RAIB

Rail Accident Investigation Branch

Rail Accident Report

Derailment at Bletchley Junction, Bletchley
3 February 2012

Report 24/2012
November 2012

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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Derailment at Bletchley Junction, Bletchley 3 February 2012

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Summary

At 02:27 hrs on 3 February 2012, an electric locomotive that was being driven from Crewe to Wembley, on the West Coast Main Line, derailed as it negotiated the diverging route at Bletchley Junction. The locomotive was travelling at a speed of 65.5 mph (105.4 km/h) when it derailed: the speed limit for the diverging route was 15 mph (24 km/h). The driver received minor injuries and significant damage was caused to the underside of the locomotive, the track and the overhead electrification equipment.

The driver of the locomotive correctly reduced its speed on the approach to the red signal before the junction but when this changed to green, with an 'F' indication meaning that the locomotive was to take the diverging route, the driver applied full power in the belief that he was going straight on. It is likely that the driver only realised that he was to take the diverging route around the time he was passing the signal, by which time it was too late to prevent the derailment.

The RAIB found that the driver did not immediately observe and/or register what was displayed by the signal's route indicator even though he understood its meaning. This was despite the fact that the approach view of the route indicator was found to be satisfactory, free of obstructions and with sufficient time for a driver to see and understand its meaning. The RAIB has concluded that the driver's belief that he was continuing on the up slow line overcame the fact that the 'F' indication was clearly visible to him.

The RAIB has made one recommendation to Virgin Trains covering the training and assessment of drivers' route knowledge, and two recommendations to Network Rail. The first of these relates to the assessment of the risk from overspeeding at diverging junctions when the signal before the junction clears from red to a proceed indication, and the second relates to clarifying the status of the Weekly Operating Notice, an operating publication which is issued to drivers, and which contained information about engineering work south of Bletchley requiring trains to take the diverging route at Bletchley Junction.

Introduction

Preface

1 The purpose of a Rail Accident Investigation Branch (RAIB) investigation is to improve railway safety by preventing future railway accidents or by mitigating their consequences. It is not the purpose of such an investigation to establish blame or liability.

2 Accordingly, it is inappropriate that RAIB reports should be used to assign fault or blame, or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

Key definitions

3 All dimensions and speeds in this report are given in metric units, except speeds and locations which are given in imperial units, in accordance with normal railway practice. Where appropriate the equivalent metric value is also given.

4 The report contains technical terms (shown in *italics* the first time they appear in the report). These are explained in appendix A.

The accident

Summary of the accident

5 At 02:27 hrs on 3 February 2012, train reporting number 0A90, the 01:03 hrs *light engine* from Crewe to Wembley, was completely derailed as it traversed Bletchley Junction (figure 1) at excessive speed. The junction was set so that the class 90 electric locomotive would diverge from the *up* slow line, on which it was travelling, to the up fast line.

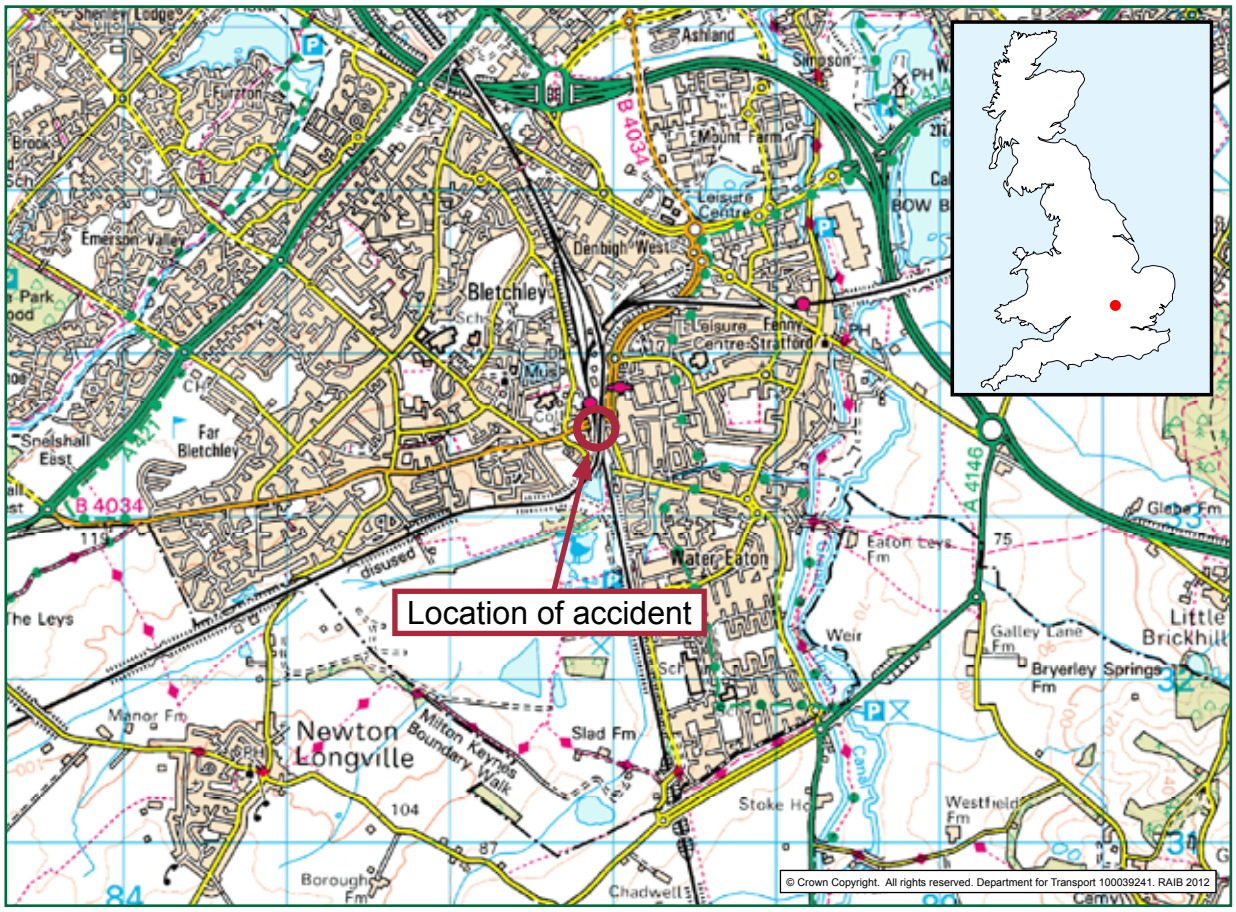

Figure 1: Extract from Ordnance Survey map showing location of accident

6 The driver responded correctly to the sequence of signal *aspects* displayed on the approach to the signal that protected Bletchley Junction, signal BY19. As the locomotive approached it, this signal cleared to a green proceed aspect with a letter 'F' showing in the *route indicator.* This advised the driver that he was to be switched to the up fast line (figures 2 and 4). However, the driver accelerated the locomotive in the belief that he was continuing on the up slow line rather than continuing at slow speed for the diverging move.

7 The locomotive derailed as it negotiated the diverging route while travelling at 65.5 mph (105.4 km/h) (figure 3). It should have been travelling at no more than 15 mph (24 km/h).

8 The driver received minor injuries. The locomotive's underframe, the track and overhead line equipment were all significantly damaged.

