Rail Accident Investigation Branch

Rail Accident Report

Collision between two freight trains at Loversall Carr Junction, Doncaster
5 July 2022

Report 08/2023
August 2023

This investigation was carried out in accordance with:

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

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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.

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 RAIB has described a factor as being linked to cause and the term is unqualified, this means that RAIB has satisfied itself that the evidence supports both the presence of the factor and its direct relevance to the causation of the accident or incident that is being investigated. However, where RAIB is less confident about the existence of a factor, or its role in the causation of the accident or incident, RAIB will qualify its findings by use of words such as 'probable' or 'possible', as appropriate. Where there is more than one potential explanation 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 or incident but are associated with the underlying management arrangements or organisational issues (such as working culture). Where necessary, words such as '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 accident or incident 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 RAIB, expressed with the sole purpose of improving railway safety.

Any information about casualties is based on figures provided to RAIB from various sources. Considerations of personal privacy may mean that not all of the actual effects of the event are recorded in the report. RAIB recognises that sudden unexpected events can have both short- and long-term consequences for the physical and/or mental health of people who were involved, both directly and indirectly, in what happened.

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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Summary

At around 06:21 hrs on Tuesday 5 July 2022, freight train 4E11 passed a signal at danger and collided with the rear of a stationary freight train.

Train 4E11 was travelling from Felixstowe to Masborough (a freight terminal near Rotherham) and comprised a diesel-electric locomotive and 35 wagons. Train 4E11 had left the East Coast Main Line at Loversall Carr Junction near Doncaster and was travelling at 48 mph (77 km/h) when it passed D197 signal. D197 was at red (danger) to protect a second freight train, 4E82, which was standing in the section ahead. Train 4E11 struck 4E82 while travelling at approximately 28 mph (45 km/h).

The driver of 4E11 was taken to hospital as a precaution and was discharged later that same day. The driver of 4E82 did not sustain any injuries. The collision caused significant damage to the infrastructure, the leading locomotive and wagons of 4E11 and the rear wagons of 4E82. The route remained closed for 26 days for recovery and track repair work.

The accident occurred because the driver did not control the speed of train 4E11 to enable it to stop at signal D197. This was because the driver had experienced a loss of awareness of the driving task, probably due to the effects of fatigue. It is also possible that the driver's awareness was affected by their low workload before the train approached Loversall Carr Junction, and by their expectation, based on previous experience, of the aspect which signal D197 would be showing.

RAIB found that the driver's working pattern was likely to cause fatigue, and they had experienced a low quality of rest, primarily caused by an undiagnosed sleep condition. The management systems of their employer, the freight operating company GB Railfreight (GBRf), had not detected that the driver was at risk of fatigue.

RAIB also found that the engineered systems in place on the railway infrastructure and on the train did not mitigate the driver's loss of awareness.

Underlying factors to the accident were the management of fatigue by GBRf which did not follow current industry good practice. GBRf's risk assessment processes also did not identify the hazards created by a driver driving while being fatigued.

RAIB has made two recommendations. The first is addressed to GBRf to reduce the risk of train driver fatigue, including improving risk assessments, processes and following industry good practice. The second is addressed to the Rail Safety and Standards Board, working in conjunction with freight and other train operators, to include the identification of sleep disorder indicators in current standards for safety-critical medical assessments. A recommendation on the detection of driver attention loss has not been made because a previous recommendation on this issue made as a result of the Kirkby investigation (RAIB report 07/2022) is less than a year old and is still being considered by the rail industry.

RAIB has also identified a learning point to remind train drivers of the importance and meaning of flashing yellow signals.

Introduction

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 acronyms, which are explained in appendix A. Sources of evidence used in the investigation are listed in appendix B.

The accident

Summary of the accident

3 At around 06:21 hrs on Tuesday 5 July 2022, a freight train, reporting number 4E11, passed signal D197 at red (danger). Train 4E11 then collided with the rear of another freight train (train 4E82), which was standing stationary ahead with its locomotive brake applied. Train 4E11, which was travelling north, had diverged from the East Coast Main Line (ECML) at Loversall Carr Junction near Doncaster (figure 1). It was travelling at 48 mph (77 km/h) when it passed the signal at red.

