Rail Accident Investigation Branch

Rail Accident Report

Derailment at Knaresborough
7 November 2015

Report 16/2016
August 2016

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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This report is published by the Rail Accident Investigation Branch, Department for Transport.

Preface

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. 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.

The RAIB's findings are based on its own evaluation of the evidence that was available at the time of the investigation and are intended to explain what happened, and why, in a fair and unbiased manner.

Where the RAIB has described a factor as being linked to cause and the term is unqualified, this means that the RAIB has satisfied itself that the evidence supports both the presence of the factor and its direct relevance to the causation of the accident. However, where the RAIB is less confident about the existence of a factor, or its role in the causation of the accident, the RAIB will qualify its findings by use of the words 'probable' or 'possible', as appropriate. Where there is more than one potential explanation the RAIB may describe one factor as being 'more' or 'less' likely than the other.

In some cases factors are described as 'underlying'. Such factors are also relevant to the causation of the accident but are associated with the underlying management arrangements or organisational issues (such as working culture). Where necessary, the words 'probable' or 'possible' can also be used to qualify 'underlying factor'.

Use of the word 'probable' means that, although it is considered highly likely that the factor applied, some small element of uncertainty remains. Use of the word 'possible' means that, although there is some evidence that supports this factor, there remains a more significant degree of uncertainty.

An 'observation' is a safety issue discovered as part of the investigation that is not considered to be causal or underlying to the event being investigated, but does deserve scrutiny because of a perceived potential for safety learning.

The above terms are intended to assist readers' interpretation of the report, and to provide suitable explanations where uncertainty remains. The report should therefore be interpreted as the view of the RAIB, expressed with the sole purpose of improving railway safety.

The RAIB's investigation (including its scope, methods, conclusions and recommendations) is independent of any inquest or fatal accident inquiry, and all other investigations, including those carried out by the safety authority, police or railway industry.

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7 November 2015

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Summary

At 07:22 hrs on 7 November 2015, a Northern Rail passenger service from York to Harrogate derailed on a set of points on the approach to Knaresborough station. The train consisted of two class 150, 2-car multiple units.

The leading five bogies derailed and damage was sustained by both the train and track. None of the train crew or five passengers on board were injured. The line was re-opened at 12:58 hrs on 8 November 2015.

The signaller in Knaresborough signal box had authorised the train to pass a signal at danger (red), without realising that the set of points beyond the signal was in an unsafe condition. The signaller had not checked the associated points position indicator in the signal box and misinterpreted the significance of being able to reverse the signal lever, leading him to believe that the route was correctly set and safe.

The signaller in Knaresborough signal box that day was a mobile operations manager. As a mobile operations manager, his core work was to respond to faults and incidents on the railway network; he operated signal boxes infrequently.

The RAIB concluded that the signaller did not have a full understanding of the working of Knaresborough signal box and that this lack of knowledge may have been the result of either poor initial training or the way his knowledge had been maintained.

An underlying factor to this incident was the lack of robustness of Network Rail’s competence management system for non-signallers (the people within Network Rail whose core duty is not to operate signal boxes but who occasionally have to do so).

In March 2016, Network Rail re-issued the operations manual for the staff in charge of operating signalling equipment. In April 2016, Network Rail started an end-to-end review of the way it manages the competence of its signallers.

As a result of this investigation, the RAIB has made one recommendation on Network Rail to review whether the changes that it has recently made to the operations manual have resulted in non-signallers maintaining the required level of knowledge and experience.

The RAIB has identified five learning points. The first three learning points relate to the actions of signallers in degraded operating conditions. The fourth learning point relates to the importance of investigating and understanding the underlying reasons for repeated asset failures. The final learning point relates to the actions of drivers when authorised to pass a signal at danger and after an incident.

Introduction

Key definitions

1 Metric units are used in this report, except when it is normal railway practice to give speeds and locations in imperial units. Where appropriate the equivalent metric value is also given.

2 The report contains abbreviations and technical terms (shown in *italics* the first time they appear in the report). These are explained in appendices A and B. Sources of evidence used in the investigation are listed in appendix C.

The accident

Summary of the accident

3 At 07:22 hrs on Saturday 7 November 2015, the 06:52 hrs Northern Rail passenger service from York to Harrogate derailed at the 'A' end of points 3 (referred as points 3A in the rest of this report) on the approach to Knaresborough station. The train, reporting number 2C07, consisted of two class 150, 2-car multiple units.

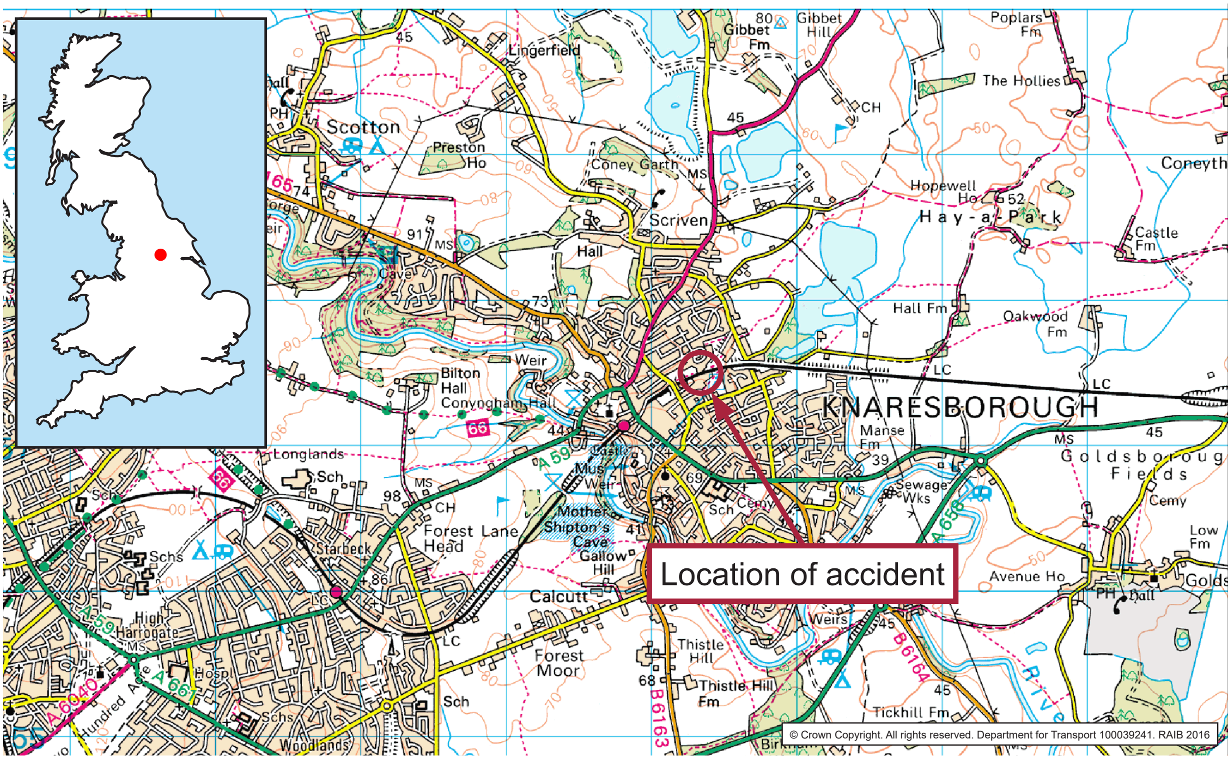

Figure 1: Extract from map showing location of accident

4 The first five bogies derailed and damage was sustained by both the train and track. None of the train crew or five passengers on board were injured. The line was re-opened at 12:58 hrs on Sunday 8 November 2015.

Context

Location

5 Knaresborough station, on the London North East and East Midlands route, area North (LNE-EM North), is located on the line between York and Leeds via Harrogate. It is between Starbeck station to the west and Cattal station to the east. Cattal, Knaresborough and Starbeck stations are respectively located at 10 miles 17 *chains*, 16 miles 50 chains and 18 miles 27 chains from York. There is a signal box at each location.

