the whole duration of the event (e.g. they refer to the recovery of derailed vehicles), and have no specific focus on the immediate actions to be taken when a controller is first notified of an accident or incident.

209 Network Rail reports that it is currently investigating whether there is a simple means to achieve an understanding of commonality of new recommendations with previous recommendations (paragraph 126), including the classification of accident/incident causes according to ten standard factors (one of which, 'personal factors', encompasses fatigue). Network Rail is working with the RSSB to establish whether their Safety Management Information System (a database of incidents and accidents occurring on the national railway network) can be adapted as a means for tracking commonality in causes/recommendations.

Actions reported which address factors which otherwise would have resulted in an RAIB recommendation

210 Network Rail and EWS's investigation into the derailment at East Somerset Junction recommended that the person acting as pilotman on the night of the accident (the Swindon MOM) should be retrained on the responsibilities of setting up working by pilotman with particular attention to the completion of paperwork accurately and appropriately. This addresses the issue raised in paragraph 66, so no recommendation is necessary.

Recommendations

211 The following safety recommendations are made[11]:

Recommendations to address causal and underlying factors

1 *The purpose of this recommendation is for Network Rail to introduce a 'self-checking' procedure for staff working on their own, to be used when they are required to implement procedures to deal with specified types of equipment failure:*

Network Rail should consider how signallers working on their own can affirm that they have taken the correct actions when implementing procedures to cope with equipment failures that result in a degraded level of safety, and issue requirements to the routes on this subject. The guidance should identify whether there are any circumstances under which it will be mandatory for signallers to obtain verification of their actions by a second competent person, taking into account risk associated with speeds, frequency of movements and traffic type and include consideration of human factors (paragraph 200b).

2 *The purpose of this recommendation is for Network Rail to improve the current rostering arrangements for signallers at Westbury by reducing or eliminating twelve-hour night shifts:*

Network Rail, Western Route should review the current roster pattern at Westbury Power Signal Box to reduce the duration of, or eliminate, twelve-hour night shifts and make changes to the roster as appropriate (paragraph 201).

continued

[11] 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 ORR to enable them to carry out their duties under regulation 12(2) to:

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

(b) report back to RAIB details of any implementation measures, or the reasons why no implementation measures are being taken.

Copies of both the regulations and the accompanying guidance notes (paragraphs 167 to 171) can be found on RAIB's web site at www.raib.gov.uk.

3 *The purpose of this recommendation is for Network Rail to extend the use of the Fatigue and Risk Index or apply other suitable assessment tools to proposed or amended rosters for signallers and other safety-critical staff:*

Network Rail should develop criteria to determine the circumstances under which proposed or amended rosters to be worked by signallers and other safety-critical staff should be evaluated using the Fatigue and Risk Index or other suitable assessment tools (with the aim of ensuring that defined thresholds are not exceeded) and provide guidance to the routes on this subject (paragraph 202a).

4 *The purpose of this recommendation is for Network Rail to enhance company standard NR/SP/ERG/003 by widening its focus to incorporate an extended set of limits on working time:*

Network Rail should amend its company standard NR/SP/ERG/003 to include an extended set of limits on working time for safety-critical staff, considering the scope and range of parameters applied to air traffic controllers, the guidance contained in the ROGS regulations, use of both the fatigue and risk elements of the Fatigue and Risk Index and advice from their human factors department (paragraph 202b).

5 *The purpose of this recommendation is for ORR to ensure that Network Rail is making timely and adequate progress in implementing Recommendation 4 and to take suitable action if they are not satisfied:*

The ORR should agree with Network Rail appropriate timescales for the implementation of Recommendation 4 and devise a programme of intervention to ensure that Network Rail develops and implements adequate measures, as described in Recommendation 4, to address the risk arising from fatigue within those timescales. If the ORR is not satisfied that Network Rail's proposals to change standard NR/SP/ERG/003 address the risk, or consider that insufficient progress is being made, the ORR should consider devising and implementing its own set of working time limits to be applied to Network Rail's safety-critical staff (paragraph 202c).