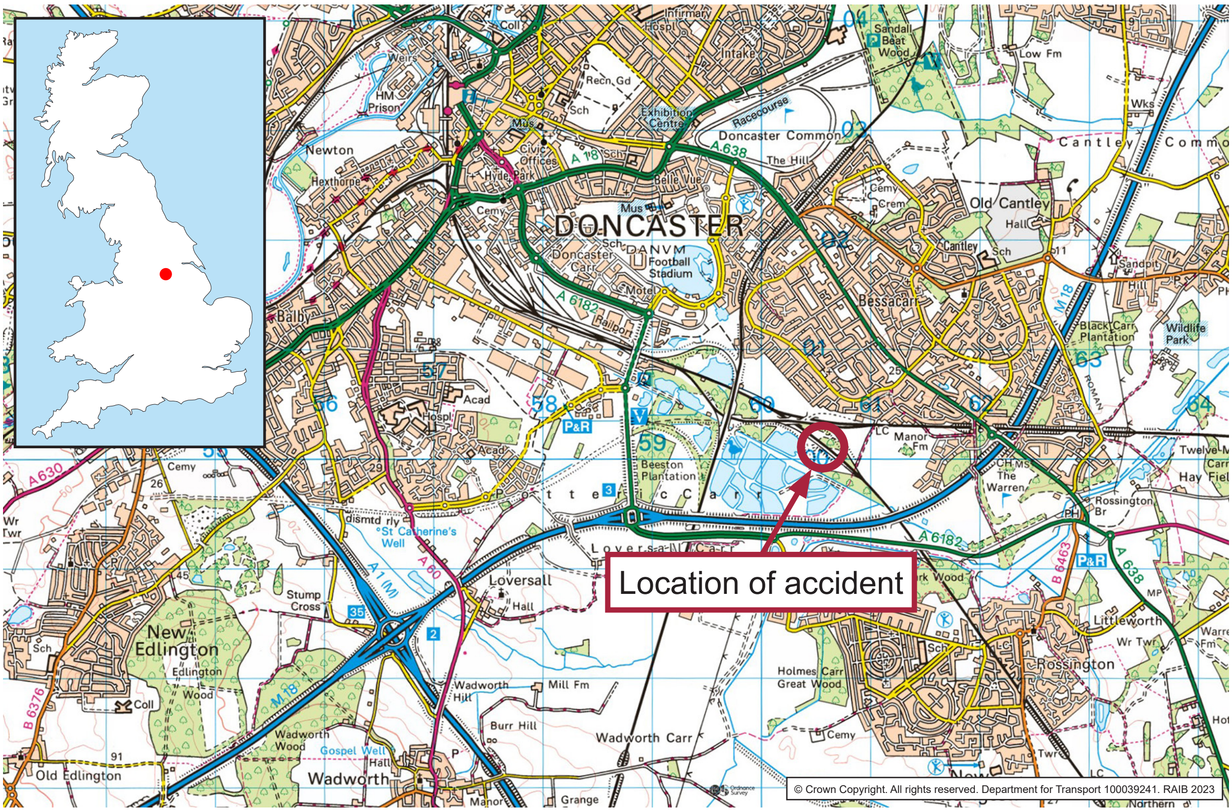

Figure 1: Extract from Ordnance Survey map showing the location of the accident at Loversall Carr Junction.

4 The rear of train 4E82 was approximately 231 metres beyond signal D197. The driver of 4E11 applied the train's emergency brakes 82 metres beyond signal D197 but there was insufficient distance remaining to prevent the collision. Train 4E11 collided with the rear of 4E82 while travelling at 28 mph (45 km/h) (figure 2).

5 The driver of 4E11 was taken to hospital as a precaution and was discharged later that same day. The driver of 4E82 did not sustain any injuries. The collision caused significant damage to the infrastructure, the leading locomotive and wagons of 4E11 and the rear wagons of 4E82. The route remained closed for recovery and repair work until 31 July 2022.

Figure 2: The final position of train 4E11 after the collision with train 4E82.

Context

Location

6 The accident occurred between Loversall Carr Junction and Flyover West Junction near Doncaster (figure 1). The Down Slow/Up West Slow single line diverges from the Down Fast line of the ECML at Loversall Carr Junction and meets the line from Lincoln at Flyover West Junction (figure 3).

7 The Down Slow/Up West Slow line is a section of bi-directional single track (meaning trains can travel in either direction on the same track), with overhead electrification. The ECML Down Fast line has a permissible speed of 125 mph (201 km/h) on the approach to the junction. Trains diverging from the ECML at Loversall Carr Junction have a reduced maximum permitted speed of 70 mph (112 km/h) when routed onto the Down Slow/Up West Slow line. There is a further reduction in maximum permitted speed to 50 mph (80 km/h) before signal D207.

8 The Down Slow/Up West Slow line is level after diverging from the ECML until signal D197, after which it has a rising gradient of 1:170. The track is straight from the junction until the approach to signal D197 which is on a slight left-hand curve (in the direction of travel of train 4E11). After signal D197, the track is again straight until it reaches Flyover West Junction. D207 is the next signal beyond D197. It protects trains on the Flyover lines from trains converging from the Down Slow/Up West Slow line at Flyover West Junction (figure 3).