6 Running east to west, the line between Cattal and Knaresborough stations is a bi-directional single line (known as the 'Harrogate single'). The line between Knaresborough and Starbeck is double track (figure 3).

Figure 2: Train 2C07 at the site of derailment

7 Points 3A, on which the derailment took place, are where the single line between Cattal and Knaresborough becomes double track (a crossover). For a train travelling from Cattal to Knaresborough, such as train 2C07, points 3A enable the train to move onto the DownYork line heading towards Harrogate and Leeds. For a train travelling from Knaresborough to Cattal, points 3B[1] and 3A enable the train to move from the Up York line onto the single line.

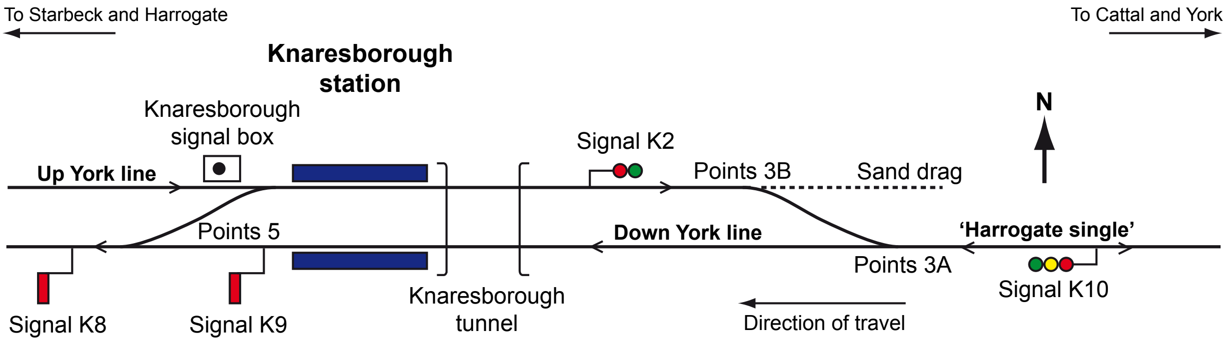

Figure 3: Overview of site showing geographical relationship of key features

8 The crossover is protected by signals:

a. on the single line, signal K10, a three-aspect *colour light signal* situated approximately 205 metres away from the *toe* of points 3A;

b. on the Up York line, signal K2, a two-aspect colour light signal situated approximately 250 metres away from the toe of points 3B.

[1] Points 3B is the 'B' end of points 3.

9 Train movements in the area are controlled by the signaller at Knaresborough signal box (16 miles 54 chains). *Absolute block regulations* apply between this location and the adjoining Starbeck signal box. *Electric token block regulations* apply from Cattal signal box to Knaresborough. A train travelling from Cattal to Knaresborough on the single line will be issued with a token at Cattal. This token will be surrendered by the driver to the signaller at Knaresborough on arrival at the station. Only one token can be issued at any one time.

Organisations involved

10 Train 2C07 was operated by Northern Rail who also employed the driver.

11 The track, signalling infrastructure and signal boxes are owned and managed by Network Rail, who also employed the signaller who was on duty in Knaresborough signal box at the time of the derailment.

12 Northern Rail and Network Rail freely co-operated with the investigation.

Train involved

13 Train 2C07 was a *diesel multiple unit* with unit 150133 leading and unit 150204 trailing. The train was driven from vehicle 57133.

Rail equipment/systems involved

14 Points 3A are of the *E-type*, using *flat bottom rails* laid vertically. The points are fitted with an electrical ‘*clamp lock*’ machine and a mechanical *back drive* used to move the *switch rails* from one position to the other. When in the ‘*normal*’ position, the points are set for a train approaching from the single line to remain on the DownYork line. When in the ‘*reverse*’ position, the points are set for a train approaching from the Up York line moving onto the single line.

Figure 4: Points 3 in the ‘normal’ position and signal K10

15 Knaresborough signal box dates back to 1872. It is a grade 3 signal box[2] which means that it can only be operated by signallers who have achieved this grade of competence and above. According to Network Rail’s records at the time of the derailment, 3 *resident signallers*, 5 *relief signallers* and 4 *Mobile Operations Managers* (MOMs) were certified competent to operate this signal box.

[2] Network Rail signal boxes and control centres are graded from 1 to 9. An increasing number indicates an increasing complexity and traffic density.

16 Knaresborough signal box is fitted with a frame containing 12 mechanical levers. The levers are used to operate the points and signals controlled by the signal box. The area controlled by the box spans from Oakwood Farm crossing to the east to signal K8 on the DownYork line to the west.

Figure 5: Knaresborough signal box lever frame

17 There are two sets of points controlled by this signal box: points 3 and points 5. Unlike points 3 which are power operated, points 5 are mechanical points where the movement of the switch rails is mechanically driven, using rods, by the signaller moving the corresponding lever.

18 The signals controlled from Knaresborough signal box are a mixture of *semaphore* (eg K8 and K9) and electrically operated colour-light signals (eg K2 and K10). The semaphore signals are mechanically operated by wire from the signal box, and the arm of the signal moves when the signaller operates the corresponding lever.

Staff involved

19 The driver of train 2C07 had 14 years of experience as a driver. He had not been involved in any previous incidents and at no point had his employer identified any issues with his competence. His competence was certified by Northern Rail and the certification was in date.

20 The signaller in Knaresborough signal box at the time of the derailment was from a different area: he was a Mobile Operations Manager (MOM) from Knottingley reporting to the Ferrybridge *Local Operations Manager* (LOM). He joined Network Rail in 2008 as a trainee signaller attending the signalling school in Leeds. He then worked as a resident signaller on the Harrogate line at Hammerton for two years. Towards the end of his time at Hammerton, he was given time to learn the operations of the other boxes on the Harrogate line (except Harrogate signal box) and in summer 2010, he became a relief signaller on the line. This is when he learnt how to operate Knaresborough signal box.

21 In May 2012, he became a MOM at Thirsk. In December 2013, he was seconded as a MOM to Darlington and then in May 2014, he took up his position as a Knottingley MOM. Throughout his time as a MOM, he retained the authority to operate Knaresborough signal box which he had acquired when working as a relief signaller on the line. He was a grade 7 signaller meaning that, provided he was certified as having completed location specific learning, he could operate any signal box or control centre up to a grade 7.

External circumstances

22 It was raining at the time of the derailment. The sun rose at 07:18 hrs shortly before the derailment but the overcast weather limited the ambient light. The limited ambient light may have affected the driver’s ability to ascertain the way the points were set (paragraph 55).

23 There was no other traffic in the immediate vicinity at the time of the derailment but train 2C06 (the 06:36 hrs Leeds to York service) was approaching Knaresborough station on the Up York line (paragraph 45).

Background information

Operation of mechanically operated signals and points via lever frames

24 Mechanically operated semaphore signals are moved by a wire which pulls the arm to the '*clear*' (or 'off') position when the signaller reverses the corresponding lever. An indicator, located on the shelf above the signal lever provides the signaller with confirmation of the position of the semaphore arm (figure 6).