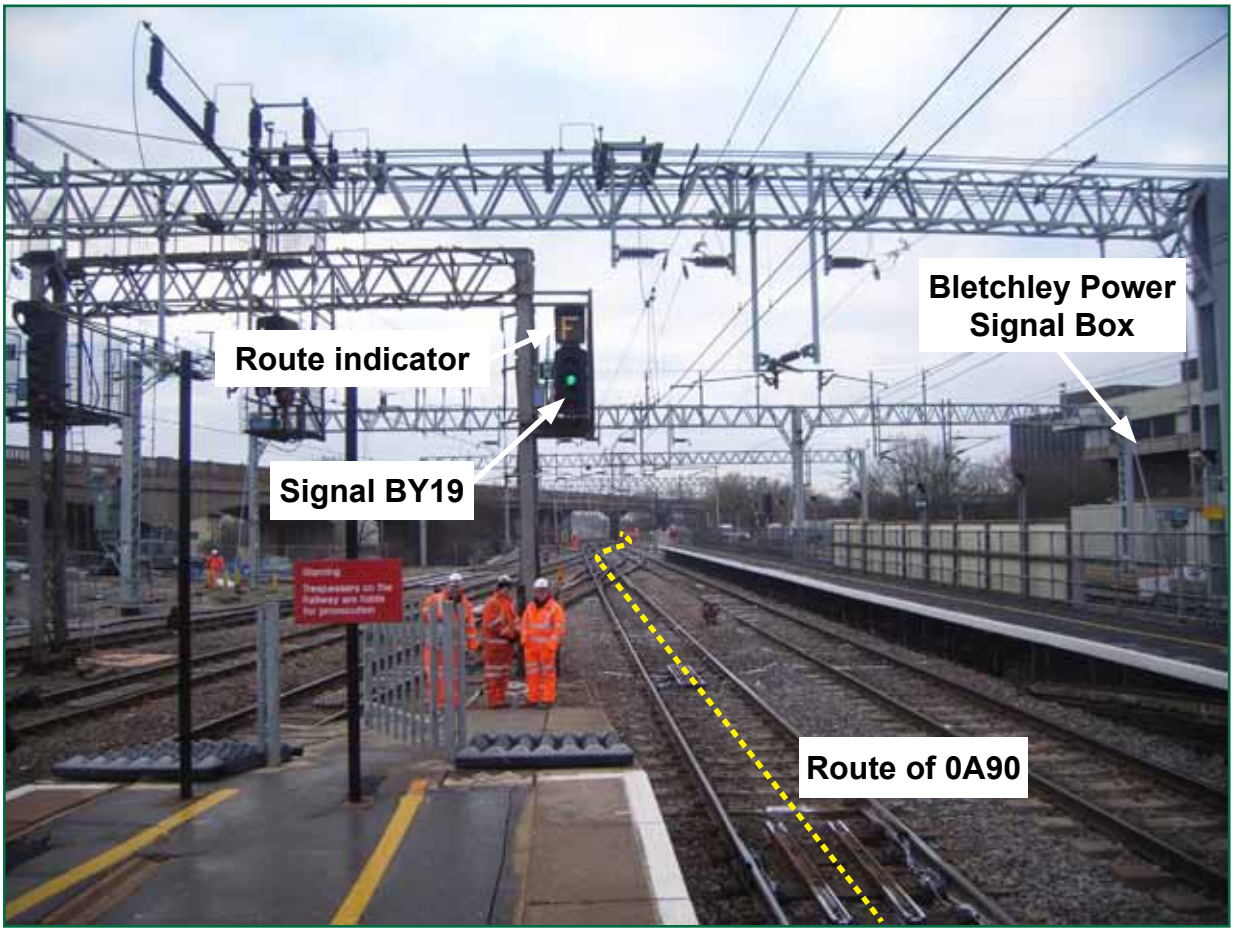

Figure 2: Daylight view of signal BY19 showing a proceed aspect and the route indicator illuminated for a move from the up slow line to the up fast line

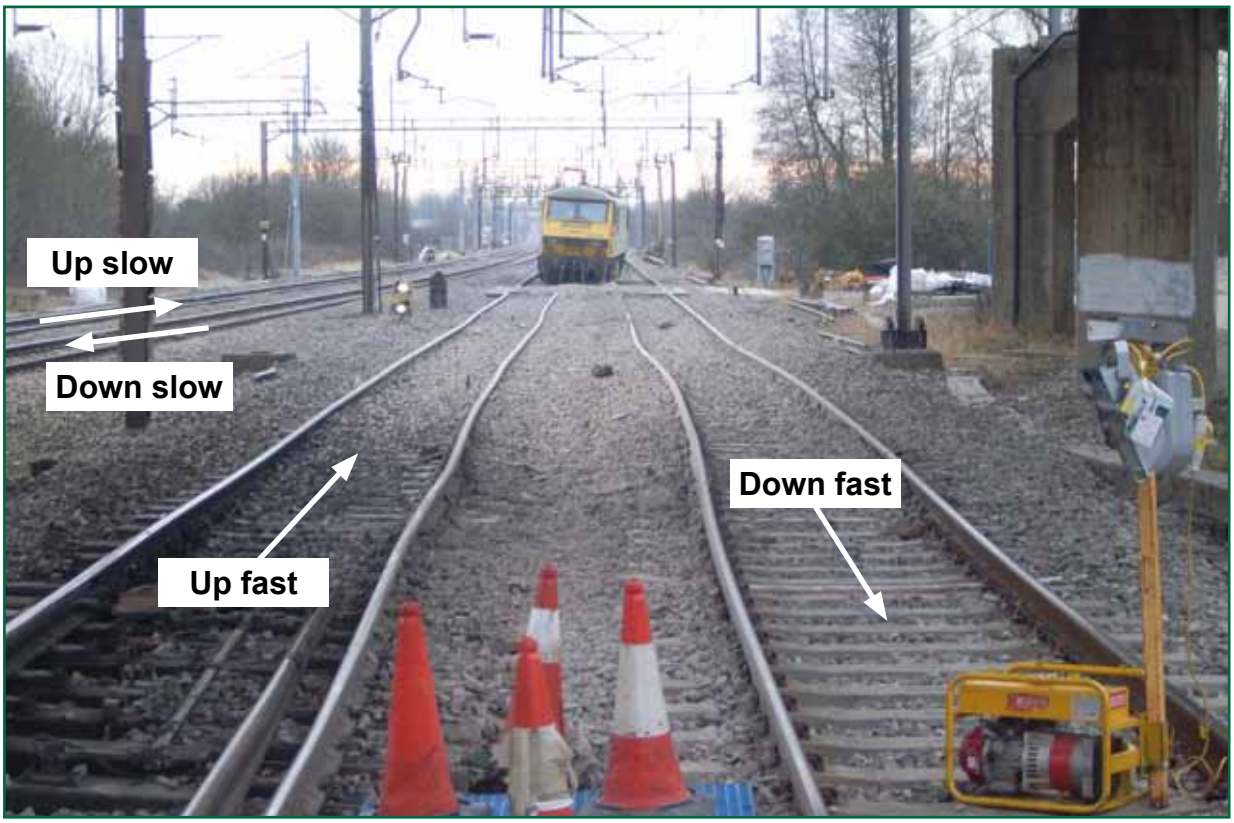

Figure 3: The derailed locomotive no.90046 following the accident

Context

Location

9 Bletchley Junction is on the West Coast Main Line which is electrified with 25 kV overhead equipment. There are four tracks designated from east to west; up slow, *down* slow, up fast and down fast. It is located immediately south of the platforms of Bletchley station and is 46 miles 43 chains, measured from a datum of zero miles, north of London Euston. The junction enables trains to be switched from the up slow line to the up fast line (figure 4).

10 The maximum permitted speed of trains on the up slow line approaching Bletchley Junction is 75 mph (120 km/h), but at the time of the accident there was a longstanding 50 mph (80 km/h) *temporary speed restriction* in force through Bletchley station and finishing beyond Bletchley Junction because of the condition of the track.

11 The maximum permitted speed of trains using Bletchley Junction to cross from the up slow line to the up fast line is 15 mph (24 km/h). As with other changes of permissible speeds, this is indicated by a sign at the junction. The purpose of the sign is to inform drivers and to supplement their route knowledge, which is the primary means of ensuring that permissible speeds are not exceeded. Drivers are trained and examined on route knowledge so that they should be aware of signalling and track layouts, permissible speeds, and other route features such as gradients.

12 There is no system at Bletchley Junction to provide automatic regulation of a train's speed; it is the driver's responsibility to drive according to the permissible speeds.

13 Bletchley Junction is used infrequently because the junction speed is low and there are higher speed junctions elsewhere north and south of Bletchley. It is usually used in connection with engineering work when the slow lines are closed to traffic because of an engineering *possession* south of Bletchley.

14 At the time of this report, Network Rail was planning to replace Bletchley Junction with a new, higher speed, junction just south of Bletchley.

Organisations involved

15 The class 90 electric locomotive is owned by Freightliner Ltd, but was on hire to Virgin Trains. The driver was employed by Virgin Trains.

16 Network Rail manages the infrastructure and also provides and operates the railway signalling equipment.

17 Both Virgin Trains and Network Rail freely co-operated with the RAIB's investigation.

Train involved

18 The class 90 locomotive is one of a fleet of electric locomotives built by British Rail Engineering Limited from 1987 to 1990. They have four axles, can develop 5000 brake horse power, and are used to haul both express passenger trains and freight trains. They are currently in service with several train operators on the main British railway network.

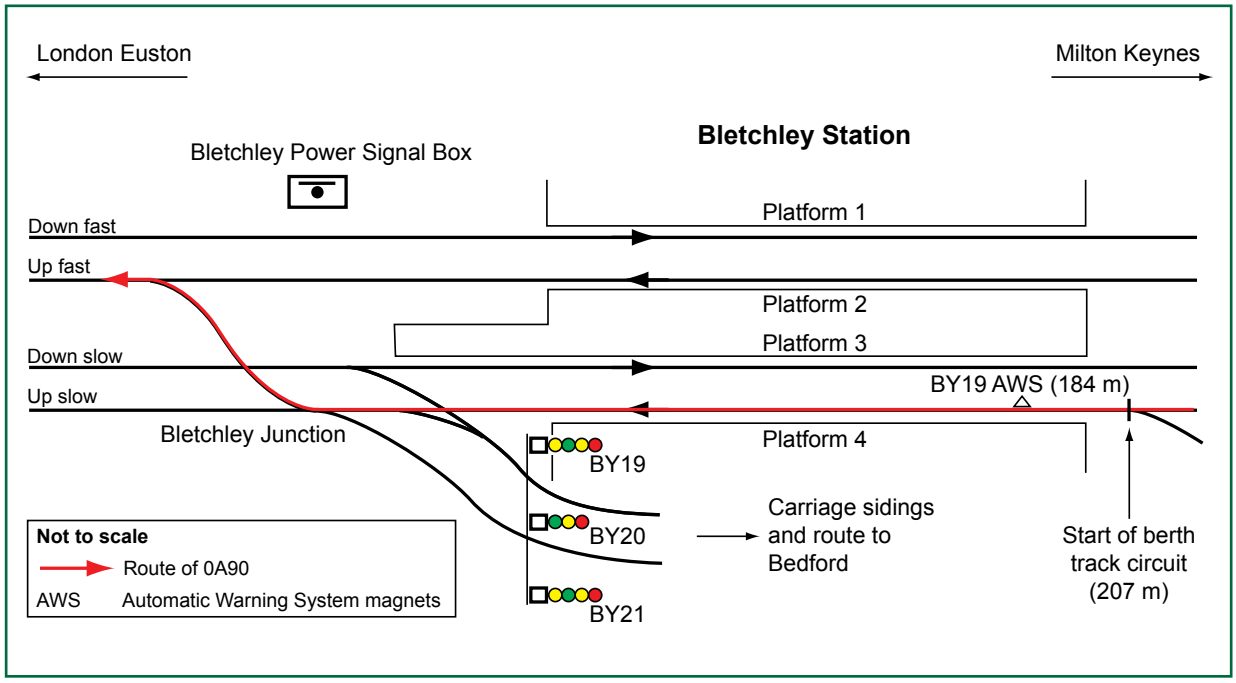

Figure 4: Track layout of Bletchley Junction (distances shown are from BY19 signal)

19 Class 90 locomotives have a top speed of 110 mph (177 km/h) when hauling passenger trains, but when operating as light engines they are limited, as are light engines of all types, to the following speeds because of their braking performance:

- 60 mph (96 km/h) where the maximum permitted line speed is 85 mph (137 km/h) or less;
- 75 mph (121 km/h) where the maximum permitted line speed is 90 mph (145 km/h) or more.