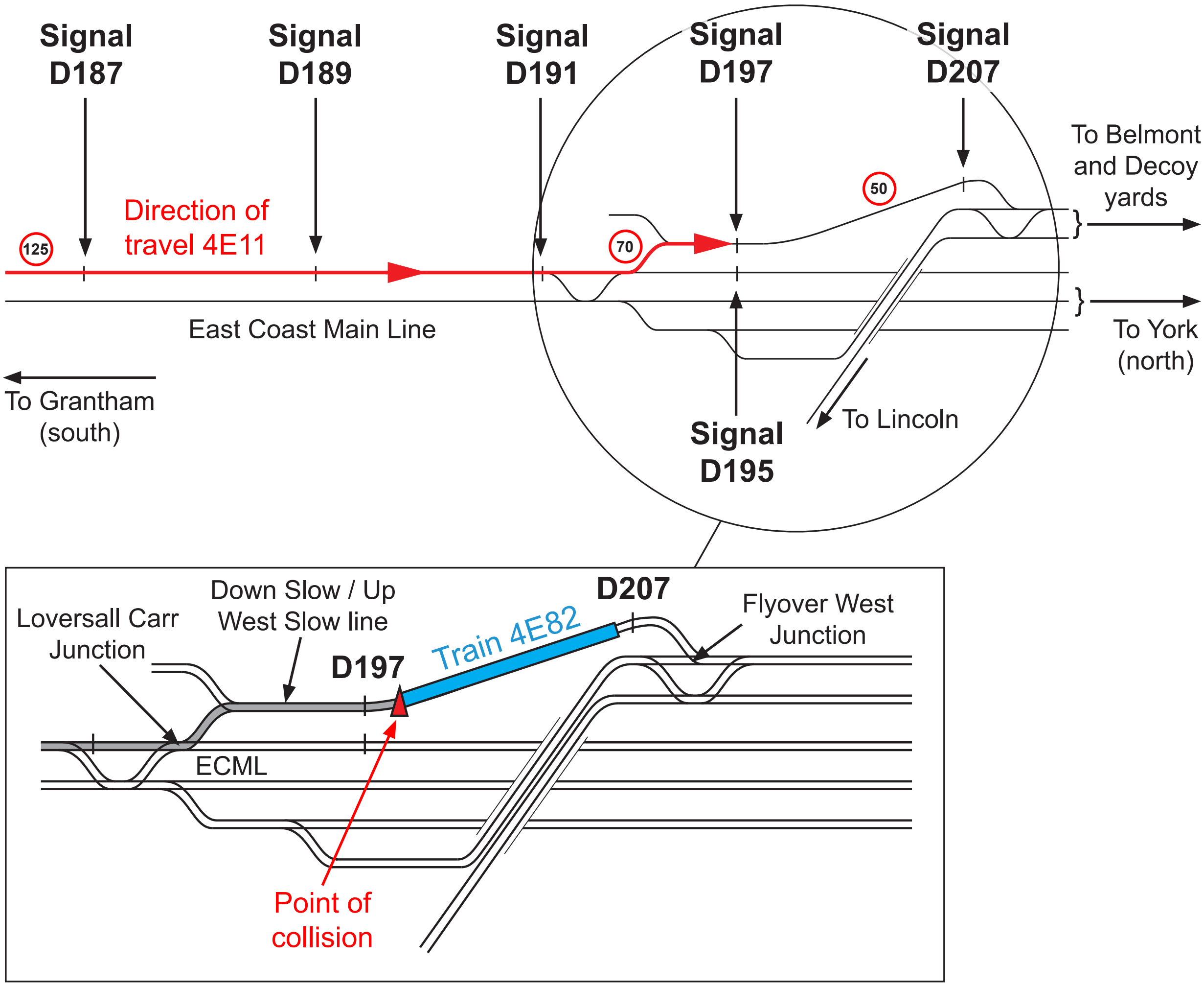

Figure 3: Simplified track layout at Loversall Car Junction, Doncaster.

9 The Down Slow/Up West Slow line is mainly used by freight trains accessing Doncaster Decoy and Belmont yards (which are groups of sidings to the south of Doncaster) but is also occasionally used by passenger services running into Doncaster station. The yards are additionally used for stabling freight trains and as a location where freight train driver changes can take place without causing congestion on the ECML.

10 A train approaching and diverging from the ECML at Loversall Carr Junction from the south (as was train 4E11) will encounter the following signals:

- D187 exhibiting double flashing yellow aspects. The flashing yellow (cautionary) aspects notify the driver that they are going to be diverted from their current route at the next junction, and that they need to control the train’s speed accordingly.
- D189 exhibiting a single flashing yellow aspect.

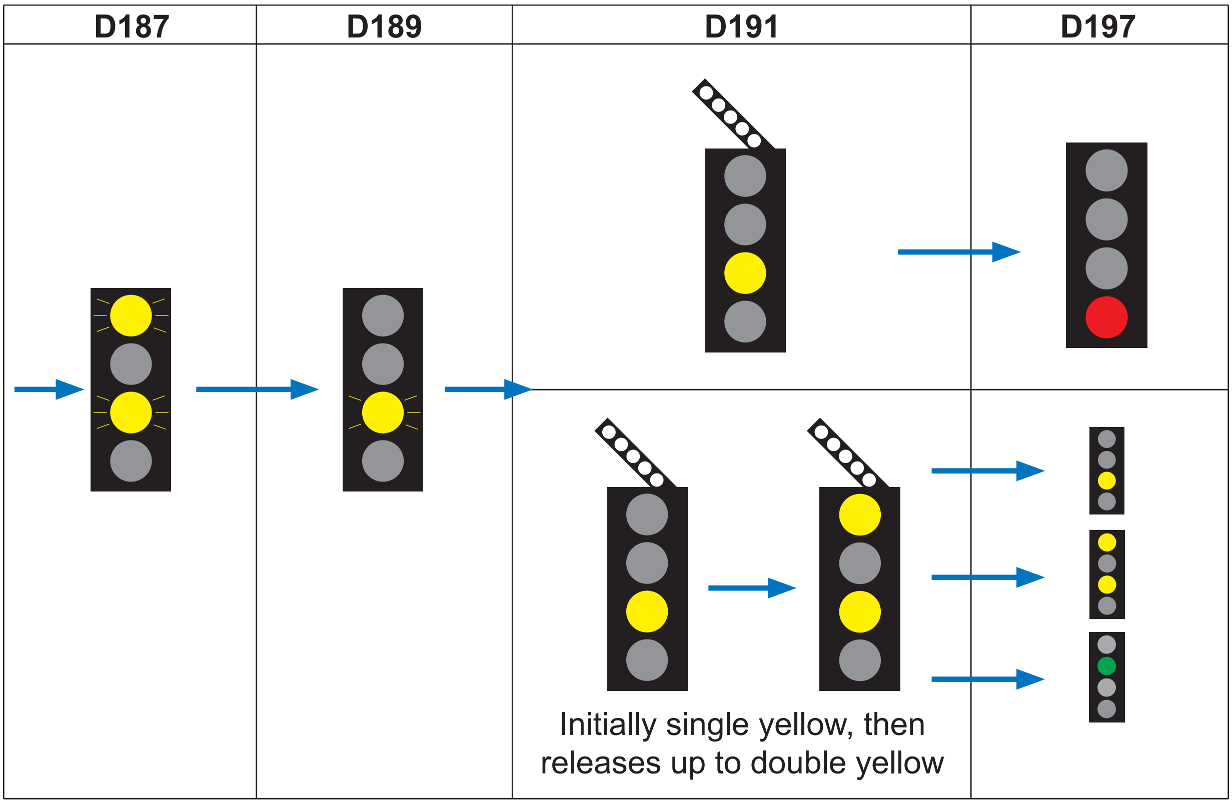

Figure 4: Signal sequence as observed by trains diverging at Loversall Carr Junction from ECML Down Fast to Down Slow/Up West Slow.

- D191 exhibiting a single yellow aspect with a junction indicator (figure 4). This confirms that the train is being diverted from its current route, and to proceed and be required to stop at the next signal (D197). As the approaching train is detected on approach to D191, this signal can change to exhibit two yellow aspects and a junction indicator provided that the next signal (D197) is not showing a red (danger) aspect. If D197 is showing a red aspect (as at the time of the accident), D191 will continue to exhibit a single yellow aspect (and junction indicator) to inform the driver to be prepared to stop at D197 signal.
- D197 which will exhibit an aspect which is determined by the occupancy of the track section ahead. At the time of the accident, D197 was at red as the section ahead was occupied by train 4E82. D197 was the signal passed at red by train 4E11 before the collision.
- D207, the signal immediately before Flyover West Junction. Train 4E82 was standing at this signal, which was displaying a red aspect when the collision occurred.