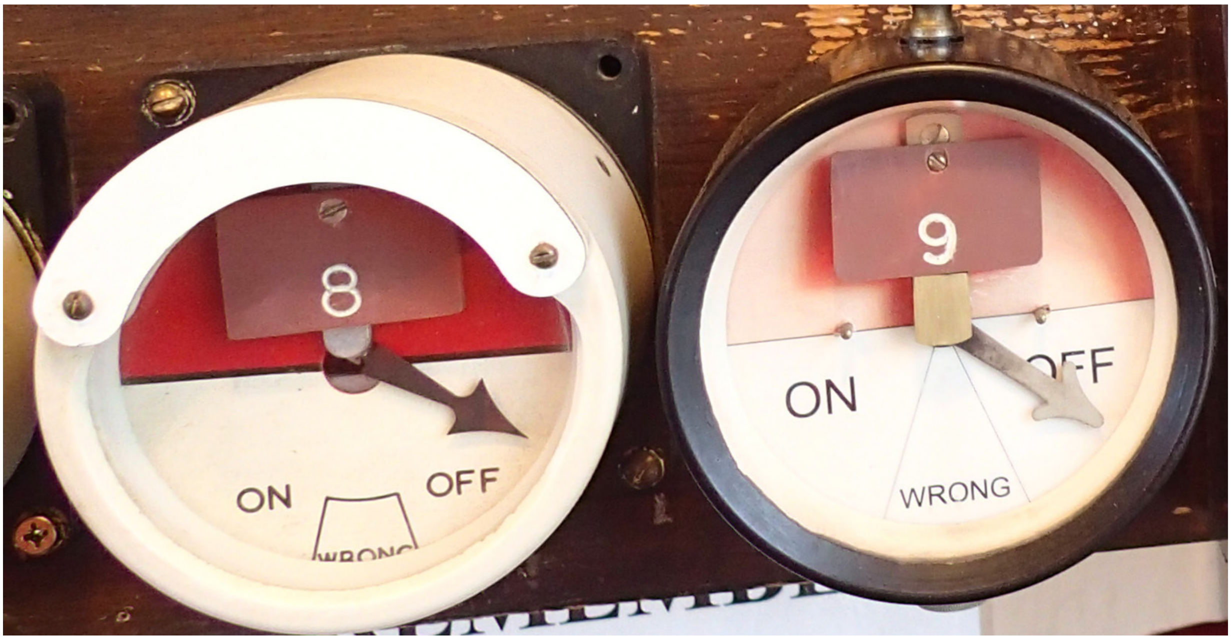

Figure 6: Signal aspect indication at Knaresborough signal box for signals K8 and K9 (semaphore)

25 Mechanically operated points are also moved by the signaller pulling a lever. This drives the movement of the switch rails by means of rods. In the case of many points, including those that can be used by passenger trains in a facing direction, the signaller must then secure the points in the correct position by pulling another lever that operates the facing point lock (FPL). This is a mechanical bolt which proves that the points are set in a safe position (normal or reverse) and locks them in that position. Only when this lever is pulled, so proving that the points are safe, will the mechanical *interlocking* between the levers permit the operation of the levers which work the associated signals. This mechanical arrangement therefore provides two indications to signallers if the points are not correctly set (ie the FPL lever cannot be fully engaged when pulled, and the associated signal lever is locked).

Operation of electrically operated signals and points via lever frames

26 In the case of levers controlling electrical functions, the lever is not used to mechanically drive the equipment on the ground but instead activates an electrical switch which, provided that certain electrical conditions are met, sends an electrical command to the equipment on the ground to operate. The electrical interlocking to achieve this is a series of switches that have to be closed to prove that other equipment is in the correct position to allow the commanded equipment to change state. Once the electrical command has been sent, received and successfully executed, the commanded equipment on the ground sends electrical feedback information to the signal box which indicates to the signaller that the command has been successful. This information is displayed in the signal box as a set of indication lights above the corresponding lever (figure 7).

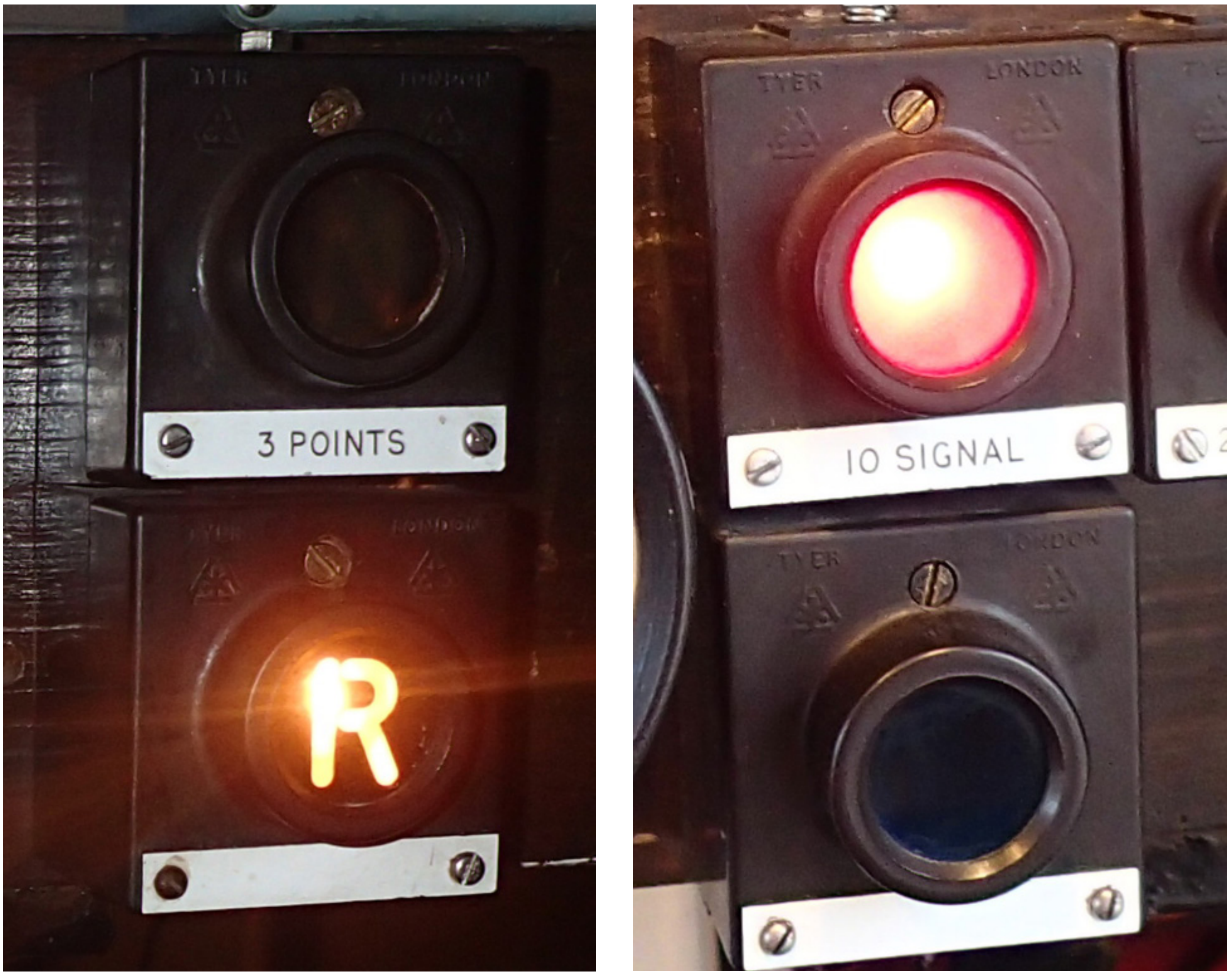

Figure 7: Points position indication[3] and signal aspect indication

[3] The points position indication for points 3 requires both points 3A and 3B to have obtained detection before it shows 'N' or 'R'.

27 An important feature of electrically operated signals in lever frames is that the signal lever may be free to move regardless of whether the interlocking has detected that the associated points have reached the commanded position (unless the lever(s) have been fitted with additional lock(s) – see paragraph 74). Safety is assured by the electrical interlocking which prevents the signal from clearing until the points are detected in the correct position. Since the detection and locking of points is proved electrically, there is no FPL lever associated with points which are electrically controlled. Confirmation of points detection is therefore provided to the signaller by an indicator located above the corresponding lever. The signaller needs to check this indication in order to know that the points are detected and locked in the correct position.

28 Levers which control purely electrical functions have their handles shortened to enable the signaller to easily distinguish them from levers operating mechanical equipment, as they require much less effort to operate them (eg the levers operating points 3 and signal K10 at Knaresborough signal box have short handles). Knaresborough signal box was the only signal box with power operated points which the Knottingley MOM was certified as competent to operate.

Sequence of events

Events preceding the accident

29 On Thursday 29 October 2015, shortly after the start of his shift at 14:43 hrs, one of the resident signallers (referred to as resident signaller A) in Knaresborough signal box hurt his back when pulling the mechanical lever controlling points 5. Having reported the injury to his line management, he completed his shift on the basis that points 5 did not need to be used again. He was due to work the following day but called in sick because of his bad back and was replaced by a MOM from York.