20 Class 90 locomotives are fitted with a speed set function (figure 5) in which the driver can set the desired maximum speed on a dial. The driver can control the rate of acceleration using the power controller, but the speed will then be limited to and controlled at the value of the speed set without further driver intervention.

21 The locomotive was required at Virgins Trains' Wembley depot to haul a rake of coaches which was later to work the 18:43 hrs Fridays-only passenger service from London Euston to Crewe. This is the only locomotive hauled passenger train normally operated by Virgin Trains; all other trains being formed of class 390 Pendolino electric units and class 221 Super Voyager diesel units.

22 The condition of the locomotive did not contribute to the occurrence of the accident.

The driver of train 0A90

23 The driver of train 0A90 entered service with Virgin Trains on 16 November 1998 and, following completion of a driver training programme, was passed out for driving duties (including class 90 locomotives) on 14 June 1999. Virgin Trains qualified him as competent to drive over all the routes worked by their drivers based at Euston.

24 More details of the driver and his competency are provided in paragraphs 28 to 37.

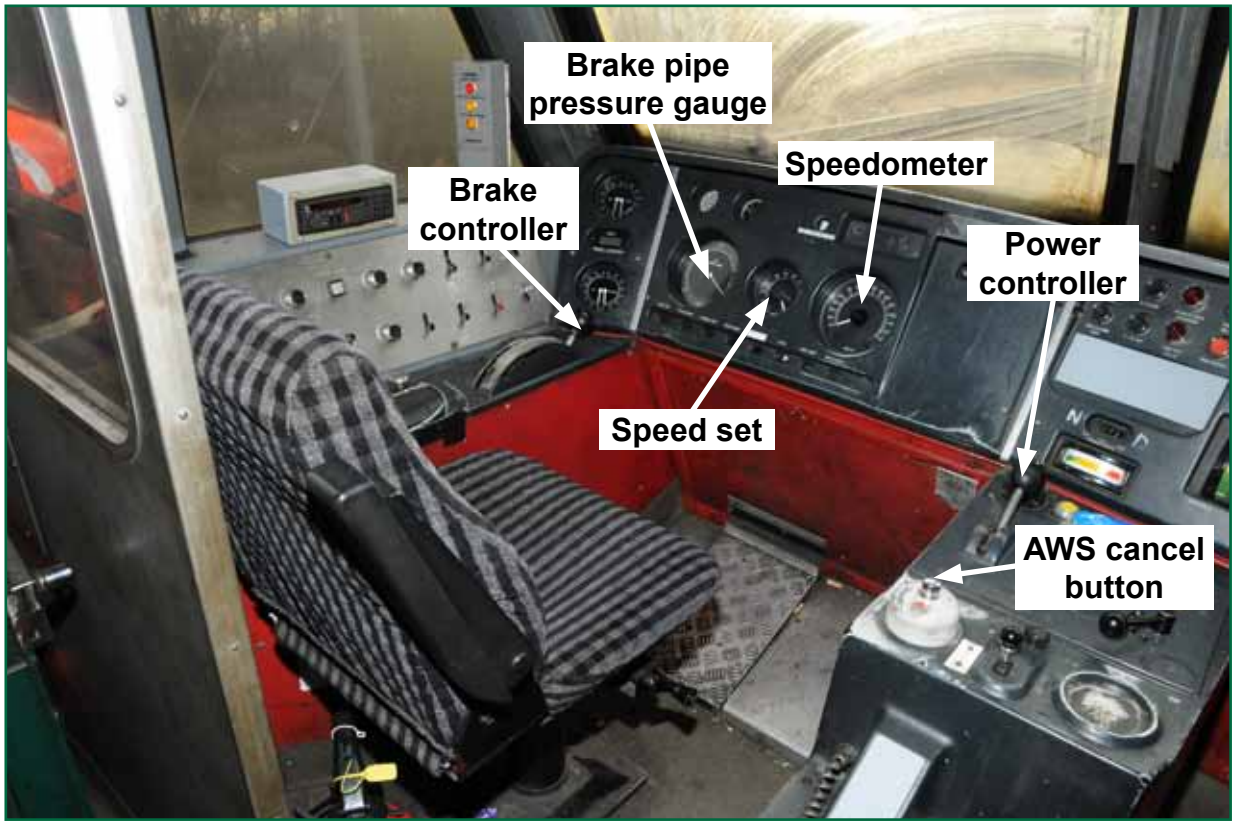

Figure 5: Layout of cab controls, class 90 locomotive

External circumstances

25 When the accident occurred, it was dark and the weather was clear and dry with a hard frost. Since the view through the cab windscreen was not obstructed by excessive soiling, the visibility of signals from the driving cab of 0A90 would have been good. The driver made no allegation that his view through the cab windscreen was adversely affected.

26 The approach to signal BY19, located at the end of the up slow line platform at Bletchley, is relatively straight with no obstructions to obscure its view. Although the station lights were on, work commissioned by the RAIB to examine any *sighting* and *human factors* issues associated with the signal (described later in paragraph 88) concluded that they did not affect, or detract from, the visibility of this signal.

The investigation

Sources of evidence

27 The following sources of evidence were used:

- site photographs and measurements;
- observations at the site;
- witness statements;
- data from the locomotive's *on-train data recorder* data;
- signalling data;
- recordings of voice communications;
- analysis of mobile phone use;
- documentation concerning the training and competence of the driver;
- documentation concerning the competence management system;
- documentation concerning the design of the signalling at Bletchley Junction;
- video footage taken from a subsequent working of 0A90;
- a report on the sighting and human factors issues associated with signal BY19 commissioned by the RAIB; and
- a review of previous RAIB investigations that had relevance to this accident.

Key facts and analysis

Background information

The driver

28 In accordance with procedures in Virgin Trains, the driver was subject to a normal two year cycle of competence assessments, expiring on 11 April 2013. This consisted of a rules assessment, and for the class 390s that he drove most commonly:

- one practical driving assessment per year where the driver is accompanied during a normal driving turn by a driver team manager;
- one assessment of driving competence per year based on the analysis of an on-train data recorder download, which is able to give information on the method of driving such as the use of the brake and the speeds driven at; and
- one day on a class 390 simulator which is used to assess the response to out-of-course events that do not occur during normal train working.

Additionally, for class 90 locomotives, the driver was required to be assessed once on his practical driving ability during each two year period. No assessments by data recorder download were carried out because Virgin Trains did not have the capability to analyse them (it did have arrangements with Freightliner to download and analyse class 90 on-train data recorders when requested, but this was only undertaken following incidents, and not as part of the cycle of ongoing competence assessments).

29 Virgin Trains had no specific arrangements in place to carry out practical driving assessments of class 90s when operating as light locomotives, although the general requirement for one practical driving assessment during each two year period could include light locomotive working as well as when hauling trains.

30 There were no records of any practical driving assessment having been carried out of the driver in the Bletchley accident while driving a light class 90 locomotive.

31 The dates of the driver's last assessments prior to the accident were:

Assessment	Date
Assessment by data recorder download (class 390)	29 January 2012
Practical driving assessment (class 390)	19 July 2011
Rules assessment	11 April 2011
Simulator assessment (class 390)	7 March 2011
Practical driving assessment (class 90 hauling coaches in passenger service)	13 August 2009

Table 1: Dates of driver's previous assessments

These assessments confirmed that the driver was competent and the feedback given by the assessors was that the driver met a good standard. Nothing of concern was raised.

32 The rules assessment included questions to test route knowledge, but route knowledge is generally self-monitored by drivers who certify their own competence on a route card. This is also signed by the assessor to confirm they are satisfied with the driver's knowledge. In addition, the rostering of drivers by the Virgin Trains resource centre at Preston is automatically monitored and if a driver has not driven over a route during the previous six months, the rostering system will not roster a driver to drive over that route. The driver's home depot is advised so that arrangements can be made for the driver to be given re-familiarisation of the route concerned. The driver had signed off his route card certifying he considered himself as competent on 11 April 2011. It was also signed by the assessor.

33 Drivers are entitled to a route refresher day every five weeks, which they can use to re-familiarise themselves with sections of route. The onus is on the driver to identify what aspect of route knowledge they need refreshing and this can be satisfied by the driver visiting the locations concerned, carrying out cab rides (Virgin Trains has arrangements with other train operating companies so that their drivers can ride in other companies' cabs), or visiting the route training school which is set up to be able to deliver film footage of routes and has large scale route maps available. A trainer is also available to give further guidance.

34 The driver had a route refresher day on 24 September 2011 when he requested to re-familiarise himself with the Bletchley area. There are no records available to confirm whether, or to what extent, this was achieved, and the driver could recall nothing about it.