6 *The purpose of this recommendation is for Network Rail to ensure that there is adequate human factors' input to decisions taken at Recommendations Review Panels:*

Network Rail should include on its Recommendations Review Panels a representative from the human factors department with full membership status (paragraph 202d).

continued

7 *The purpose of this recommendation is for Network Rail to improve its processes for monitoring causes of previous accidents and incidents and for reviewing the effectiveness of recommendations previously made:*

Network Rail should develop and implement a monitoring system that will enable its Recommendations Review Panels to identify recurring causes in all investigations into accidents and incidents on, or relevant to, its network and to enable them to identify whether previous responses to relevant recommendation have been effective (paragraph 202e).

Recommendations to address other matters observed during the investigation

8 *The purpose of this recommendation is for Network Rail, Western Route to make greater use of simulators to help signallers to maintain their competence:*

Network Rail, Western Route should arrange for signallers to practise a range of infrequently encountered situations (such as the introduction of pilot working) on a simulator at regular intervals within the three-year competence cycle (paragraph 203).

9 *The purpose of this recommendation is for Network Rail to make greater use of simulation techniques to help controllers maintain their competence in responding to emergency incidents:*

Network Rail should introduce simulated emergency exercises for all controllers who have not experienced handling NRN emergency messages during the three-year competence cycle (paragraph 204).

10 *The purpose of this recommendation is for Network Rail to enhance its standards, training and reference material for controllers to assist them when they are notified of an accident:*

Network Rail should amend company standard NR/L3/OCS/043/2.1 to identify key information to be gathered by controllers when receiving an NRN emergency call, or when they are advised of an accident having made a NRN emergency call, and ensure that training and reference material for controllers encompasses this change (paragraph 205).

11 *The purpose of this recommendation is to provide Network Rail managers with greater clarity over the circumstances under which it is necessary to arrange relief for signallers who have been involved in an accident or incident:*

Network Rail should enhance guidance contained in Procedure 2-05 of the Operations Manual to define the factors that should be taken into account when deciding whether a signaller who has been involved in a serious accident should be allowed to remain on duty. This guidance should include reference to volume of train movement expected, consideration of whether the signaller is working on his/her own and the maximum time that they can be permitted to continue working (paragraph 208).

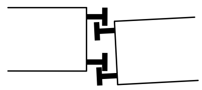
Appendices

Appendix A - Glossary of abbreviations and acronyms

EWS Railways Ltd	English, Welsh and Scottish Railways Ltd
FRI	Fatigue and Risk Index
LOM	Local Operations Manager
MOM	Mobile Operations Manager
NRN	National Radio Network
ORR	Office of Rail Regulation
ROGS (regulations)	Railways and Other Guided Transport Systems (Safety) Regulations 2006
RSSB	Rail Safety & Standards Board

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

Aspect	An indication displayed by a signal.*
Box wagon	A basic open wagon comprising four sides and a fixed floor.
Buffer locked	Buffers of one vehicle trapped behind the buffers of the adjacent vehicle as shown. 
Diesel electric locomotive	A locomotive whose source of power is a diesel engine and whose transmission is electrical, typically a generator and motor pair.*
Engineers' Possession	A period of time during which one or more tracks are blocked to trains to permit work to be safely carried out on or near the line.
Fatigue and Risk Index	An index developed for the Health and Safety Executive. The fatigue element enables the assessment of the cumulative effects of hours worked on an individual's propensity to fatigue. The risk element represents the relative risk of the occurrence of an incident on a particular shift in comparison with a roster pattern of two day shifts, two night shifts and four days off.
Hopper wagon	A colloquial description of any open-topped chute-equipped wagon designed for transporting coal or aggregates between supplier and consumer.*
Local Operations Manager	An individual who manages the day to day operation of a given area of Network Rail infrastructure.
Mobile Operations Manager	An individual who manages specified operational issues within an area of Network Rail infrastructure including being the first line of management attendance at operational incidents. Reports to the local operations manager.
National Radio Network	A dedicated national radio network operated and maintained by Network Rail that allows direct communication between driver and network controller.*
Normal (points position)	The points direction setting which carries the dominant traffic flow.
Operations Manual	A document that contains mandatory procedures applicable to Network Rail operations and customer services functions.
On-track machines	Any piece of specialist railway plant which moves only on the rails and is normally self propelled.*