30 At 10:56 hrs on Saturday 31 October 2015, the resident signaller for the morning shift (resident signaller B) reported an intermittent indication fault on points 3 in the signal box. Resident signaller A resumed his normal duties on Saturday 31 October 2015 in the afternoon.

31 On Thursday 5 November 2015, resident signaller A, who was on a rest day, called in to say that he would not be able to complete his shifts on Friday 6 November and Saturday 7 November because of his back injury. The route resourcing team[4] located in York was able to organise cover for Friday 6 November using one of the relief signallers and started exploring the options available to cover Saturday 7 November.

32 Later that evening, at approximately 18:50 hrs, the Signalling and Telecommunication (S&T) fault team arrived at Knaresborough signal box to address the intermittent fault reported several days before. Unable to recreate the fault, they replaced the lamps in the indicators for points 3 in the signal box, as a precaution.

33 On the morning of Friday 6 November, the resourcing team concluded that it could not find adequate cover for the morning shift at Knaresborough signal box on Saturday 7 November. Having exhausted all available options, the resourcing team left a voicemail with the LOM for the Harrogate line at around lunchtime to report the lack of cover. The Harrogate LOM is the person responsible for the management of signalling operations on the Harrogate line.

34 At around 15:20 hrs, the Harrogate LOM called the Knottingley MOM to discuss the upcoming work as a *points operator* that the Knottingley MOM was scheduled to undertake on the Saturday morning at Harrogate[5]. During the discussion, the Harrogate LOM mentioned that he was struggling to find someone to operate Knaresborough signal box at the same time. The Knottingley MOM, knowing that he was still certified as being competent to operate the signal box, offered to cover the shift at Knaresborough, provided that someone could cover his points operator's work at Harrogate.

[4] The resourcing team is in charge of rostering the signallers on the route to ensure that all shifts are staffed.

[5] A large possession was planned at Harrogate over the weekend of 7/8 November 2015.

35 As it was easier to find someone to cover the points operator's work at Harrogate, the Harrogate LOM took up the offer. He contacted the resourcing team to advise that the Knottingley MOM would be operating Knaresborough signal box on the morning of Saturday 7 November 2015. He then organised for the points operator's work to be covered by alternative means. The Knottingley MOM is referred to as the 'signaller (MOM)' in the rest of this report.

Events during the accident

36 On the morning of Saturday 7 November 2015, at 06:20 hrs, the signaller (MOM) opened Knaresborough signal box. From 06:50 hrs to 07:07 hrs, he successfully signalled the first train (train 2C02) from Starbeck on the Up York line onto the single line. He stated that he replaced No 3 points lever to the normal position in the frame to normalise the points after train 2C02 reached the single line.

37 At 06:52 hrs, train 2C07 left York station in the direction of Leeds via Harrogate.

38 At 07:10 hrs, the signaller (MOM) received a *bell code* from Cattal signal box to indicate that train 2C07 was entering the section of single line track between Cattal and Knaresborough.

39 At around 07:14 hrs, as train 2C07 occupied the *track circuits* on the approach to Oakwood Farm crossing, the signaller (MOM) pulled signal levers K9-K8-K10 in this order, expecting all three signals to clear, but signal K10 did not.

40 Having remembered that the signals at Knaresborough signal box need to be pulled in a specific order for them to clear (K10-K9-K8), he replaced all three levers. This action meant that there was then a two-minute period during which signals K9 and K10 could not be operated (the intent of this is to prevent points locked by the signals being changed as a train approaches or passes over them, and give time to the signaller to reflect on the situation).

41 At 07:19 hrs, the signaller (MOM) received a call from the driver of train 2C07 which by now had stopped at signal K10 at *danger*. The signaller (MOM) explained that he had pulled the levers in the wrong order and asked the driver to wait.

42 At approximately 07:20 hrs, once it was possible to do so, the signaller (MOM) pulled the signal levers in the sequence K10-K9-K8 fully expecting signal K10 to clear this time. However, signal K10 remained at danger and the corresponding signal aspect indicator in the signal box continued to display a red light.

43 The signaller (MOM) stated that he stepped back away from the lever frame and observed it. Unable to identify anything that would explain why signal K10 remained at danger, he concluded that there must have been something wrong with the signal and decided to authorise the driver to pass the signal at danger. A train passing a signal at danger following verbal instructions from a signaller is allowed by railway rules in certain specified circumstances, including signal failures (paragraph 54).

44 At 07:20 hrs, the signaller (MOM) called the driver of train 2C07 to authorise him to pass signal K10 at danger. He instructed him to proceed at caution and to draw into the platform. The driver showed that he had understood the message by repeating it.

45 At 07:21 hrs, the driver of train 2C07 started the authorised move. Shortly afterwards he correctly overrode the *Train Protection Warning System* (TPWS) which operated as his train passed signal K10 at danger. He sounded the horn of his train for the footpath crossing that is just beyond the signal and accelerated. At the same time, the signaller (MOM) received a bell code from Starbeck signal box advising that train 2C06 was entering the section of track between Starbeck and Knaresborough on the Up York line. Having logged this in the *train register book*, he left the signal box to go to the platform to collect the token from train 2C07.

46 At 07:22 hrs, as it was travelling over points 3A, train 2C07 derailed. RAIB's analysis of the on-train data recorder indicates that the train was travelling at approximately 18 mph (29 km/h) as it passed over the points[6]. It took a couple of seconds for the driver to realise what was happening after which he started applying the brakes on the train in *step* 1, 2 and 3 to eventually bring his train to a stand with five out of the eight bogies derailed.

Events following the accident

47 At 07:23 hrs, the driver of train 2C07, now at a stand, called Knaresborough signal box using the yellow button[7] on the *Global System for Mobile communication -Railway* (GSM-R) terminal. The phone rang within Knaresborough signal box but nobody picked it up as the signaller (MOM) was still on the platform waiting for the train to arrive, and for its driver to give up the single line token.

48 The driver of train 2C07 then decided to use the Railway Emergency Call (REC) button on the GSM-R terminal which initiated a call that was handled by Network Rail's Route Control. This call lasted approximately 13 minutes and the signaller (MOM) joined the call after about 1 minute and 20 seconds, having just re-entered the signal box. During this conversation, the signaller (MOM) confirmed that he had no lit position indicator light for points 3. He was unable to recall whether either the normal or reverse position indicator light was lit before the passage of the train.

[6] This speed, derived from the on-train data recorder, is in excess of the 15 mph (25 km/h) limit that applies when driving over points after having been authorised to pass a signal at danger (rule book GE/RT8000/S5). The marginal exceedance is unlikely to have had a significant influence on the consequences of the derailment.

[7] The yellow button on the GSM-R terminal initiates a call between the driver and the signaller in the controlling signal box (figure 10 shows a picture of the GSM-R terminal). The red button on the terminal (Railway Emergency Call – REC) sends an 'all train stop' signal to any train in the same operational area.

Key facts and analysis

Identification of the immediate cause

49 **Train 2C07 derailed on points 3A on the approach to Knaresborough station because the signaller (MOM) authorised the train to proceed towards the points when they were not set in either normal or reverse.**

50 There was no *data-logger* at the signal box to confirm the state of the points at the time of the derailment. The lack of tell-tale derailing wheel marks on the switch rails after the derailment, indicated that the derailed wheels had passed between the switch and *stock rails* on both the left and right-hand sides (figure 8). This shows that the points were not set in either the normal or reverse position at the time (ie neither switch rail was fully in contact with the adjacent stock rail).