35 The driver had two incidents on his record: the first on 14 January 2002 when he took the wrong route at Tamworth that had been set by the signaller; and the second on 22 June 2009 when he drove a class 390 from just north of Euston to Coventry with a brake fault alarm visually indicated and sounding audibly. This was potentially more serious than the first incident and could have indicated that a seized wheelset had occurred, but in the event the alarm was spurious. Virgin Trains concluded that the driver required more training on the meaning of alarms and the action required in response. This was given before he was allowed to resume driving duties.

36 Virgins Trains considered that the driver's previous record showed that he was a driver of good standard, and there were no apparent warning signs to indicate a propensity to incidents or accidents.

37 The driver's last routine medical was on 26 August 2009, which he passed. He was not required to wear spectacles for driving duties.

The signalling

38 Lines in the Bletchley area are signalled using *track circuits* and conventional lineside colour light signals operated by a signaller at Bletchley power signal box. The main running signals on the fast and slow lines are of the four aspect type and fitted with the *automatic warning system*.

39 In four aspect signalling, the normal sequence of aspects is that if a signal is at red, the previous signal displays a single yellow 'caution' aspect; the signal before that displays a double yellow 'preliminary caution' aspect; and the signal before that displays a green aspect. On sighting a signal at double yellow, a driver is required to reduce the speed of his train so that he can stop at the signal at red. To this end, the signals are spaced so that the distance between any two signals showing double yellow and red is sufficient to allow trains that are running at the permitted maximum speed of the route and with the worst braking performance to stop at the red signal. The signals at and on the approach to Bletchley Junction on the up slow line are shown in table 3, later in the report.

40 When signals display double yellow, yellow or red, the driver receives an audible warning when the train passes over track mounted automatic warning system magnets (usually located about 180 m before the signal concerned). The driver is required to acknowledge this by pressing a button (figure 5) to prevent the brakes being applied automatically. When a signal is at green, the automatic warning system causes a different tone to be sounded and the driver needs to take no action.

41 When a train is to take a relatively low speed diverging route at a junction, the signalling system controls the signal protecting the junction so that it displays a restrictive aspect (red or single yellow) until the train is at a specific distance from it[1]. The signal will then clear from its restrictive aspect to a less restrictive aspect, dependent on the status of the line ahead, by a process known as *approach control.* The purpose of approach control is to cause the driver to slow the train down while approaching the junction and to reduce the probability of it exceeding the permitted speed as it takes the diverging route. Signal BY19 at Bletchley Junction is fitted with approach control from a red aspect for diverging moves to the up fast line.

42 Approach control relies upon the driver of a train correctly responding to the signal aspect displayed following the clearance of the junction signal and does not mitigate the risk from a train subsequently being accelerated to an excessive speed before reaching the junction points. This risk is increased in the case of light locomotives and modern rolling stock with rapid rates of acceleration.

43 Signals protecting junctions which if passed at danger could lead to a head on, converging, or crossing collision are, in addition, fitted with the *train protection warning system*[2] (TPWS). This is primarily a means to reduce the risk from signals being passed at danger. The system initiates an emergency brake application if a train is detected travelling at too high a speed towards a signal at danger, or when passing a signal at danger. Signal BY19 is fitted with this system to reduce the signal passed at danger risk.

44 TPWS is also fitted on the approach to permanent speed restrictions where a significant reduction in speed is required[3] and detects trains that have failed to brake as required and are therefore travelling too fast. The system initiates an emergency brake application if this occurs.

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[1] This is in accordance with *Railway Group Standard* GK/RT0045 'Lineside Signals, Indicators and Layout of Signals' and Network Rail's standard NR/L2/SIG19609 'Requirements for Colour Light Junction Signalling'.

[2] This system was fitted to the network in response to the Railway Safety Regulations 1999 SI1999/2244.

[3] Where the approach speed is 60 mph (96 km/h) or more and a third or more reduction in speed is required. TPWS is not required to be fitted in all such cases following the granting of an exemption by the *Office of Rail Regulation* in 2007.

45 TPWS is not fitted to permanent speed restrictions associated with diverging junctions fitted with approach control signalling[4]. Therefore, while signal BY19 is fitted with TPWS to control the signal passed at danger risk, there is no TPWS to control the risk from exceeding the permissible speed for the diverging route on the approach from line speed. Even if TPWS had been fitted for this purpose, it would not protect against a train which accelerated to too high a speed following the clearance of the junction signal as occurred at signal BY19.

46 Signals at junctions are fitted with *junction indicators* to advise drivers of approaching trains whether they will be taking the diverging route (or which diverging route if there is more than one). Junction indicators can be of the following types:

- A position light junction indicator (often referred to as a 'feather') which indicates the route to be taken by the angle at which a row of white lights is displayed (figure 6). It is designed to be able to be read[5] from a maximum distance of 800 m and is usually the preferred choice for simple junctions at any speed.
- A standard alphanumeric route indicator (figure 2), as fitted to signal BY19, which displays an illuminated character as an indication of what route a driver is to take. It is designed to be read from a maximum distance of 250 m and is generally used in slow speed areas. Exceptionally, Network Rail's standard NR/L2/SIG19609 allows an alphanumeric route indicator to be used in higher speed areas where a position light junction indicator cannot be accommodated, because of the physical constraints of the location, and there is only one route over 60 mph. In this case, the alphanumeric route indicator gives no indication for the highest speed, non-diverging, route. Signal BY19 therefore shows no route indication for movements continuing on the up slow line.

47 For crossing moves to the up fast line, signal BY19 clears from red to a proceed aspect (providing the route ahead is clear) once the approaching train occupies the track circuit (known as the berth track circuit) that extends from a point 207 m on the approach to signal BY19 (figure 4). The signal changes to a proceed aspect and the alphanumeric route indicator displays the letter 'F' (figure 2) to advise the driver that he is taking the diverging route at the junction.

48 The automatic warning system magnets associated with signal BY19 are located between the running rails 184 metres on the approach to it (figure 4). The indication given to the driver by the automatic warning system will depend on the aspect displayed by signal BY19 (paragraph 40).

[4] When TPWS was installed on the national rail network (completed in December 2003), Network Rail considered fitting TPWS on the approach to diverging junctions with approach controlled signalling to control the risk of overspeeding approaching from line speed but they did not believe it was justified by the level of risk. They were also concerned by the practical difficulties of fitting it (it would need to be switchable between routes). *HM Railway Inspectorate* concurred with this view and granted an exemption on 20 October 2003 for these locations against the Railway Safety Regulations 1999.

[5] Reading a signal is the process by which a driver identifies the signal as applying to his train and correctly notes the aspect displayed.

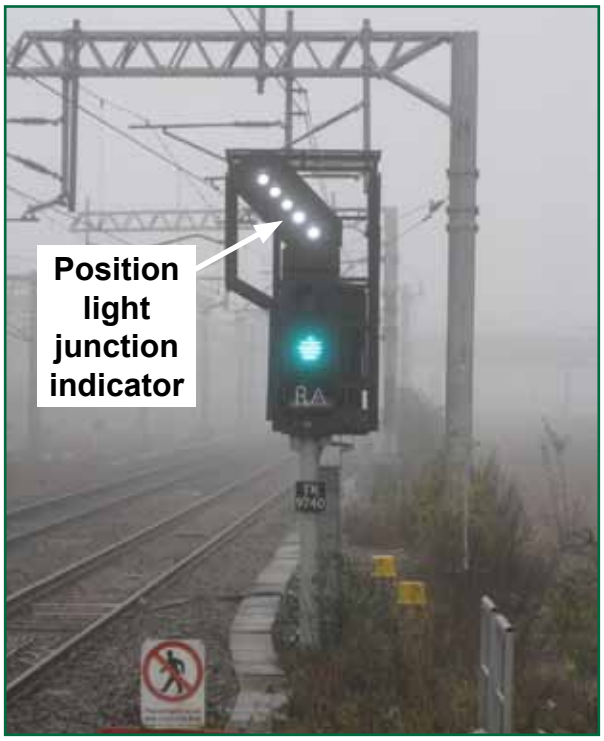

Figure 6: Signal fitted with a position light junction indicator (showing the junction ahead of the signal is set for a diverging movement to the left)

Sequence of events

Events preceding the accident

49 On Sunday 29 January 2012, the driver of train 0A90 signed for the *Weekly Operating Notice* for the week commencing on 28 January 2012 to confirm that he had collected it and would read it. This contained details of temporary speed restrictions, including the speed restriction applying to the up slow line through Bletchley station. It also contained details of engineering work that was taking place on the slow lines south of Bletchley during the night of 2/3 February 2012, necessitating a possession of those lines south of Bletchley Junction.

50 The driver's turns of duty in the week before the accident are shown in table 2.

Day	Date	Turn of duty	Driving activity
Saturday	28 January	Rest day	None
Sunday	29 January	05:20 to 15:39 hrs	Euston – Birmingham/ Wolverhampton
Monday	30 January	13:13 to 21:34 hrs	Euston – Birmingham/Preston
Tuesday	31 January	13:00 to 21:00 hrs	Route refresher in and around the Euston/Willesden area
Wednesday	1 February	16:00 to 02:00 hrs	Standby turn. Did not drive. Actually finished at about 22:30 hrs
Thursday	2 February	21:40 to 05:58 hrs (working rest day)	To work train 0A90 01:03 hrs from Crewe to Wembley (the accident occurred at 02:27 hrs)

Table 2: The driver's turns of duty in the week before the accident

51 The driver stated that following his turn of duty on 1 February, he had a good night's sleep. Then, in preparation for the night turn to come, he had a further two or three hours sleep in the early afternoon of 2 February.

52 At 20:47 hrs, on 2 February, before leaving home, the driver telephoned Virgin Trains' Control to check that the train was running and to request an early departure from Crewe. The controller responded that the driver would have to speak to the signaller at Crewe power signal box when the locomotive was ready to depart.