11 All signals in the area are four-aspect signals controlled from Doncaster power signal box (PSB). All signals are fitted with Automatic Warning System (AWS) (see paragraph 112) equipment while signals D187, D189, D191 and D207 are fitted with Train Protection and Warning System (TPWS) equipment. Signal D197 is not fitted with TPWS (see paragraph 115).

12 Signal D197 was visible in forward facing closed-circuit television (CCTV) footage from train 4E11 for around nine seconds before reaching the signal. This demonstrates that the driver of 4E11 had more than the minimum seven seconds of sighting time of the signal required by Network Rail's standards. The approach to D197 is on a slight curve with the Down Slow/Up West Slow line running alongside the ECML but separated by vegetation. Signal D197 is parallel to signal D195 on the ECML, but there is clear and distinct separation between the two signals, minimising any risk of a driver reading across to D195 in error. Signal D195 was exhibiting a double yellow aspect at the time of the accident.

13 No faults were found regarding the functioning of the signalling equipment following the accident and there was no allegation of improper function. No evidence was found of any issues with the sighting of any of the signals involved in the accident.

Organisations involved

14 GB Railfreight (GBRf) operated train 4E11 and employed the driver. GBRf leases the locomotive from Porterbrook Leasing Company Limited.

15 Train 4E82 was operated by Freightliner, who employed the driver of that train.

16 Network Rail is the infrastructure manager of the railway where the accident occurred. This area lies within the East Coast route of Network Rail's Eastern region. Network Rail owns, operates, and maintains the infrastructure, and employed the signallers on duty at the time of the accident.

17 All of the organisations involved freely co-operated with the investigation.

Trains involved

18 Train 4E11 was a freight train, carrying shipping containers from the port at Felixstowe to Masborough (a freight terminal near Rotherham). The train was composed of a class 66 diesel-electric locomotive (number 66729) and a mixed rake of 35 intermodal wagons of types FEA (13 wagons), FIA (one wagon), and FWA (21 wagons). The total train weight was 2112 tonnes, and its maximum permitted speed was 75 mph (120 km/h).

19 Train 4E82, operated by Freightliner, was another freight train travelling from Felixstowe port to a terminal at Tinsley (near Sheffield). This train was formed of a class 66 locomotive and 29 intermodal wagons.

20 Maintenance records show that there were no defects on the locomotives or wagons forming either train which could have contributed to the accident.

Staff involved

21 The driver of 4E11 had been working on the railway for over 40 years and had been qualified as a train driver since 1988. At the time of the accident, the driver had been working for GBRf for four years and was originally contracted to work based at Immingham. When GBRf's freight traffic from Immingham ceased, the driver's signing-on point was relocated to Doncaster. This increased the driver's journey to work by road from six minutes to close to an hour. GBRf drivers commute to a location, stated in their contract of employment, where they use an electronic sign-on system to register the start of a shift.

22 Train drivers are regularly assessed to verify their knowledge of the traction types that they drive, and the routes over which they operate trains. The driver's traction and route knowledge assessments were up to date, with the most recent GBRf certificate of competency issued in January 2022. The driver's next assessment was due in September 2022 and rules theory assessment in 2025 in line with the GBRf three-year competence assessment cycle. The driver had extensive route knowledge and was very familiar with the route taken by train 4E11.

23 The medical fitness of train drivers is assessed regularly. The driver of 4E11 was up to date on their routine medicals (see paragraph 94).

24 The driver of 4E82 was employed by Freightliner. They were assessed as fully competent to drive that train on that route by Freightliner.

25 The signaller, whose competencies were up to date, was based at Doncaster PSB and employed by Network Rail.

External circumstances

26 The accident took place during daylight (sunrise was at 04:42 hrs) and the weather was dry and cloudy, with a temperature around 13°C recorded at Doncaster Sheffield Airport weather station (5 km from the accident location). The sun direction did not affect the readability of the signals nor create glare for the driver within the cab. There is no evidence that external circumstances played any part in the accident.

The sequence of events

Events preceding the accident

27 On Monday 4 July 2022, the driver of train 4E11 signed on for work at 20:09 hrs. This was the fifth consecutive shift that the driver had worked since their last rest day, and as part of the signing-on process that day, the driver was required to contact the GBRf control office. This was not usually part of the signing-on process, but the call was triggered so that the control staff could confirm the driver's understanding of the work to be carried out during the upcoming shift.

28 The driver first operated train 6L84, which departed from Doncaster Decoy yard on time at 21:41 hrs and arrived at Whitemoor (Cambridgeshire) at 23:35 hrs. The driver then returned to Peterborough, arriving at approximately 02:00 hrs (Tuesday 5 July 2022), in the locomotive cab of another freight train, driven by a different driver.

29 The driver then had a period of around three hours at Peterborough, waiting for train 4E11 to arrive from Felixstowe. Train 4E11 was scheduled to leave Felixstowe at 00:46 hrs on Tuesday 5 July but departed 13 minutes early.

30 During this time, the driver read and had refreshments, but did not sleep. At around 04:30 hrs, the driver took a taxi to meet train 4E11 at Peterborough station. Upon taking control of a train, a driver is required to enter their personal details into the locomotive's on-train data recorder (OTDR). The OTDR recorded the driver entering their details at 04:59 hrs.

31 Train 4E11 was scheduled to depart from Peterborough at 05:46 hrs, to arrive at Doncaster Decoy North Junction at 07:17 hrs, where another driver was due to take charge of the train for the final part of the journey. Train 4E11 departed at 05:00 hrs, 46 minutes early. Soon after leaving Peterborough, the driver was required by GBRf's operating rules to carry out a running brake test. The OTDR shows that the driver did not undertake this test.

32 After leaving Peterborough, the train travelled north along the ECML. At Peascliffe Tunnel (north of Grantham), the locomotive OTDR recorded 4E11 travelling at a speed that exceeded the speed restriction applicable to trains carrying 'high cube' containers (such as train 4E11). Travelling north on the ECML, train 4E11 received green aspects at every signal until encountering the flashing yellow signal sequence (paragraph 10) for Loversall Carr Junction, at approximately 06:17 hrs.