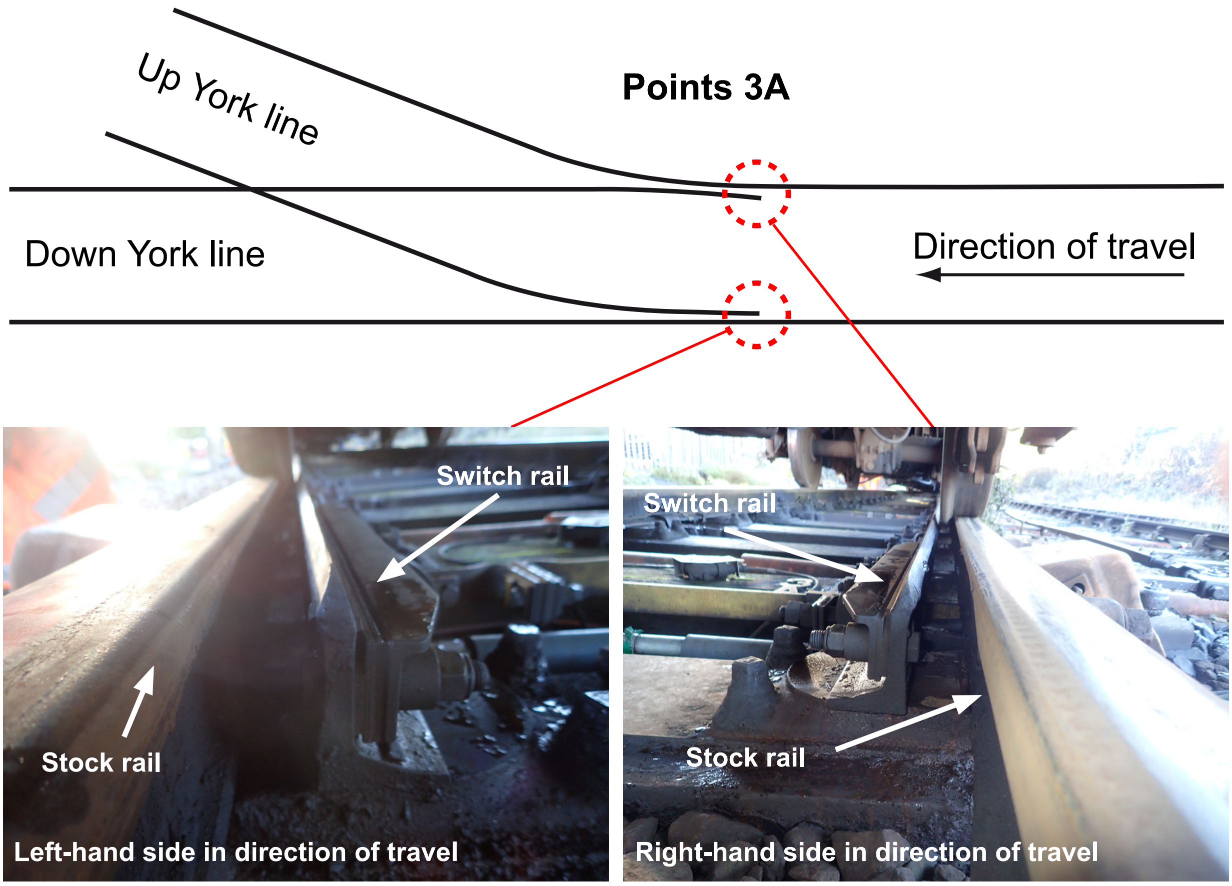

Figure 8: Toes of points 3A after the derailment

51 Points 3 are interlocked with signal K10. The fact that points 3A were not set in either normal or reverse would explain why signal K10 remained at danger when the signaller (MOM) tried to clear the signal for a second time[8] (paragraph 42). When tested after the accident the interlocking and indicator worked correctly.

[8] Signal K10 is also fitted with an electrical lock which requires signal K9 to be 'at danger' for signal K10 to clear (hence the required sequence of K10-K9-K8). The first time the signaller (MOM) tried to clear signal K10, this lock would also have prevented the signal from clearing.

52 A review of the voice communications and witness evidence confirmed that the signaller (MOM) authorised the driver of train 2C07 to pass the signal at danger and proceed towards the station. The signaller (MOM) asked the driver to proceed at caution but did not ask him to examine the line to specifically look for a hazard.

Identification of causal factors

53 The derailment occurred due to a combination of the following causal factors:

a. The switch rails of points 3A were not set in either the normal or reverse position, most likely because of high friction at the *baseplate* to switch rail interfaces (paragraph 56); and

b. The signaller (MOM) did not realise that the points were not set in either the normal or reverse position and interpreted his ability to reverse the signal lever as proof that the route was correctly set and safe (paragraph 69).

54 The railway *rule book* GE/RT8000 module S5[9] places a duty on the signaller to make sure that the route is safe before authorising a train to pass a signal at danger. This includes making sure that points are set in the correct position and locked. However, the rule book also recognises that the train driver can help prevent a derailment, or to limit its consequences, by observing the lie of the points, where possible.

55 In this case, the derailment took place shortly after sunrise, with the ambient light being limited by clouds and rain. These conditions were not ideal for the driver to identify that the points were not set correctly. However, the time it took for the driver to respond to the developing incident and bring his train to a stop suggests that he did not closely observe the lie of the points (Learning point 5).

Points 3A not set correctly

56 **The switch rails of points 3A were not set in either the normal or reverse position, most likely because of high friction at the baseplate to switch rail interfaces.**

57 Points may fail in an intermediate position for a variety of reasons, and such failures of points are not uncommon on the railway. In these circumstances, safety is assured by the inability to clear the last signal immediately before the points, thereby preventing trains from passing. A failure of a set of points is therefore generally seen as a reliability issue and rarely becomes a safety issue. However, the failure of points 3A on 7 November 2015 did lead to the derailment of train 2C07. As unreliable points will often lead to a degraded form of operation which introduces new operational risks, the RAIB investigated the cause of the failure of points 3A.

[9] GE/RT8000/S5 issue 6 – Passing a signal at danger or end of authority without a movement authority – September 2015.

58 Following the derailment and after the train had been re-railed and moved away from the site of the accident, points 3A were subjected to a visual examination by the RAIB and functional testing by Network Rail. This testing revealed no mechanical or electrical fault, and did not reveal the presence of any obstruction which would have explained why the points stopped in an intermediate position. The RAIB considered that the most likely cause of the failure was high friction at the baseplate to switch rail interfaces. The RAIB examined the baseplate to switch rail interfaces on site and found evidence of debris, rust, uneven contacts and the use of incorrect lubricant which could all lead to high friction (figure 9). The RAIB shared this evidence with Network Rail who agreed that it was indicative of high friction.

59 The RAIB identified a number of factors that, when combined, were likely to have led to this situation. These were:

a. the lack of adherence to the lubrication application guidelines combined with the poor installed geometry of the points (paragraph 60); and

b. the repeated maintenance interventions in response to similar previous failures on points 3A did not trigger a review of the effectiveness of the lubrication scheme at this location (paragraph 65).

Each of these factors is now considered in turn.

Lubrication application process and points geometry

60 **The lack of adherence to the lubrication application guidelines, combined with the poor installed geometry of the points, resulted in higher than expected friction.**

61 The product used to lubricate the baseplate to switch rail interfaces was first introduced on Network Rail's infrastructure in 2010 to lubricate baseplates on points fitted with *hy-drive* equipment. It was validated for this application at the time by Network Rail's National Reliability team. In 2011, it was certified by Network Rail to be used nationally on baseplates of points fitted with clamp lock machines (with or without mechanical back drive), such as fitted to points 3A. The LNE-EM route introduced this product to lubricate its baseplates in 2012. Initial local trials led to a refinement of the procedure for applying the product to the baseplates during maintenance by optimising the quantity of product to be used.

62 The lubrication principle relied on two layers of the lubricant: a base layer which was applied only once and a second layer which was renewed during routine maintenance every 4 weeks. The application of the first layer involved cleaning the baseplates back to bare metal, applying a thin, uniform layer of lubricant and letting it dry. The application of the second layer involved, among other steps, wiping clean the baseplates down to the base layer to remove all contamination, and smearing the product across the baseplates if there was evidence that the switch rail might not uniformly contact the baseplate when the points were thrown. Witness evidence indicated that these steps were not always followed by the patrollers during routine maintenance.

Figure 9 – Switch rail to baseplate interfaces (representative examples)

63 The photographic evidence captured by the RAIB of the baseplates showed that close to the toe of points 3A, the switch rails were not riding correctly on the baseplates on both sides. This suggested that the bearers (sleepers) had been incorrectly installed at an angle and were causing high spots on the baseplates.