53 The driver booked on duty at London Euston at 21:40 hrs by phoning the automated booking on system and obtained an indication that Virgin Trains' resources centre at Preston wished to speak to him. The resources centre wished to confirm the details of a taxi that the driver had previously arranged to transport him home from Wembley depot at 04:00 hrs. Although the booked arrival time for train 0A90 at Wembley was not until 04:50 hrs, the driver expected it to arrive early. This was based on his previous experience of working this train and knowledge of the arrival times when worked by other drivers.

54 The driver then travelled as a passenger to Crewe on the 22:00 hrs train from Euston to Manchester. This train arrived at Crewe at 00:03 hrs on 3 February.

55 The driver located the class 90 locomotive that was to form train 0A90 in one of the south end bay platforms at Crewe station. It had been left there by Freightliner and required the driver to operate the battery switch, raise the *pantograph,* release the parking brake and switch on the head, marker and tail lights. He then contacted the signaller at Crewe power signal box to advise that he was ready to depart from Crewe station. The train was 33 minutes early when it departed at 00:30 hrs. The driver did not take his break at Crewe, as scheduled, having considered that he had had sufficient break during the journey from Euston.

56 During the journey from Crewe to Bletchley (figure 7), train 0A90 encountered cautionary signal aspects because of preceding freight trains on the same line. Otherwise, the driver used the speed set function to set and automatically maintain the locomotive's maximum speed. Several times the driver exceeded the speed limit for a light locomotive (paragraph 19) on sections of the route where the line speed was 75 mph (121 km/h). As an example, the on-train data recorder showed that part way through the journey, the driver drove at 77.1 mph (124.1 km/h) for 5.5 miles (8.8 km) when he should have been doing no more than 60 mph (96 km/h). South of Rugby, 0A90 was routed via Northampton and kept to the up slow line through Milton Keynes all the way to Bletchley. This was because the fast lines were under possession between Rugby and Milton Keynes.

57 With the slow lines under possession south of Bletchley, 0A90 had to be switched to the up fast line at Bletchley Junction. Although this is a low speed junction, it was the only junction that could be used to switch 0A90 onto the up fast line because of the engineering work taking place elsewhere. Several freight trains had already used Bletchley Junction to cross from the up slow line to the up fast line.

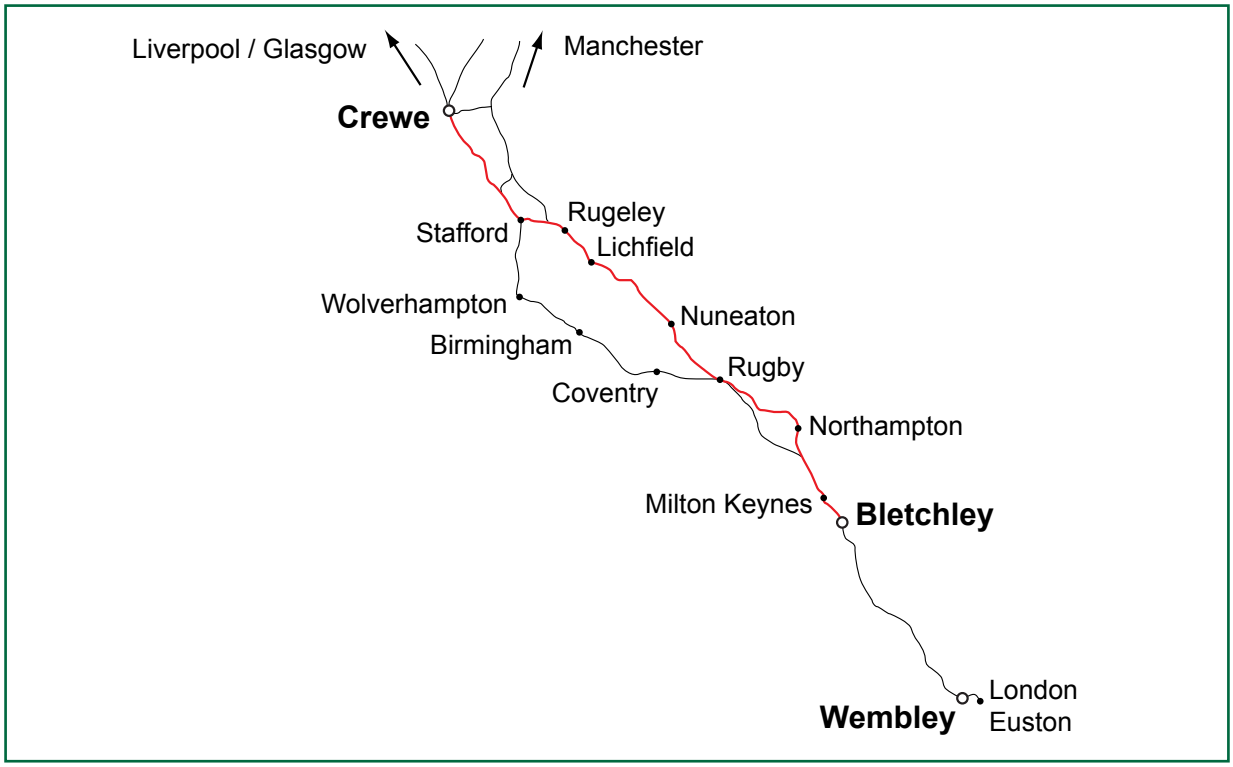

Figure 7: The route of train 0A90 between Crewe and Bletchley

58 The signal aspects and speeds of 0A90 approaching Bletchley were as shown in table 3.

Signal number	Aspect shown	Distance to next signal yards (metres)	Speed of 0A90**
TK5232*	Green	1585 (1449)	75.3 mph (121.2 km/h)
BY39	Double yellow	859 (785)	52.2 mph (84.0 km/h)
BY36	Yellow	1612 (1474)	40.6 mph (65.3 km/h)
BY19	Red	-	12.4 mph (20.0 km/h)

*Table 3: Signals on the approach to Bletchley Junction on the up slow line (*signal TK5232 is controlled by Rugby signalling control centre; **the speed shown is that recorded by the on-traindata recorder at the associated automatic warning system magnets (paragraph 40))*

In addition, between signals BY39 and BY36, the driver obtained a warning from the automatic warning system for the 50 mph (80 km/h) temporary speed restriction through the platforms at Bletchley station (paragraph 10). Other than acknowledging the warning, he did not need to take any immediate action as a result of this because he was already braking in response to the signal aspects displayed.

59 When the locomotive occupied the last track circuit on the approach to signal BY19, the signal changed from a red aspect to a green aspect with the letter 'F' displayed by the route indicator. The 'F' displayed momentarily before the green aspect because the signalling circuitry checks that the route indicator is lit before displaying a proceed aspect. Approximately a half a second to a second later, the driver received the tone from the automatic warning system indicating that signal BY19 was showing a green aspect. At this point, the train was running 84 minutes ahead of schedule.

60 A detailed timeline of the events just before and during the accident can be found in appendix B.

Events during the accident

61 When signal BY19 cleared to a green aspect, the driver applied full power to the locomotive. Signal BY19 was passed 16-17 seconds later at 53.7 mph (86.4 km/h), which was more than the 50 mph (80 km/h) temporary speed restriction in place on the up slow line through Bletchley station (paragraph 10).

62 The locomotive's on-train data recorder showed that, having travelled a further 77.9 m and reached 63.8 mph (102.7 km/h), the driver shut off traction power and made a partial brake application. A fraction of a second later, and having travelled another 6.5 m, the train reached the junction *facing points* and took the diverging route. The maximum permitted speed of the diverging route is 15 mph (24 km/h). Around two seconds later, having travelled a further 51.9 m, the data recorder suggests that the pantograph left the overhead line equipment when the *vacuum circuit breaker* opened and is probably the point at which the locomotive derailed.

63 The locomotive derailed all its wheels, remained upright and came to rest a further 12 seconds later, at 02:27 hrs, foul of the down fast line.

Events following the accident

64 The driver pressed the emergency button on the *national radio network* console and was connected to Network Rail's route control in Birmingham. In response, a controller made an emergency radio broadcast to all trains in the Bletchley area to tell them to stop. This was received by the driver of train 2K99, the 01:34 hrs passenger train from London Euston to Milton Keynes which was on the down fast line and due to call at Bletchley. This train was heading directly for the derailed class 90 locomotive, standing foul of the down fast line, but would have slowed for the station stop as it approached Bletchley station.

65 Separately, and at about the same time, the signaller at Bletchley power signal box saw a flash and heard a loud bang as the derailment occurred. He acted promptly to replace signal BY10, the last signal on the down fast line before reaching Bletchley, to danger. The driver of train 2K99 saw the previous signal change to single yellow and stopped at signal BY10, which was about 550 m from the derailed locomotive.

66 Route control called the emergency services which attended the accident site, gave treatment to the driver of train 0A90, and took him to hospital.

67 Train 2K99 was subsequently authorised by the signaller to proceed in the wrong direction back to Leighton Buzzard station where the train was taken out of service. Taxis were arranged to take the passengers to their destinations.

68 The slow lines were re-opened at 15:38 hrs the same day, but the fast lines were not re-opened until 05:33 hrs on 6 February 2012.

69 The signalling equipment was tested by Network Rail under the supervision of the RAIB. This found no evidence that any *wrongside failure* had occurred and concluded that the signalling had worked as designed. The driver of train 0A90 made no allegations against the signalling system.