33 Train 4E82 had preceded 4E11 along the ECML and was also running early. It was scheduled to arrive at Loversall Carr Junction at 06:49 hrs, but had arrived at 06:08 hrs.

34 Train 4E82 was due to change drivers at Decoy yard. However, because 4E82 was running early the replacement driver had yet to arrive. To avoid congestion within Decoy yard, the Doncaster signaller chose to hold 4E82 at signal D207. The use of the Down Slow/Up West Slow to hold trains outside Decoy yard is not a common operation, but is permitted to the signaller by the signal box instructions and the signalling system.

35 The rear of 4E82 was protected by signal D197 being at red. A standard overlap[1] of 200 yards (183 metres) existed beyond signal D197. The rear of train 4E82 was approximately 253 yards (231 metres) beyond D197, so 53 yards (49 metres) beyond the end of the overlap. As the overlap was unoccupied, the signaller was able to route train 4E11 past signal D191 and towards signal D197.

Events during the accident

36 The driver of train 4E11 expected to be routed off the ECML at Loversall Carr Junction as they were being relieved by another driver at Decoy yard. The route via the junction and the Down Slow/Up West Slow provided the normal route for this train to reach Decoy yard and the driver was prepared to be routed this way. The driver was also expecting to see flashing aspects at signals D187 and D189 (paragraph 10) (figure 4). As the train approached these signals, signal D187 was displaying a double flashing yellow aspect, followed by D189 displaying a single yellow flashing aspect. These warned the driver that the diverging route at Loversall Carr Junction had been set for the train.

37 The driver acknowledged the AWS warning (see paragraph 112) for signal D187 in 0.3 seconds,[2] and the warning for D189 in 1.2 seconds. OTDR data shows that, during this time, the driver was reducing the locomotive power setting, with the power handle reaching the 'OFF' position after the train passed signal D189. Train 4E11 was traveling at 68 mph (110 km/h) when the power handle was moved to 'OFF' and the driver made an initial brake application, the normal minimum train brake application.

38 As the train approached signal D191, it was displaying a single steady yellow aspect and the junction indicator informing the driver that they should be prepared to stop at the next signal and for leaving the ECML at Loversall Carr Junction. The driver acknowledged the AWS warning for D191 in 1.1 seconds (figure 5).

39 The driver made two further train brake applications, which had reduced the train's speed to 54 mph (86 km/h) at the point they acknowledged the AWS warning for signal D197 (in 0.5 seconds). Witness evidence, forward-facing CCTV and OTDR data show that the driver made a full train brake application at a point when signal D197 is visible. This was a few seconds before the flashing tail light on the rear of 4E82 were visible.

40 This was insufficient to prevent the train passing D197 at danger but had reduced the speed of 4E11 to 48 mph (78 km/h) as it passed the signal, 13 seconds before the collision.

41 Four seconds after passing signal D197, the driver used the locomotive's emergency brake plunger (see paragraph 54). Train 4E11 collided with the rear of train 4E82 at 06:21 hrs, while travelling at 28 mph (45 km/h).

[1] The distance beyond a signal that is proved clear before the signal on the approach to it being cleared (Ellis's British Railway Engineering Encyclopaedia © Iain Ellis. www.iainellis.com).

[2] The timings given in this section are based on data from the train's OTDR, CCTV systems and other electronic data sources. Timings from individual systems have been corrected where necessary to match the central timing recorded by the railway's signalling equipment.