64 An examination of the full length of the points showed uneven contact between the baseplates and switch rails on more than 50% of the baseplates. An uneven contact between the baseplates and the switch rail meant that the lubrication product was not uniformly smeared over the baseplates when the points were thrown from one position to the next, possibly leading to high friction.

Repeated points failure

65 **The repeated maintenance interventions in response to similar previous failures on points 3A did not trigger a review of the effectiveness of the lubrication scheme at this location.**

66 According to Network Rail's records, points 3A had previously failed on three separate occasions in 2015: on 9 January 2015, on 27 April 2015 and on 21 August 2015. All three instances had been attributed to high friction and had been addressed by the S&T fault team by re-applying the lubrication product[10]. It is also possible that the indication fault reported by the signaller on 31 October 2015 (paragraph 30) which the S&T fault team could not replicate on 5 November was also associated with high friction.

67 Witness evidence indicates that despite these repeated failures, points 3A were not a concern for those in charge of track maintenance in the area. Network Rail uses tools to monitor repeated asset failures which are intended to raise a flag for repeat events within a given time interval. However, the failures on points 3A fell marginally outside of this interval. The tools used by Network Rail to monitor repeated asset failures did not bring points 3A to anyone's attention.

68 Nevertheless, witness evidence also indicates that some people within the LNE-EM route had become concerned over the repeated interventions on points at various locations because of high friction at the baseplate to switch rail interface. In one case, at Hull Paragon in September 2015, this had led to the change of lubrication product. However, this concern did not lead to a review of the lubrication scheme at any other locations, possibly because there was a reluctance within the route to use a different, non-standard, lubrication product.

The actions of the signaller (MOM)

69 **The signaller (MOM) did not realise that the points were not set in either the normal or reverse position and interpreted his ability to reverse the signal lever as proof that the route was correctly set and safe.**

70 During the emergency call immediately after the derailment, the signaller (MOM) stated on two separate occasions that he could not understand how the points could have been in an incorrect position because he had been able to pull the lever controlling K10 signal. He referred to the signal lever being able to go to the reverse position as proving the interlocking.

[10] The S&T fault team also carried out a 10-point check of the points at the time of intervention.

71 This understanding was derived from the signaller's previous experience of operating mechanical signal boxes where the mechanical interlocking would prevent a signaller pulling a signal lever to the reverse position, until the relevant conditions, including the locking of the points on the route using the FPL, had been met. However, this is not necessarily the case in a signal box, such as Knaresborough, where there are power-operated points and interlocking is provided both mechanically and electrically. In Knaresborough signal box, provided that the lever for points 3 was in the 'normal' position to meet the mechanical interlocking conditions, a signaller would be able to pull K10 signal lever even if there was no detection at the points. However, the signal would not clear because the electrical interlocking would identify that the necessary conditions had not been met (ie the points were not detected to be in the 'normal' position), and the indication in the signal box above the signal lever would remain at red.

72 The signaller (MOM) did not check the indication on points 3. Had he checked the indication, he would have discovered that neither the normal nor reverse lamp for points 3 was illuminated, indicating that the points were not correctly set. Signal K10 did not clear because of a points failure, and for no other reason.

73 The mistake made by the signaller (MOM) shows a problem with his basic knowledge of the working of Knaresborough signal box, or a problem with the way his knowledge had been maintained. Knowledge is one of the key components of competence along with skills and experience and all three aspects are interlinked. The RAIB sought to establish whether the competence of the signaller (MOM) was originally lacking or whether it had faded (paragraphs 77 to 90).

Design of Knaresborough signal box

74 The RAIB looked to establish whether any additional engineered safeguards could have been provided within Knaresborough signal box to prevent the signaller (MOM) from misunderstanding the meaning of the ability to reverse the signal lever. The RAIB found that an additional electrical lock could have been fitted on the signal or points lever that might have provided an indication to the signaller that the points were not in the correct position. The RAIB also found that there was no requirement in standards for these engineered safeguards to be fitted.

75 However, there is a requirement for the risks associated with the operations of signalling installations which use mechanical and electrical operation of points and signals within the same signal box to be controlled[11]. This requirement only applies following major upgrade or renewal. At Knaresborough, the introduction of the standard post-dated the installation of the equipment. Considering the limited consequences of a derailment under these circumstances at this location, it is unlikely that such a risk assessment would have justified the need for further protection anyway.

[11] NR/L2/SIG/30009/GKRT0039 issue 1 – 6 September 2014 – Semaphore and mechanical signalling (former Railway Group standard GK/RT0039 – issue 1 – dated July 1997).

Underlying factor

76 **An underlying factor in this accident was the lack of robustness of Network Rail's competence management system for non-signallers.**

Initial competence

77 The signaller (MOM) had learnt how to operate Knaresborough signal box in 2010, when he was training to become a relief signaller on the Harrogate line (paragraph 20). In order to learn the operation of a specific signal box, a signaller must complete a training plan tailored for that location. The onus is on the signaller to obtain the information that is needed to demonstrate their core competence as a signaller at the location and to record this in the training plan. This is achieved by the signaller being mentored by another experienced signaller in the signal box. Once completed, the training plan is reviewed by a competent manager during a final assessment after which the signaller is declared competent for the location.

78 Network Rail was unable to provide the completed training plan for the signaller (MOM) demonstrating competence to operate Knaresborough signal box. The RAIB spoke to the manager who passed the signaller (MOM) as competent at Knaresborough but, as the events took place six years ago, he was unable to recall any details other than confirming that the signaller (MOM) had been passed out as competent at Knaresborough. In view of the lack of available evidence and as the signaller (MOM) did not work any other signal boxes with power-operated points, the RAIB cannot discount the possibility that his knowledge of the specific aspect of the operations of Knaresborough signal box that caused this accident, might have been lacking in the first place.

Maintenance of competence

79 The signaller (MOM) did not operate signal boxes on a regular basis. A MOM is the first line of response to any incident that affects the safe operation of the railway. This includes responding to fatalities, trespass and vandalism, as well as operating ground equipment or carrying out failure investigations. However, a MOM can be asked to operate a signal box in the event of staff shortages. The RAIB investigated whether the competence of the signaller (MOM) to operate Knaresborough signal box had been appropriately maintained.

80 In 2015 the signaller (MOM) had operated signal boxes in three separate periods:

a. in January, he operated Knaresborough signal box twice and Poppleton signal box once within the space of 4 days – this was the last time he operated Knaresborough signal box before the day of the derailment (a 10-month gap);

b. he operated Hammerton and Poppleton signal boxes in May 2015 (one instance each); and

c. he operated Starbeck signal box on 31 October 2015.

Before January 2015, he last operated Knaresborough signal box 12 months before in January 2014. Table 1 shows the number of shifts that the signaller (MOM) carried out when operating as a signaller in the last 3 years.

Year	All signal boxes	Knaresborough signal box
2013	12	6
2014	10	2
2015	6	2

Table 1: Experience of the signaller (MOM) as a signaller in the last 3 years

81 The RAIB concluded that the frequency of the signaller (MOM) operating signal boxes in general, and Knaresborough signal box in particular, had reduced over time.

82 It is common practice in cases where practical experience of operating a given signal box in the normal course of a job may not be sufficient to maintain competence, to compensate with simulations or refresher sessions at the location. Relief signallers in the York area would normally refresh themselves when they knew that it had been a while since they last visited a signal box that they signed for. The resourcing team in York was also aware of the need for relief signallers to regularly visit all the signal boxes that they signed for and would endeavour to adapt the roster accordingly.

83 There was no similar process for the MOMs. The time since any MOM had last operated a particular signal box was not monitored. Indeed, the signaller (MOM) operated Starbeck signal box on 31 October 2015 having not operated this box for 3 years and 2 months.

84 The RAIB concluded that the competence of the signaller (MOM) had not been appropriately maintained. It is therefore possible that his knowledge of the operations of Knaresborough signal box had faded over time.

85 A review of 20 months of data covering the period between 1 February 2014 and 4 October 2015 showed that, of the other three MOMs who Network Rail had declared competent to operate Knaresborough signal box (paragraph 15):

a. one had operated the box six times;

b. one had operated the box once; and

c. one had not operated the box at all[12].