Pilotman	A member of railway staff whose duty is to ensure that trains are worked safely (e.g. one at a time) over a single line section during times of signal failure or during emergencies by riding on each train through the section or being present to authorise it to enter the section.*
Pilot working	A method of running trains on a temporary single line or un-signalled line by means of a pilotman.*
Point clip	A device similar to a G-clamp used to securely clamp the closed switch in position when required.*
Point scotch	A device inserted between the open switch of the points and the adjacent rail to ensure that the points do not move.
Points	An assembly of two movable rails, the switch rails, and two fixed rails, the stock rails. Also known as a set of switches. Used to divert vehicles from one track to another.
Power signal box	A large signal box which controls the points and signals over a large area by electrical means.
Relay interlocking	A collection of relays (electromechanical switches) used to control points and signals within specific geographical boundaries in a manner that prevents the signaller from setting conflicting train movements.
Relay room	A building housing relays and related control equipment for signals and points.
Route setting card	A document which defines the correct position for specific sets of points in a given route between two signals, which will allow the safe passage of a train along that route when normal signalling arrangements have failed.
Rule book	Railway Group Standard (RGS) GE/RT8000, which is the publication detailing the general responsibilities of all staff engaged on the railway system, and the specific duties of certain types of staff. *
Signalling fault team	A Network Rail team comprising trained signalling technicians who are deployed to deal with faults in signalling and points equipment as they occur.
Tamping machine	An on track machine (OTM) that can (generally) lift and slew the track and simultaneously compact the ballast under the sleepers.*
Track circuit	An electrical or electronic device used to detect the absence of a train on a defined section of track by using the running rails as part of an electric circuit.*

Track Circuit Block Regulations	The set of regulations applying to those sections of the railway where the safe operation of trains is achieved by proving the status of the line as far as the overlap beyond the next signal using track circuits or axle counters. The regulations are part of the Rule Book.
Trap points	Worked switches intended to derail rail vehicles in the event of their unauthorised movement.*

Appendix C - Key standards current at the time

GE/RT8000/P2, Issue 2 (October 2007)	Working single and bi-directional lines by pilotman
GE/RT8000/S5, Issue 2 (June 2008)	Passing a signal at danger
GE/RT8000/T5, Issue 1 (June 2003)	Operating power-operated points by hand
NR/L3/OCS/041, Issue 16 (June 2008)	Network Rail Operations Manual
NR/L3/OCS/043/2.1, Issue 1 (March 2008)	Network Rail National Control Instructions (Section 2.1, Communications)
NR/SP/ERG/003, Issue 4, April 2006	Control of Excessive Working Hours for Persons Undertaking Safety Critical Work

Appendix D - Fatigue and the Fatigue and Risk Index

1 Although controlling hours worked and ensuring adequate rest periods contribute to reducing the risk of fatigue, they are not the only relevant factors. The RAIB investigated an accident involving a signal being passed at danger and subsequent derailment at Brentingby (RAIB report No. 01/2007), where driver fatigue was considered to be a factor in the causal chain. The report described fatigue and the factors affecting it.