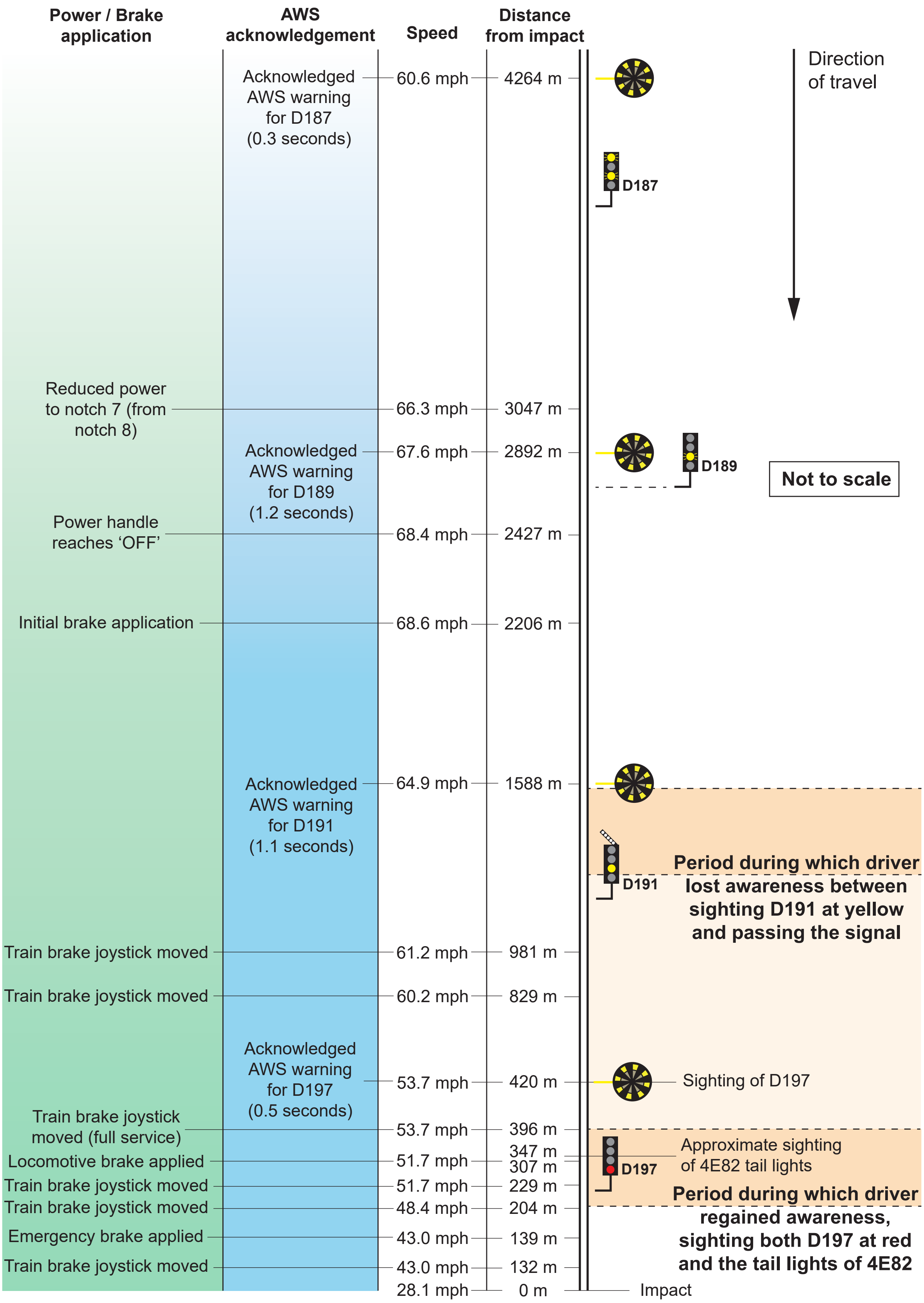

Figure 5: Timeline of events, from the approach of 4E11 to signal D197 to the collision.

42 The impact from train 4E11 moved train 4E82 forwards, with the front of 4E82 almost passing signal D207. OTDR fitted to the locomotive of 4E82 recorded a forward movement of approximately 10 metres during the collision. Damage was caused to the locomotive of 4E11 and to multiple wagons in the train (figure 6). The wagon damage was mainly related to compression and overriding at the couplers. Train 4E82 also sustained damage to the rear four wagons and their containers. A total of nine wagons and one locomotive were derailed. Railway infrastructure was also damaged in the collision.

Figure 6: Aerial view of the accident site (courtesy of British Transport Police ECML South Disruption Tasking Team).

Events following the accident

43 The driver of 4E11 remained in the cab of the locomotive during the accident and was very shaken but not physically injured. The driver of 4E11 made an emergency call to the signaller to report the accident using the locomotive's radio system.

44 The signaller blocked the Down Slow/Up West Slow line from the ECML to signal D207 where 4E82 was standing. The signaller asked the drivers of trains 4E82 and 4E11 to check that the vehicles involved in the accident were not fouling the ECML.

45 Both drivers had to work together to open the cab door of the locomotive of 4E11 as its driver was unable to either open this door or egress through the locomotive engine room due to the damage it had sustained. The two drivers then walked to the rear of 4E11 and confirmed that the back of the train was not fouling the ECML.

46 After the accident, GBRf tested the driver of train 4E11 for the presence of non-medical drugs and/or alcohol.[3] The driver tested clear for both. As a precaution, the driver went to hospital after the accident and was released later that day.

47 The line was closed for 26 days to enable recovery and infrastructure repair work and was reopened on 31 July 2022.

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[3] Rail Industry Standard RIS-8070-TOM 'Testing Railway Safety Critical Workers for Drugs and Alcohol' issue 1, December 2016, states that a test result for drugs is positive if it shows 'The presence of drugs for which there is no legitimate medical need for either their use or the quantity of their use.' Available from www.rssb.co.uk.

Analysis

Identification of the immediate cause

48 Train 4E11 passed signal D197 at danger and did not stop before the collision.

49 Signal D197 was displaying a red signal to protect train 4E82, which was standing in the section of track ahead. Train 4E11 did not stop at the signal, passing it when it was at red. The driver fully applied the train's brakes (see paragraph 55) but there was, by this point, insufficient time for the train to stop and for the collision to be avoided. This is evidenced by forward-facing CCTV, signalling records, OTDR and witness evidence.

Identification of causal factors

50 The accident occurred due to a combination of the following causal factors:

a. The driver did not control the speed of train 4E11 on approach to signal D197 to enable it to stop before passing the signal at red. This was due to the driver losing awareness of the driving task (paragraph 51).

b. The engineered systems in place did not mitigate the loss of driver awareness (paragraph 109).

Each of these factors is now considered in turn.

The actions of the driver

51 The driver did not control the speed of train 4E11 on approach to signal D197 to enable it to stop before passing the signal at red. This was due to the driver losing awareness of the driving task.

52 Train 4E11 was travelling at 54 mph (86 km/h) when the driver acknowledged the AWS warning for signal D197 (which was displaying a red aspect). The AWS magnet is located at the same position where signal D197 first comes into the driver's view. GBRf requires drivers to control the speed of trains so that they are travelling at no more than 10 mph (16 km/h) when the train passes over an AWS magnet on the approach to a signal displaying a red aspect.

53 GBRf was unable to provide RAIB with OTDR records for any other GBRf trains which had approached D197 while it was showing a red aspect (the reasons for this are discussed at paragraph 107). RAIB analysed OTDR records from other GBRf trains which were approaching signal D197 displaying a green (proceed) or double yellow or yellow (preliminary caution and caution) aspect. This analysis showed that the speed of approach of train 4E11 to D197 was comparable to other trains approaching this signal when it was displaying a proceed or cautionary aspect (figure 7).