This shows that the signaller (MOM) was not the only person whose competence, with regard to operating signal boxes, was not being actively managed by Network Rail.

[12] Network Rail identified post-incident that this MOM was not passed out as being competent to operate Knaresborough signal box. His name should not have been on the list of people competent to operate this signal box.

Network Rail's Competence Management System

86 At the time of the accident, Network Rail's competence management system (CMS) for operators of signalling equipment was described in procedure 4-20[13] of its Operations Manual[14]. The procedure differentiated between signallers, for whom operating signalling equipment is the core duty, and non-signallers such as the signaller (MOM), for whom it is not.

87 The requirements in the procedure for signallers to maintain their pre-existing competence were based on a combination of:

a. regular practical observations;

b. assessment and development days during which the signallers undertook knowledge tests and simulations;

c. operational safety briefings; and

d. voice communication checks.

The CMS ran over a three-year cycle broken down into 6-month modules. At the start of every three-year cycle, each signaller was issued with an Authority to Work (ATW) valid for three years. Each module concentrated on specific operational matters (for instance, the module current at the time of the derailment included a topic on authorising a train to pass a signal at danger). Network Rail used a computer based system, known as the 'Academy' system, to monitor and manage the application of its CMS. The Academy system gathered competence records and schedules, training needs, progress and performance of all signallers and non-signallers.

88 The requirements in the CMS for non-signallers were generally less stringent than for signallers. For example, non-signallers were specifically excluded from the requirement to be observed operating a location. This was due to the limited opportunities to observe non-signallers carrying out signaller's duties as they only rarely operated a signal box. Hence, the signaller (MOM) had not been observed at Knaresborough signal box since he became a MOM in May 2012. The required frequency of the assessment and development days was also less than for signallers (two days over the three-year cycle instead of one every six months for signallers).

89 The RAIB concluded that the CMS allowed non-signallers, who were potentially more at risk of making a mistake when operating a signal box, as they were relatively less experienced than signallers who operated a box on a daily basis, to follow a less stringent programme of competence development, maintenance and assessment.

90 The three-year CMS cycle for the signaller (MOM) had started on 1 June 2014. The current module was running from 1 June 2015 to 1 December 2015. The RAIB makes the following three observations with respect to the implementation of the CMS process to the signaller (MOM):

a. His line manager had not reviewed his ATW in accordance with the local practice to do so annually, however, it was still in date at the time of the derailment;

[13] Procedure 4-20 Competency standard operating signalling equipment – issue 2 – 3 March 2012.

[14] NR/L3/OCS/041 – issue 35 - Operations Manual - Contents & Responsibilities Matrix – 6 June 2015.

b. His line manager did not revisit the questions he had answered incorrectly in the previously-completed knowledge tests during the assessment and development day (this was due to the signaller (MOM) having to leave the assessment day to attend an incident);

c. His voice communications had not, so far, been reviewed within this cycle.

The RAIB found that these issues would not have had any bearing on this accident.

Factors affecting the severity of consequences

<u>The actions of the train driver</u>

91 **The actions of the driver could have affected the severity of the derailment.**

92 During the derailment, the driver brought his train to a stop using a succession of brake applications in various brake steps. Had he used the emergency brake, the distance travelled post derailment would have been less and therefore the damage caused could have been reduced.

93 The driver used the yellow button on his GSM-R terminal to try to contact the signaller after the derailment (figure 10). This was unsuccessful as the signaller was on the station platform at the time, waiting for the token to be handed back to him. This had no effect on the incident but it would have been more appropriate to immediately use the REC button to raise the alarm. The REC button sends an 'all trains stop' signal to any train in the same operational area to reduce the risk of a secondary collision.

Figure 10: GSM-R terminal

Previous occurrences of a similar character

94 The RAIB has reviewed its previous investigations to identify factors relevant to this investigation. In all of the incidents below, the actions of the signallers involved led the RAIB to make a recommendation on the management of the competence of signallers:

a. On 30 November 2005, a passenger train passed a signal at danger at Lewes due to poor adhesion. This resulted in a near-miss with another passenger train ('Autumn Adhesion Investigation Part 2: Signal LW9 Passed at Danger at Lewes', RAIB Report 25 (Part 2)/2006).

b. On 19 July 2007, two wagons ran away near Camden Road tunnel as a result of a broken screw coupling (‘Runaway of two wagons from Camden Road Tunnel’, RAIB Report 12/2008).

c. On 10 November 2008, two locomotives hauling a freight train derailed on a set of trap points (‘Derailment of two locomotives at East Somerset Junction’, RAIB Report 28/2009).

95 Additionally, the RAIB published a bulletin on the following incident:

a. On 14 November 2008, a passenger train derailed outside Bognor Regis station (‘Passenger train derailed in November 2008’, RAIB Bulletin 04/2009). The derailment occurred during a period of degraded working due to a resignalling project. The signaller initially overlooked a set of points when manually setting a route out of the station for the incident train. The train proceeded over the points which led it into the path of a stationary train. The driver realised the mistake and stopped his train short of the stationary train. On setting the route back towards the station, the signaller did not realise that another set of points had been damaged by the train and were now not safe for the passage of trains. The train derailed on this second set of points.

Summary of conclusions

Immediate cause

96 Train 2C07 derailed on points 3A on the approach to Knaresborough station because the signaller (MOM) authorised the train to proceed towards the points when they were not set in either normal or reverse (**paragraph 49, Learning points 1, 2 and 3**).

Causal factors

97 The causal factors were:

a. Points 3A had failed in an intermediate position, most likely because of high friction at the baseplate to switch rail interfaces (**paragraph 56**, no recommendation). This causal factor arose due to a combination of the following:

   i. the lack of adherence to the lubrication application guidelines combined with the poor installed geometry of the points (**paragraph 60**); and

   ii. the repeated maintenance interventions in response to similar previous failures on points 3A did not trigger a review of the effectiveness of the lubrication scheme at this location (**paragraph 65, Learning point 4**).

b. The signaller (MOM) did not realise that the points were not set in either the normal or reverse position and interpreted his ability to reverse the signal lever as proof that the route was correctly set and safe (paragraph 69, no recommendation). This causal factor arose because the signaller (MOM)'s knowledge of Knaresborough signal box was either lacking or had faded over time (paragraphs 78 and 84, **Recommendation 1**).

Underlying factors

98 The underlying factor was:

a. The lack of robustness of Network Rail's Competence Management System for non-signallers (**paragraph 76, Recommendation 1**).

Factors affecting the severity of consequences

99 The driver's actions during the incident could have exacerbated the consequences of the derailment (**paragraph 91, Learning point 5**).

Previous RAIB recommendations relevant to this investigation

Competence

100 None of the recommendations, which were made by the RAIB as a result of its previous investigations (paragraph 94), have direct relevance to this investigation: they all dealt with the competence of signallers instead of non-signallers as was the case at Knaresborough.

Track maintenance

101 As part of the investigation into the derailment of a passenger train at Grayrigg in 2007 (RAIB report 20/2008), the RAIB made a recommendation to Network Rail to monitor and identify, at a national level, accident precursor events in its points. The Office of Rail and Road (ORR) reported that Network Rail has implemented this recommendation.

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

102 On 5 March 2016, Network Rail re-issued the Operations Manual and significantly altered procedure 4-20 which deals with the CMS requirements for signallers and non-signallers. The relevant changes include the need for non-signallers to comply with the same CMS requirements as for signallers and to refresh all locations that they are certified as competent to operate at least every 6 months.

103 In April 2016, Network Rail started working on a new signaller competence action plan. The 18-month plan aims to overhaul the entire competence management system for signallers. The plan includes, among many other activities, a review of the effectiveness of the revised procedure 4-20.

104 Shortly after the derailment, the Harrogate LOM issued a local notice to remind signallers to check the detection indication before authorising a train to pass a signal at danger. This notice was issued to all signal boxes in the York area by the other LOMs.