> 'There is a difference between fatigue and sleepiness but both interact. Fatigue can be defined as the impairment of mental activity associated with the pattern of work and rest, whereas sleepiness is the propensity of an individual to fall asleep. Alertness is related to both of these and can be defined as a state of wakefulness when a person is best able to process information and be responsive to the external environment.
>
> 'The level of alertness is firstly determined by the amount of prior sleep that has been obtained and the time since last awakening; and secondly by the body's internal clock known as the circadian rhythm. The circadian rhythm programmes maximum sleepiness at night and maximum wakefulness during the day. Sustaining alertness during the night can therefore be difficult, because the circadian rhythm causes alertness to be lowest between 02:00 hrs and 06:00 hrs and highest in the late afternoon about 12 hours later.
>
> 'The circadian rhythm has a strong influence over the duration and timing of sleep; for example, individuals trying to sleep during the day may experience greater difficulties getting to sleep and then maintaining sleep than those sleeping at night.
>
> 'With the onset of fatigue, the reduction in alertness that occurs can lead to errors where critical events may be missed.
>
> 'Possible causes of fatigue are the pattern of shift rosters; workload; individual characteristics, and social circumstances. A person who has not had enough sleep will feel sleepy if their workload is boring and undemanding. An individual's diet, age, personality and fitness can all have a bearing on fatigue, and if their social circumstances are such that they cannot get sufficient sleep at home, then the onset of fatigue will be exacerbated.'

2 A 'Fatigue Index' was developed by the Centre for Human Sciences at the Defence Evaluation and Research Agency (now known as QinetiQ) in a research project commissioned by the Health and Safety Executive. This was to provide a means to assess the short-term, daily fatigue and cumulative fatigue risk associated with shift work.

3 The previous HSE Fatigue Index has been updated in the form of a Fatigue and Risk Index (FRI). The FRI consists of two separate indices, one of which is related to fatigue but utilises a model that has been updated from the earlier edition, whereas the other is related to risk. The output from the risk index represents the relative risk of the occurrence of an incident on a particular shift. The risk component was based on research into trends in risk related to shift work, including accidents and incidents involving shift workers. The principal difference between the two indices reflects the research findings that the peak in risk occurs shortly before midnight, whereas the peak in fatigue occurs in the early hours of the morning . This difference is reflected in the way that the respective components of the FRI assign scores to the hours worked in a sequence of shifts.

4 Both indices take account of three individual components known to have an impact on fatigue and the risk arising from shift work:

- A component associated with duty timing (effect of start time, shift length and the time of day that the shift is being worked).
- A component associated with the job content (demands from the activity being undertaken and the availability and duration of breaks).
- A cumulative component, which relates to the sequence of shifts being worked and is affected by the pattern of work in the days preceding the specific shift that is being reviewed. The FRI takes account of the effects on the individual of trying to sleep at different times of day. The FRI was developed using data from field studies to estimate how the duration of sleep at different times of day would vary and how this would impact on fatigue. Those studies showed, for example, that on average, somebody going to bed at around 23:00 hrs will obtain between 7.5 and 8 hours sleep while somebody going to bed at around 07:00 hrs will obtain between 4.5 and 6 hours sleep.

5 For each component a scoring system operates. The FRI can be used to compare different shift patterns. It can also be used to identify peaks of fatigue within a shift pattern so that suitable control measures can be put in place. Work undertaken by the Health & Safety Laboratory for the Office of Rail Regulation (ORR) in 2008 included a review of the FRI 'good practice thresholds'. For night shifts, the report recommended a threshold value of 45 as representing an upper limit for fatigue; fatigue index scores above this value imply a high probability of fatigue affecting an individual's actions. For fatigue index scores above 45, duty holders need to satisfy themselves that their control or mitigation measures are sufficient. Thus the figure of 45 is not an absolute. Duty-holders can exceed this figure providing that mitigation is in place to address the increased risk of fatigue. The risk index is presented on a different scale, where a figure of one represents the risk from a shift roster sequence of two day-shifts, two night-shifts and four rest days. A figure of two represents a doubling of the risk from this sequence.

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