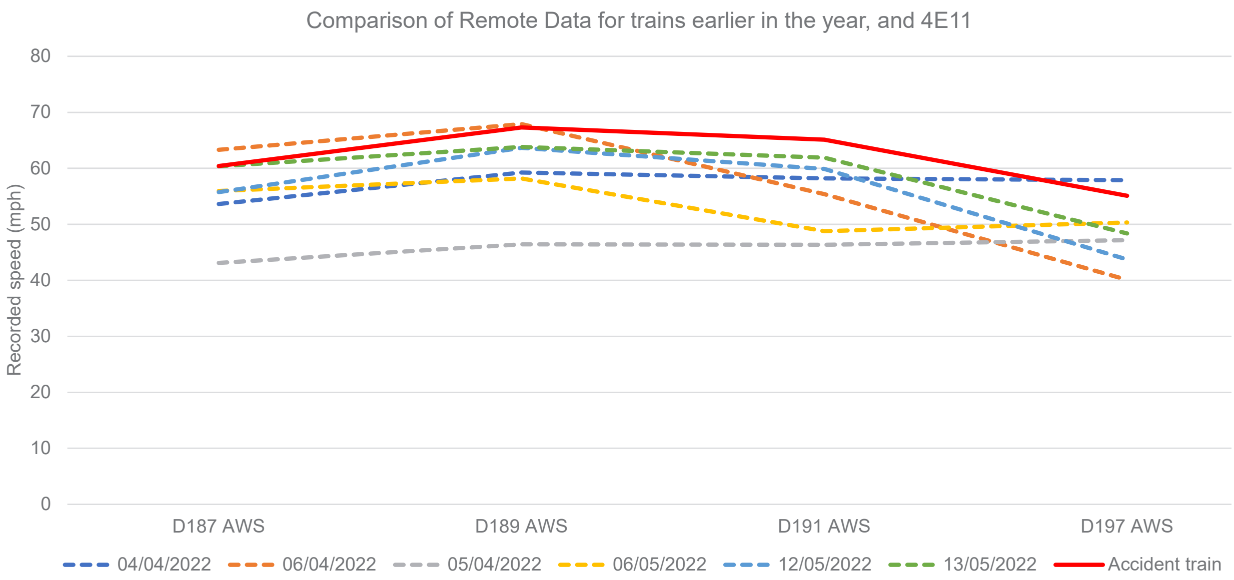

Figure 7: Comparison of speed of approach to signal D197 between train 4E11 and other freight services.

54 Class 66 locomotives are fitted with several means of controlling the air brake system on the locomotive and on the train (figure 8). They are:

- The locomotive brake, also known as the direct brake controller or straight air brake, which controls the brakes only on the locomotive – it has no effect on the brakes fitted to the rest of the train. It is normally used for holding the locomotive once stationary and when the driver needs to control smaller movements such as during shunting and coupling.
- The train brake, also referred to as the automatic air brake, which controls air brakes on both the locomotive and the train. It is normally controlled using a joystick. The train brake is used to manage the speed of the train while in motion and is frequently used during a journey. It is also used to hold the train when stationary. The joystick control is located closest to the driver on the driver's side desk within the cab (figure 8).
- An emergency brake plunger, which provides a means of making a rapid application of the automatic air brake. It applies the brakes on the locomotive and train and is the quickest way to stop a moving train. On class 66 locomotives (and therefore trains hauled by such locomotives), the use of the emergency brake plunger effects a rapid application of the automatic air brake. There is no difference between the brake force generated by means of the automatic air brake or the emergency brake plunger, although use of the plunger will lead to that force being generated more rapidly.

55 The forward-facing CCTV shows that D197 signal (at red) became visible to the driver approximately 200 metres before the train reached it. The flashing tail light of train 4E82 was visible approximately 116 metres before the signal, and 347 metres before the collision.

Figure 8: Desk within the drivers cab of a class 66 locomotive showing location of brake controllers (images courtesy of GBRf).

56 OTDR data from the locomotive hauling train 4E11 showed that a number of brake applications were made before and after the point where both signal D197 and the taillights of train 4E82 became visible. Analysis showed that:

- Around 86 seconds and approximately 2200 metres before the collision, the driver made an initial automatic air brake application.
- Around 44 seconds and approximately 980 metres before the collision, the driver slightly increased the existing brake application.
- Around 21 seconds and approximately 400 metres before the collision, the driver made a full service application of the automatic air brake. This was around 1.2 seconds after signal D197 was first visible on forward-facing CCTV.
- Around 17 seconds and approximately 300 metres before the collision, the driver applied the locomotive brake. This was around 86 metres before signal D197.
- About 9 seconds and approximately 140 metres before the collision, the driver made an emergency brake application using the emergency brake plunger.

The latter two actions had a minimal effect on the train's deceleration since the driver had already made a full service application of the train's brakes.

57 RAIB's analysis shows that, if the driver had used the emergency brake plunger on sighting the red aspect at signal D197, the train would still have passed D197 at danger. However, in these circumstances the speed at which the collision occurred would have been significantly reduced.

58 The driver, therefore, did not correctly control the speed of the train on the approach to signal D197 or react appropriately once the red aspect was visible. This strongly suggests that the driver experienced a loss of awareness of the driving task during this period.

59 The driver stated that they acknowledged the AWS for signal D191, and then lost their awareness at some point after seeing the junction indicator and D191 displaying a single steady yellow. The driver recalled regaining awareness on seeing signal D197 showing a red aspect and the red flashing tail light of train 4E82 ahead.

60 On the day of the accident, D191 continued to display a single yellow aspect as the train passed it. However, the driver had lost awareness before reaching the point, where, in their experience (see paragraph 106), signal D191 normally changes to show double yellow, a less restrictive aspect (paragraph 10).

61 Studies have demonstrated that, despite the absence of awareness and behavioural responsiveness, people can '*still extract task-relevant information from external stimuli and covertly prepare for appropriate motor responses*'.[4]

62 During the time the driver reported this loss of awareness, OTDR data shows that they were making initial applications of the train brake and reacting to the AWS. Data from the OTDR showed that the driver acknowledged the in-cab AWS warning for signal D197 in 0.5 seconds. RAIB considers that this may have been an automatic response rather than any indication that the driver was actively concentrating on the driving task (see paragraph 109).

63 During the time in which the driver was regaining awareness and was becoming fully conscious of the high-risk situation they were facing, OTDR data shows that they used the braking systems that they use more commonly in normal operations. These braking systems would probably have been established in their cognitive and physical memory (paragraph 61), explaining why the driver used them even though earlier use of the emergency plunger could have reduced the consequences of the accident (paragraph 57). This also suggests that the driver was experiencing a lack of awareness.

64 There is no evidence that the driver was distracted during the journey. They were alone in the cab, and RAIB analysis of phone records shows that the driver's mobile devices were not in use leading up to or during the time the accident occurred. The driver stated that they kept their mobile phones and GBRf-issued tablet computer in a zipped bag, on the floor of the cab throughout the journey from Peterborough.

[4] S Kouider et al, Inducing Task-Relevant Responses to Speech in the Sleeping Brain, Sept 2014. Available from www.cell.com.