70 Network Rail also convened a *signal sighting committee* to examine signal BY19 and to identify any possible features which could obstruct its approach view. No issues were found by this committee. The RAIB's own examination of the sighting of signal BY19 is covered later in the report (paragraph 88).

71 The driver was tested for drugs and alcohol as part of the normal industry processes and found to be negative.

72 Had the accident not occurred, the driver's following turn of duty was due to start at 18:13 hrs on 3 February when he would have worked the 18:43 hrs train to Crewe using the same class 90 locomotive (paragraph 21).

Identification of the immediate cause[6]

73 **The immediate cause of the derailment was that the driver drove the locomotive at significantly higher than the permitted speed when taking the diverging route from the up slow line to the up fast line at Bletchley Junction.**

74 When signal BY19 cleared from red to green, the driver applied full power to the locomotive and traversed the junction points at 63.8 mph (102.7 km/h). This was significantly greater than the maximum permitted speed of 15 mph (24 km/h) for the junction points.

Identification of causal factor[7]

75 **When signal BY19 changed to green, the driver did not observe, and/or register the meaning of, the route indication that was displayed until it was too late. This is a causal factor.**

76 The driver not observing and/or registering the route indication displayed occurred due to the following factors and possible factors:

Factors:

- the driver had developed an expectation of how he should drive over Bletchley Junction; and
- the route risk assessment process had not identified the overspeeding risk at Bletchley Junction.

Possible factors:

- the sighting of and form of junction indicator fitted to signal BY19; and
- the driver was distracted by matters external to his work.

The above factors are discussed more fully in the following paragraphs.

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

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

Driver's expectation

77 The driver had developed an expectation of how he should drive over Bletchley Junction from his previous, repeated, experience of driving the route along the up slow line many times in the past (including the previous time he drove train 0A90 on 30 September 2011), combined with his lack of experience of driving the diverging route to the up fast line.

78 When signal BY19 cleared, the driver's evidence was that he did not perceive the 'F' indication in the route indicator and thought he was to continue along the up slow line. In consequence, he accelerated the locomotive in accordance with that belief, although the speed reached was in excess of the 50 mph (80 km/h) temporary speed restriction in force (paragraph 10), or the permitted maximum speed (60 mph (96 km/h)) for a light locomotive (paragraph 19).

79 The driver confirmed that he understood the meaning of the 'F' indication and that he noticed it just as he approached and passed signal BY19, but its meaning did not immediately register. It is likely that he started to realise, around the point that he passed the signal, that he was being routed over the junction to the up fast line. This is supported by the brake application made three seconds later and still 6.5 m from the junction points (paragraph 62).

80 The driver stated that he attempted to make an emergency brake application but before he could complete the full movement of the brake controller he was thrown across the cab because of the violent movement of the locomotive when it started to derail.

81 There was no evidence that the driver had ever driven over the diverging route at Bletchley Junction and he had no recollection of doing so. The driver stated that he was aware of the junction turnout speed. However, there was no evidence that he had ever been specifically assessed on his route knowledge of Bletchley Junction. The RAIB has concluded that the driver believed he was continuing on the up slow line and accelerated accordingly. This belief persisted for around 15 seconds despite the clearly visible route indicator that was displayed as he approached the signal.

Route knowledge

82 The route risk assessment process had not identified an overspeeding risk at Bletchley Junction and therefore there was no specific route learning mitigation associated with it.

83 While route knowledge is self-monitored by drivers and checked by the rostering software (paragraph 32), the experience of driving over individual signalled routes within an overall geographical line of route is not specifically monitored and relies on drivers to identify that they need refreshing. Refresher days are provided for this purpose (paragraph 33), but there was limited follow up by managers to see whether the refresher days were successfully achieving their objectives.

84 Virgin Trains has a process in place to risk assess routes over which their drivers drive as a means to inform route knowledge training. The risk assessment process starts with the identification of features within the route which could lead to drivers making errors. Such features include signals that have been repeatedly passed at danger; signals that are located on the right-hand side of the line (rather than their more usual position of being on the left-hand side), and signals that may be misread. These features are then specially highlighted on route maps and in route DVDs and are specifically covered in route knowledge training and assessment.

85 The route risk assessment process had not identified the possible risks arising from driving over infrequently used routes. Therefore, the risk from overspeeding at Bletchley Junction had not been identified and there were no specific mitigation measures in place to ensure sufficient route knowledge of this junction.

86 The Weekly Operating Notice that the driver signed for on 28 January 2012 (paragraph 49) contained information that the slow lines were blocked for engineering work south of Bletchley Junction and that all trains would have to travel over the fast lines (figure 8). The driver stated that he had been through the notice and this is discussed further in the section of this report covering the RAIB's observations.

THURSDAY 02 to FRIDAY 03 FEBRUARY

Ref. No. P2011/1484269 Possession Manager Network Operations West Coast South

Item							
47	Bourne End Jn and Bletchley Jn	Down and Up Slow Possession	2240 THU	to	0600 FRI	Track Renewals System (TRS) Train 29m12ch and 33m4ch W2011/3072443
	Tring	Up & Down Relief Possession	2240 THU	to	0600 FRI	Follow Up Tamping (MP&I) 38m0ch and 46m20ch W2011/3071678 URFDO Inspections 38m8ch and 46m20ch W2011/3068817

ISOLATION OF ELECTRICAL SECTIONS
2240 THU TO 0600 FRI
BL 3, 4, 7, 8 complete
VL 7 & 8 complete

PROTECTION LIMITS
Down Slow: Beyond WT5151 to Approach BY216 FIXED CROSSING
Up Slow: Beyond BY217B pts to Approach WT5152

TRAFFIC REMARKS
TRAINS TO TRAVEL OVER FAST LINES. NO ACCESS TRING SIDINGS.

GENERAL REMARKS
LINE CLEAR VERIFICATION (LCV) PROCESS APPLIES WITHIN THIS POSSESSION.

Figure 8: Extract from the Weekly Operating Notice for 2/3 February 2012

The sighting of and form of junction indicator fitted to signal BY19

87 Position light junction indicators (paragraph 46) are significantly brighter than the alphanumeric type fitted to signal BY19, and their physical form (figure 6) gives a clearer indication that a diverging route is to be taken. Had one been fitted to signal BY19 rather than the alphanumeric indicator, it would probably have appeared to be more prominent in the driver's view. Therefore, it is possible that had a position light junction indicator been fitted, the driver of train 0A90 would have perceived it and been alerted to the fact that he was taking the diverging route.

88 The RAIB commissioned an examination of the sighting of signal BY19's route indicator and identification of any human factors issues that could cause errors. The approach view of the route indicator was found to be satisfactory, being free of obstructions and with sufficient time for a driver to see and interpret its meaning. No human factors issues were identified that would have increased the probability of errors being made. Figure 9 shows a night time view of signal BY19, with the 'F' illuminated, from its associated automatic warning system magnets.

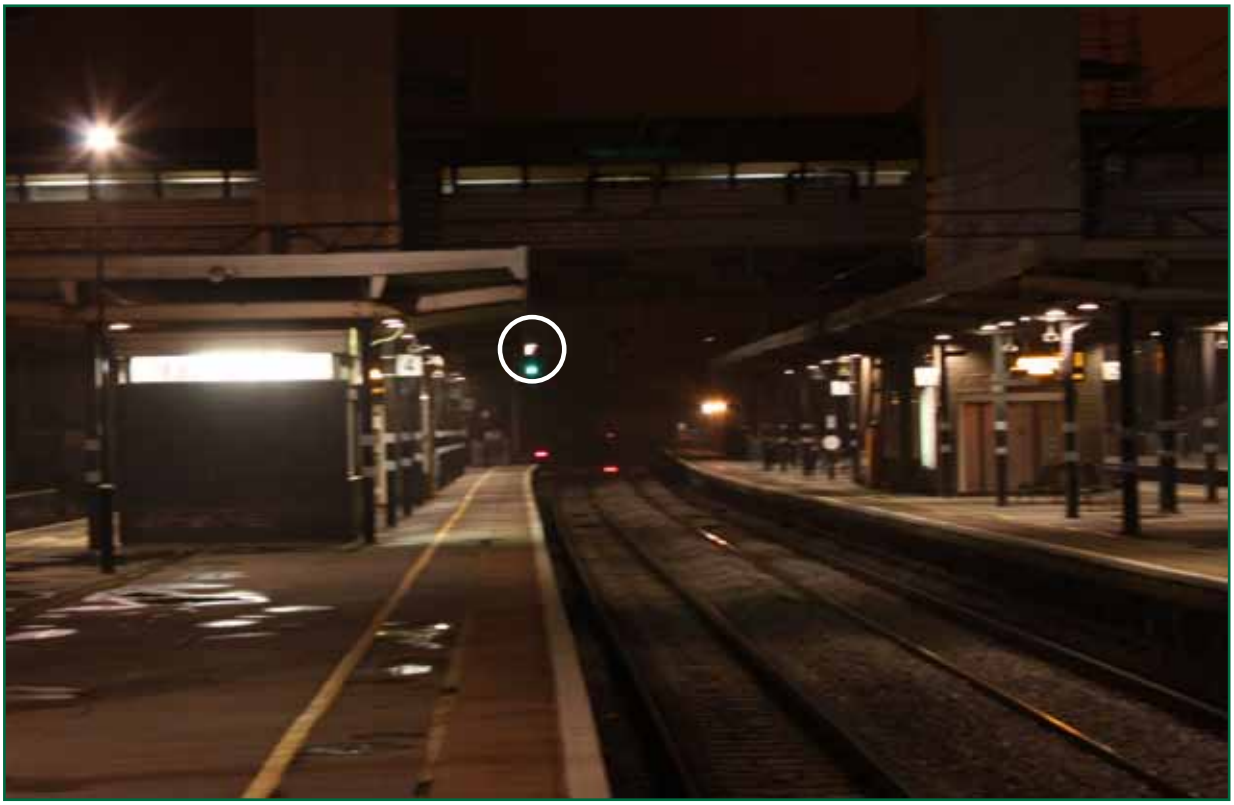

Figure 9: Night time view of signal BY19, with the 'F' indication illuminated, from the automatic warning system magnets

89 The RAIB has been unable to establish why an alphanumeric route indicator was fitted to signal BY19 when it was installed in 1965 because no records exist. It is possible that it was to provide consistency with the two adjacent signals on the same gantry which have lower approach speeds and are also fitted with route indicators (figure 2).