105 The LOMs in the York area have adapted the Academy records for the MOMs to keep track of the last time that they operated each signal box. The signaller training plans for the signal boxes in the York operational area have been updated to include a chapter on the operational features that are peculiar to each signal box. Network Rail stated that it intends to review these plans annually.

106 The maintenance team in charge of the track at Knaresborough is planning to replace the bearers under points 3A in 2017/2018 with a possibility of bringing it forward to 2016/2017.

Recommendation and Learning points

Recommendation

107 The following recommendation is made[15]:

1 *The intent of this recommendation is that signal boxes should always be operated by members of staff who have the necessary knowledge and familiarity with the signal box and its operation.*

This recommendation relates to the signaller competence action plan which was initiated by Network Rail in April 2016.

When carrying out its review of the effectiveness of the recently revised procedure 4-20 of the Operations Manual NR/L3/OPS/041, Network Rail should review whether the changes to the requirements on non-signallers have resulted in them maintaining the required level of knowledge and experience needed to operate the signalling locations for which they are authorised, including where it has not been practicable for them to operate those locations, and implement any further necessary changes.

[15] Those identified in the recommendation have a general and ongoing obligation to comply with health and safety legislation, and need to take this recommendation 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, this recommendation is addressed to the ORR 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.gov.uk/raib.

Learning points

108 The RAIB has identified the following key learning points[16]. The first two learning points were previously raised in the bulletin prepared by the RAIB following the derailment of a passenger train at Bognor Regis in November 2008 (paragraph 95a).

1 When degraded working arrangements are in operation, the protection normally provided by the interlocking may be wholly or partly absent. In these circumstances, signallers need to ensure that a route is correctly set before giving permission for a train to pass over it.

2 When an unexpected event occurs, signallers need to stop and think before trying to recover the situation: there may be pitfalls in what seems at first to be an obvious course of action.

3 This derailment acts as a reminder to signallers that should a colour light signal fail to clear, the fact that it is possible to reverse the associated lever should never be interpreted as proof that all points in the route ahead are correctly set and locked.

4 It is important to recognise that repeated failures of points could be indicative of an underlying cause. The people in charge of track maintenance should be alert to such failures so that they are investigated, as they could be precursors to a more serious incident.

5 Drivers of trains are reminded that in accordance with the rule book they must:

i. when authorised to pass a signal at danger, prepare themselves on the approach to points, observe the maximum speed of 15 mph and where possible look at the position of the points (Rule book GE/RT8000/S5 ‘Passing a signal at danger or an end of authority without a movement authority’ - Section 4 – ‘During the movement’).

ii. in the event of an emergency, bring the train to a stop by the quickest possible means and report the emergency to the signaller as soon as possible using, if available, the Railway Emergency Call button on their GSM-R terminal (Rule book GE/RT8000/TW1 ‘Preparation and movement of trains’ and GE/RT8000/M1 ‘Dealing with a train accident or train evacuation’).

[16] ‘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.

Appendices

Appendix A - Glossary of abbreviations and acronyms

ATW	Authority to work
CMS	Competence management system
FPL	Facing points lock
GSM-R	Global system for mobile communication - Railway
LNE-EM	London North East & East Midlands
LOM	Local operations manager
MOM	Mobile operations manager
ORR	Office of Rail and Road
RAIB	Rail Accident Investigation Branch
REC	Railway emergency call
S&T	Signalling & Telecommunication
TPWS	Train Protection & Warning System

Appendix B - Glossary of terms

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

Absolute block regulations	A system of signalling that is built around the principle that only one train is permitted to enter a section of track at any time. Trains are offered and accepted between signal boxes, the acceptance only being given when the correct conditions are met. This communication is by means of block instruments.*
Back drive	An arrangement of rodding and cranks, hydraulics or torsion drives that transfers some of the motion of the switch toes to one or more points further down the switch. This system compensates for the flexibility of long switch rails.*
Baseplate	A generally cast exceptionally rolled or very rarely (in the UK) fabricated steel support for flat bottom rails.*
Bell code	A means of communication between adjacent signal boxes in absolute block areas, using a morse tapper key and single stroke block bell.*
Chain(s)	A unit of length, being 66 feet or 22 yards (approximately 20.117 metres). There are 80 chains in one standard mile.*
Clamp lock	A hydraulic ram arrangement that operates and positively clamps the closed switch to the stock rail. It is actuated by a small electrically operated hydraulic pump located adjacent to the switch toe.*
Clear	In this context, describes a signal showing an aspect allowing the driver to proceed.*
Colour light signal	Railway signal which uses two, three or four coloured lights to indicate whether the driver has to stop, needs to be prepared to stop or can proceed without restriction. The lights may show: ● Green – proceed, the next signal may be displaying green, yellow or double-yellow; ● Double yellow – preliminary caution on a four aspect colour light signal, the next signal may be displaying a single yellow aspect; ● Single yellow – caution, the next signal may be displaying a stop aspect; and ● Red – stop.
Danger	A signal indication or aspect meaning that the driver must stop.*
Data logger	Equipment recording the times at which there are changes in the state of the relays which control signals, points and level crossing equipment.

Diesel multiple unit	A train consisting of one or more vehicles, semi-permanently coupled together, with a driving cab at each end. Some or all vehicles may be equipped with axles powered by one or more diesel engines.
Electric token block regulations	A signalling system for single lines based on the issuing of tokens to trains for each section. Only one token may be released at a time and trains may not enter the section without a valid token, ensuring that only one train may occupy each section at any one time.*
E-type	The letter used to describe the length and radius of a set of points. Generally starting at A for the shortest, tightest radius and typically having the lowest turnout speed. The highest type in the UK is H-type.
Flat bottom rails	A rail section having a flat based rail foot.*
Global System for Mobile communication -Railway	A national radio system which will provide secure voice mobile communications between trains and signallers, relaying calls via radio base stations built alongside the railway or on suitable vantage points.
Hy-drive	A type of back drive.
Interlocking	Controls fitted between points and signals that prevent the signaller from setting conflicting routes.*
Local Operations Manager	An individual who manages the day to day operation of a given area of Network Rail infrastructure.
Mobile Operations Manager	An operations manager who provides first-line response to incidents.*
Normal	For a set of points, this is the default position, decided generally as being the position which permits the passage of trains on the most used route. The opposite is reverse.*
Points operator	A responsibility mandated by the rule book, covering the operating and securing of power operated points during times of points failure or in connection with possessions.*
Relief signaller	A signaller who works across a variety of locations.
Resident signaller	A signaller who works in one single location.
Reverse	For a set of points or lever this is the position opposite to ‘normal’, which either permits the passage of trains on the least used route (points) or pulls fully forward out of the frame (for a lever) respectively.
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 such as train drivers and signallers.*

Semaphore	Mechanical signals generally consisting of moveable arms, the shape, disposition and attitude of which (eg raised or lowered) all carry meaning. Most semaphore signals are operated by wires from a lever frame, but some are electrical where the distance from the signal box is great.*
Step	The different positions on the driver's brake controller representing progressively greater brake demands.*
Stock rail	The fixed rail in a switch. The other rail is the switch rail.*
Switch rail	The movable machined rail section that registers with the stock rail and forms part of a switch assembly.*
Track circuit	An electrical or electronic device used to detect the absence of a train on a defined section of track using the running rails in an electric circuit.*
Train Protection and Warning System	An automatic trackside and on-train system which enforces limits on the speeds of trains that pass so as to avoid collisions.*
Train register book	The book in which a signaller records movements of trains, visitors and completion of other regular duties.*
Toe	The end of a switch rail that is first traversed by a rail vehicle negotiating a switch in a facing direction.*

Appendix C - Investigation details

The RAIB used the following sources of evidence in this investigation:

- information provided by witnesses;
- information taken from the train's on-train data recorder (OTDR);
- site photographs and measurements;
- weather reports and observations at the site;
- minutes of meetings with stakeholders;
- review of applicable standards and rule book;
- competence records;
- rostering records;
- vehicle examination post-derailment;
- maintenance records;
- track recording vehicle recordings; and
- a review of previous RAIB investigations that had relevance to this accident.

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This report is published by the Rail Accident Investigation Branch,
Department for Transport.

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