90 The risk from signal BY19 being passed at danger was assessed using the signal assessment tool[8]. This found that the risk was low and required no further detailed examination. The assessment tool does not consider the risk from overspeeding following the clearance of the junction signal and there was no other process that would have captured it.

[8] This is a computer based numeric tool developed by Network Rail which calculates the indicative levels of risk associated with the overrunning of signals at danger. It takes into account factors such as line speed, traffic levels, type of rolling stock and crashworthiness and the safe overrun distance beyond the signal before a collision with another train could occur. The output is a risk score which determines whether the signal should be subject to more detailed assessment.

91 Signal BY19 was examined by a signal sighting committee in 2004 as part of the route modernisation project for the West Coast Main Line. The resulting report following this stated that it would be beneficial to change the junction indicator to a (brighter) fibre optic alphanumeric route indicator to assist drivers of passenger trains starting from rest at Bletchley station. The project did not carry out the change and the RAIB has been unable to establish why not.

The driver was distracted by matters external to his work

92 There is evidence to suggest that the driver's concentration may have been affected by matters external to his work, and he stated that he was thinking about these as the train passed through Milton Keynes, just north of Bletchley.

93 However, the way the train was driven on the approach to signal BY19 when displaying a red aspect shows that the driver at this time was focused on the driving task with no evidence that he was distracted. The significance of any distraction caused by matters external to his work is therefore uncertain.

Discounted factors

Driver fatigue

94 Although the driver was working a first night shift, he gave evidence of his sleeping patterns beforehand (paragraph 51) which indicated he should have been well-rested for the turn of duty working train 0A90.

95 Although at the time of day at which the accident occurred the human body's 'internal clock'[9] causes alertness to be at its lowest, the RAIB found no evidence that driver fatigue was a factor in the accident.

Distraction by activities in the cab

96 There was no evidence that the driver had been using a mobile phone while driving the class 90 locomotive.

97 The driver's actions in the way he responded to signal BY19 at red also do not suggest that he was distracted by other activity in the cab.

Observations[10]

Weekly Operating Notice

98 The Weekly Operating Notice contained details of work taking place south of Bletchley Junction requiring all trains to travel on the fast lines (paragraph 86). It also contained details of the temporary speed restriction on the up slow line through Bletchley station (paragraph 49).

99 Drivers are required to sign an acknowledgement that they have received the notice and are then expected by Virgin Trains to read it and identify what is relevant for the turn of duty they are working. They are given ten minutes for this purpose within each duty period.

[9] The causes of fatigue are discussed more fully in paragraph 20 of the report on the RAIB's investigation of the uncontrolled freight train run-back between Shap and Tebay, Cumbria, on 17 August 2010 (report 15/2011).

[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.

100 The driver of train 0A90 had signed for the notice on 29 January 2012 (paragraph 49). He stated that he had been through the notice and had it in his possession during the turn of duty working train 0A90. However, it would appear that he had not noted and understood the significance of the content of the notice referring to the line blockage south of Bletchley Junction (or had forgotten the content), as otherwise he would have been expecting to cross from the up slow line to the up fast line at that point, the last place this could be done before reaching the work taking place.

101 The role of the Weekly Operating Notice in assuring safety is not entirely clear within the railway industry. Section B of the notice, which contains details of engineering work, has a significant amount of detail that is irrelevant for drivers making it less easy for them to identify the relevant information. In addition, for a train like 0A90, the driver does not know in advance how it will be routed, and may not have read a part of the notice applicable to a section of route he subsequently drives over.

102 Drivers are able to drive safely without having first read the information in section B of the notice. Provided they respond correctly to the signalling, they do not need to know beforehand which lines they will be taking. However, reading the notice does provide them with prior warning of the likely routing of their train and may mean that they are more alert than would otherwise be the case.

103 Section A of the notice covering details of temporary speed restrictions has a greater safety significance because serious consequences can arise if a driver fails to observe a temporary speed restriction. Although temporary speed restrictions are provided with signage and automatic warning system magnets, the information provided by section A advises drivers of their presence. This is a safeguard against the possibility that a driver may not see the signs unless pre-warned to expect them, the signs/automatic warning system may have been placed in the wrong place, or they could have been removed by unauthorised persons.

Monitoring of class 90 driving standards

104 The driver exceeded the speed limit for a light locomotive, in some cases significantly, during the journey from Crewe to Bletchley and while running under green signal aspects (paragraph 56). Although the train was 84 minutes early by the time it reached Bletchley (paragraph 59), little of this gain would have arisen from the driver exceeding the speed limit. The driver did not offer any explanation for driving in this way and stated that he was aware of the speed limits applying to light class 90 locomotives (paragraph 19).

105 The two year cycle of drivers' assessments (paragraph 28) did not include analysing the downloads from the data recorders of class 90 locomotives. This made it less likely that any driver exceeding the permitted speed of light class 90 locomotives would be identified.

Previous occurrences of a similar character

106 The RAIB found no evidence of previous overspeeding incidents at Bletchley Junction, or of other derailments elsewhere on the network where excessive speed following clearance of the junction signal has occurred.

107 On 30 November 2011, the driver of a class 390 train operated by Virgin Trains did not perceive the alphanumeric route indicator fitted to signal CE107 at Crewe. When the signal cleared to green, the driver assumed that he was to continue on the down fast line, which has a maximum permitted speed of 80 mph (129 km/h), rather than (unexpectedly) via platform 11 as indicated by the route indicator. The train accelerated from a speed of 24 mph (39 km/h) and traversed the junction at 59 mph (95 km/h) rather than the specified 20 mph (32 km/h).

108 Unlike signal BY19 at Bletchley, the view of the route indicator at signal CE107 was found to be partially obstructed by overhead line equipment at the point when the signal cleared, and to be degraded by sunlight. However, the factor of the driver's expectation is similar in both cases; the route that the driver was expecting to take was not in fact the one he was actually to take.

109 On 6 August 2011 at Hampton Court Junction, the driver of a South West Trains service wrongly assumed that he was to continue on the down slow line when the junction ahead, indicated by a position light junction indicator at signal WK133, was set for the diverging route. This led to the train traversing the 30 mph (48 km/h) junction at 40 mph (64 km/h), having previously accelerated to 55 mph (88 km/h), before the driver realised his mistake. Again, the driver wrongly anticipated the route he was to take and made the error even though the more prominent type of junction indicator was fitted in this case (paragraph 87).

110 On 22 August 2007 at Didcot North Junction, the driver of a First Great Western service from London Paddington to Worcester Shrub Hill passed the signal protecting the junction, signal SB2209, at danger. The train stopped foul of the junction over which another First Great Western service had just passed.

111 This incident was investigated by the RAIB (report 23/2008) which found that the driver had an incorrect expectation of the approach to the signal and an expectation that the previous signal would change from a single yellow to a less restrictive aspect as he approached it. This caused the driver to neither register the aspect shown by the previous signal nor prepare his train to stop at signal SB2209.

112 The driver had also had limited exposure to the route past signal SB2209 in recent years, although greater than required by First Great Western's standard (he had driven the route five times during the previous two years). Although he was able to demonstrate a good knowledge of the track layout and signalling arrangements to the RAIB, the lack of exposure to actually driving the route could have been a factor in the driver's lack of understanding on the approach to signal SB2209.

113 The recommendation made by the RAIB following its investigation of the incident at Didcot North Junction which is relevant to the circumstances of the derailment at Bletchley Junction is described in paragraphs 122 and 123.

Summary of conclusions

Immediate cause

114 The immediate cause of the derailment was that the driver drove the locomotive at significantly higher than the permitted speed when taking the diverging route from the up slow line to the up fast line at Bletchley Junction (**paragraph 73**).

Causal factors

115 The causal factor was:

a. when signal BY19 changed to green, the driver did not observe, and/or register the meaning of, the route indication that was displayed until it was too late (**paragraph 75**).

The following related factors have been identified:

(i) the driver had developed an expectation of how he should drive over Bletchley Junction (**paragraph 77, Recommendation 1**); and

(ii) the route risk assessment process had not identified an overspeeding risk at Bletchley Junction and therefore there was no specific route learning mitigation associated with it (**paragraph 82, Recommendation 1**).

Additionally, it is possible that the following factors were relevant:

(iii) the form of junction indicator fitted to signal BY19 (**paragraph 87, Recommendation 2**); and

(iv) the driver was distracted by personal matters external to his work (**paragraph 92**).

Additional observations

116 Although not causal to the accident on 3 February 2012, the RAIB observes that:

a. the driver of train 0A90 had not noted from the Weekly Operating Notice the work taking place south of Bletchley Junction (**paragraph 100, Recommendation 3**); and

b. Virgin Trains had no process in place to use on-train data recorder downloads from class 90 locomotives as part of the driver competence management system. This made it less likely that any driver exceeding the permitted speed of light class 90 locomotives would be identified (**paragraph 105, Learning point 1**).

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

117 Virgin Trains no longer works train 0A90, and Freightliner is now responsible for moving the locomotive to Wembley depot.

118 Virgin Trains now routinely analyses the downloads of data recorders fitted to class 90 locomotives as part of its driver assessment competence arrangements (paragraph 116b).

119 Virgin Trains issued a reminder to its drivers about the maximum speed of light locomotives effective from 10 February 2012 (paragraph 19).

120 Virgin Trains led the railway industry's investigation of the Bletchley derailment and made a recommendation to review its processes covering route risk assessments (paragraph 84) and the examination of drivers' route knowledge, so they include low speed diverging junctions with alphanumeric route indicators. A further recommendation was to review and consider additional controls to verify drivers' methods of route learning.

121 Network Rail is planning to replace Bletchley Junction with a new, higher speed, junction, just south of Bletchley in early 2013.

Previous RAIB recommendations relevant to this investigation

122 The following recommendation was made by the RAIB as a result of a previous investigation, which addresses factors identified in this investigation:

Signal passed at danger and subsequent near miss at Didcot North Junction on 22 August 2007, RAIB report 23/2008 published 20 November 2008

Recommendation 7

First Great Western should review its systems for the management of route knowledge with the following objectives:

- to assess whether the extent of current route knowledge required by its drivers is compatible with the need for drivers to retain adequate situational awareness;
- to assess whether the currently mandated minimum frequency of exposure to each route is sufficient (this review should be updated when the actions at Recommendation 8[11] have been completed);
- to put in place systems for monitoring the actual exposure of drivers to each route they have signed for; and
- to assess the adequacy of driver training and competency management systems related to route learning and the retention of route knowledge.

123 In response to the RAIB's recommendation, First Great Western has redesigned its system of route risk assessment, route knowledge training and the assessment of route knowledge competence. It has formalised the arrangements in a new standard within its safety management system.

124 The Office of Rail Regulation (ORR) (to whom the recommendation was addressed) reported to the RAIB that First Great Western had implemented the recommendation. Although the ORR did not require Virgin Trains to take any action, Virgin Trains reported that, in response to the recommendation, it issued a revised standard on driver management, which included improvements to route learning.

[11] Recommendation was addressed to RSSB, in conjunction with the Association of Train Operating Companies, to carry out further research into the periodicity of driving turns/refresher training required to acquire and retain route knowledge.

Learning points

125 The RAIB has identified the following key learning point[12].

1 Train operators, whose drivers drive light locomotives, should be aware that inappropriate driving behaviour may develop unless such driving is monitored as part of the competence management system to enable inappropriate methods of driving to be detected and suitable remedial action taken. This could be achieved by taking downloads from locomotive on-train data recorders, or track side speed checks, at suitable intervals.

Learning point

[12] 'Learning points' are intended to disseminate safety learning that is not covered by a recommendation. They are included in a report when the RAIB wishes to reinforce the importance of compliance with existing safety arrangements (where the RAIB has not identified management issues that justify a recommendation) and the consequences of failing to do so. They also record good practice and actions already taken by industry bodies that may have a wider application.

Recommendations

126 The following recommendations are made[13]:

1 *The intention of this recommendation is that Virgin Trains' drivers have sufficient competence in route knowledge and that this knowledge is regularly reinforced by practical application.*

Virgin Trains should review, and amend as necessary, its route knowledge training and assessment process so that the risk from drivers exceeding permissible speeds at diverging junctions is adequately controlled. The review should consider the need to reinforce the knowledge by driving over the routes concerned, cab simulation, video based scenario training, or other suitable techniques, and the required frequency of each (paragraphs 115a(i) and 115a(ii)).

Note that the principle applied by this recommendation may apply to other train operators.

continued

[13] Those identified in the recommendations, have a general and ongoing obligation to comply with health and safety legislation and need to take these recommendations into account in ensuring the safety of their employees and others.

Additionally, for the purposes of regulation 12(1) of the Railways (Accident Investigation and Reporting) Regulations 2005, these recommendations are addressed to the Office of Rail Regulation to enable it to carry out its duties under regulation 12(2) to:

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

(b) report back to 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 200 to 203) can be found on RAIB's website www.raib.gov.uk.

2 *The intention of this recommendation is that, at potentially high risk diverging junctions, such as those where the approach speed is 60 mph (96 km/h) or greater and requiring a reduction in speed of a third or more, the risk from a train overspeeding on a diverging route following the clearance of the junction signal under approach control conditions is reduced. Different or additional mitigation may be justified depending on the level of risk identified; this may include replacement by position light junction indicators; replacement of junction indicator by one in modern equivalent form; alteration to signalling controls etc.*

Network Rail, in conjunction with train operators, should assess the risk from overspeeding at potentially high risk diverging junctions with approach control following the clearance of the junction signal. As a minimum, the scope should include consideration of:

- junctions where the speed of the diverging route is significantly lower than the approach speed;
- junction signals fitted with standard alphanumeric route indicators; and
- the type of traction using the junction and its ability to accelerate following the clearance of the junction signal from red.

The outcome of the risk assessments should be used to determine whether different/additional mitigation is required (paragraph 115a(iii))

3 *The intention of this recommendation is to clarify the safety significance of the Weekly Operating Notice with respect to the information that drivers need to know and the best way to present and distribute this information.*

Network Rail, in conjunction with train operating companies, should review and where necessary modify the Weekly Operating Notice to identify the information that drivers need to assure safety and how this content is presented so that it can be readily assimilated (paragraph 116a).

Appendices

Appendix A - Glossary of terms

Approach control	The clearing of a signal when the approaching train has been proved to have reduced speed sufficiently to observe the correct speed over a junction/route.
Aspect	The coloured light or lights displayed by a colour light signal.
Automatic warning system	A track inductor based system linked to the aspects of fixed lineside signals that provides audible and visual warnings to the driver on the approach to signals, certain level crossings and emergency, temporary and certain permanent speed restrictions.
Down	Running in the direction away from London.
Facing points	Points (a section of track with moveable rails that can divert a train from one track to another) positioned so that routes for trains passing over them diverge in the normal direction of travel.
HM Railway Inspectorate	Became part of the Office of Rail Regulation in 2006; the safety regulator for the railways of Great Britain.
Human factors	The science of human behaviour and its influence on the occurrence of human errors.
Junction indicator	An attachment to a colour light signal located on the approach to a facing junction which indicates to a driver either by an alphanumeric notation, or by a row of white lights, whether the train is to take a diverging route at the junction.
Light engine	A locomotive without other railway vehicles coupled to it.
National Radio Network	A dedicated radio network operated and maintained by Network Rail that allows direct communication between driver and network controller.
Office of Rail Regulation	The safety regulator for the railways of Great Britain.
On-train data recorder	The equipment on a train which records parameters such as speed, braking and distance run.
Pantograph	The folding current collector mounted on the roof of an electric train allowing current to flow from the overhead electrification equipment to the train/locomotive.
Possession	A period of time that a section of the railway is blocked to service trains so that engineering work can be safely carried out.

Railway Group Standard	A document that mandates technical and operational requirements to members of the railway group (Network Rail, train operators etc.).
Route indicator	A form of junction indicator which identifies to a driver by an alphanumeric notation whether the train is to take a diverging route at a junction.
Sighting (of a signal)	The characteristics of a signal relating to the extent to which the driver of an approaching train has sufficient time to identify, observe and interpret the information being displayed by that signal.
Signal sighting committee	A group of experts convened to examine the sighting of a signal.
Temporary speed restriction	A speed restriction imposed on trains passing over a specific section of track, which is less than the normally permitted speed, applied for a limited period because of track condition or other temporary, local constraint.
Track circuit	An electrical circuit in the running rails that detects the presence of a train.
Train protection warning system	A system fitted to certain signals which will automatically apply a train's brakes if it approaches the signal at too high a speed, or fails to stop at it, when it is set at danger.
Up	Running in the direction towards London.
Vacuum circuit breaker	A circuit breaker in which the contact surfaces completing or interrupting the electrical circuit between the overhead electrification equipment and the locomotive are contained in a vacuum.
Weekly Operating Notice	A Network Rail document published on a route basis, providing information about engineering work, speed restrictions, alterations to the network and other relevant information to train drivers.
Wrongside failure	The failure of a piece of signalling equipment to an unsafe state.

Appendix B - Detailed timeline of events just before and during the accident

Feature/activity	Time (hrs:mins:secs)	Distance from signal BY19 automatic warning system magnets yards (metres)	Accumulated time from BY19 automatic warning system (secs)	Speed of locomotive mph (km/h)	Brake pipe pressure (bar)
BY19 signal automatic warning system magnets (bell)	02:26:28	0	0	12.4 (20)	5.1
Location of BY19 signal	02:26:44	201.8 (184.5)	16	53.7 (86.4)	5.1
Traction power shut off and automatic brake partially operated	02:26:47	287 (262.4)	19	63.8 (102.7)	5.1
Toe of 216A points		294.1 (268.9)			
Brake pipe pressure reduction in response to brake application	02:26:47	296.4 (271)	19	63.8 (102.7)	4.6
Vacuum circuit breaker opened and a short period of wheelslip occurred - probable time the derailment occurred	02:26:49	350.8 (320.8)	21	65.5 (105.4)	4.6
Break in on-train data recorder data	02:26:49	354 (323.7)	21	65.5 (105.4)	4.6
On-train data recorder resumed, wheelslip occurred*	02:26:50	372.1 (340.2)	22	56.9 (91.6)	4.6
Locomotive stationary*	02:27:01	451.7 (413)	33	0	0

* Distance and speed are unlikely to be accurate because of the break in recording

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