65 Although two operating incidents occurred earlier in the journey between Peterborough and Loversall Carr Junction where the driver did not complete a running brake test (paragraph 31) and did not comply with a speed restriction (paragraph 32), RAIB has been unable to determine from the available evidence whether these incidents also resulted from lack of awareness of the driving task. Despite these earlier incidents, evidence shows that the driver was aware and alert by the time train 4E11 approached signal D187 (see paragraph 108).

66 The driver's loss of awareness of the driving task was due to a combination of the following factors:

a. The driver was probably experiencing the effects of fatigue when train 4E11 approached signal D197 (see paragraph 67).

b. The driver's awareness was possibly affected by low workload and their expectation of the aspect which would be displayed at signal D197 (see paragraph 103).

Each of these sub-factors is now considered in turn.

Fatigue

67 The driver was probably experiencing the effects of fatigue when train 4E11 approached signal D197.

The driver's working patterns

68 On Monday 27 June, the driver of train 4E11 returned to work after a week of leave to complete a day shift (05:45 hrs to 17:45 hrs). Tuesday 28 June was a rest day and they did not work. The first shift of the week began at 03:05 hrs on Wednesday 29 June, and lasted 9 hours 28 minutes. The following two shifts were identical to the first. The driver's fourth shift, on Saturday 2 July, started earlier at 01:30 hrs and was 9 hours 25 minutes long. Their fifth shift on Sunday 3 July was a day shift, which started at 11:01 hrs and lasted 9 hours 59 minutes, until 21:00 hrs. On Monday 4 July 2022, the driver of train 4E11 signed on at 20:09 hrs for a night shift. Table 1 shows the driver's rostered shifts.

	Shift number	Date	Shift start time	Shift end time	Shift duration	Cumulative hours worked
Completed shifts	1	Wed 29 June 2022	03:05	12:33	09 hrs 28 mins	09 hrs 28 mins
	2	Thu 30 June 2022	03:05	12:33	09 hrs 28 mins	18 hrs 56 mins
	3	Fri 01 July 2022	03:05	12:33	09 hrs 28 mins	28 hrs 24 mins
	4	Sat 02 July 2022	01:30	10:55	09 hrs 25 mins	37 hrs 49 mins
	5*	Sun 03 July 2022	11:01	21:00	09 hrs 59 mins	47 hrs 48 mins
Accident (06:21 05/07/22)	**6***	**Mon 04 July 2022**	**20:09**	07:59	11 hrs 55 mins	59 hrs 43 mins
Rostered shifts not worked due to accident	7	Tue 05 July 2022	19:30	07:30	12 hrs	71 hrs 43 mins
	8	Wed 06 July 2022	19:30	07:30	12 hrs	83 hrs 43 mins
	9	Thu 07 July 2022	19:30	07:30	12 hrs	95 hrs 43 mins

* Rest day worked

Table 1: Driver's shifts as worked leading up to the accident on the night of 4-5 July 2022, and as rostered after the 4-5 July 2022 (but not completed due to the accident).

69 At the time of the accident, the driver was at a point in their roster where over a period of six shifts they had worked 57 hours and were rostered for a further three shifts (table 1). If the driver had completed all rostered shifts, the cumulative total would have been 95 hours and 43 minutes. This exceeds GBRf's requirement for working no more than 60 hours.[5] However, RAIB noted that this limit is stated as being within 'available days', that is, work days that are rostered or noted as being available within the base roster (see paragraph 131), whereas the driver was working rest days during shifts five and six.

70 Managing Rail Staff Fatigue guidance (ORR, 2012) suggests that staff should work a maximum of three consecutive night shifts where those shifts are over eight hours long, and a cumulative limit of 55 hours in a rolling seven-day period.

71 The Office of Rail and Road (ORR, the safety authority for railways in Great Britain) Good Practice Guidelines Fatigue Factors[6] are a set of 25 factors in relation to shift work that have been identified as negatively impacting on fatigue. They are presented in six categories:

- time of day factors such as night shifts *(working between 00:00 to 05:00),* early shifts *(starting 05:00 to 07:00)* or very early shifts *(starting before 05:00)*
- duty length factors *(length of shift in relation to time of day started)*
- recovery time factors *(rest between block of consecutive shifts in relation to nights, early starts)*
- intervals between duties factors *(rest in 24 hour period)*
- cumulative fatigue factors *(number of consecutive shifts, how the shifts rotate, and hours worked in a 7-day period)*
- circadian phase shift (body-clock adjustment) factors *(how shifts rotate and moving from one type to another).*

72 RAIB has identified that 12 of the 25 fatigue factors were present between the start of the driver's first shift on 29 June and the time of the accident on 5 July 2022.

73 Multiple fatigue factors also coincided during the shift when the accident took place. These included:

- a long night shift
- a first night shift (following a day shift on 3 July, table 1)
- successive shift start times varying by more than two hours from the previous day
- working more than 55 hours in a 7-day period.

74 If the accident had not occurred, the driver's roster (table 1) included three more subsequent night shifts, making a total of nine consecutive shifts and 95 hours 34 minutes worked since the driver's last rest day. This would have triggered a further three fatigue factors.

[5] See clause F of GBRf Fatigue Policy Statement in appendix C.

[6] ORR, Good Practice Guidelines – Fatigue Factors, 2021. Available from www.orr.gov.uk.

Industry guidance

75 Guidance issued by ORR defines fatigue as '*a state of perceived weariness that can result from prolonged working, heavy workload, insufficient rest and inadequate sleep'*.[7] ORR's guidance states that fatigue results from a combination of:

a. The amount of time spent asleep. ORR's guidance refers to the average amount of sleep required for a person in a 24-hour period as being 8.2 hours.

b. The time since waking up. Alertness is significantly reduced after 17 hours of being continuously awake.

c. The time of day. The internal body clock or 'circadian rhythm' is the process of how physical and mental behaviours are affected by the cycle of day to night. The body clock responds to light exposure, while alertness is particularly low in the early hours of the morning, from 02:00 hrs to 06:00 hrs.[8]

76 Fatigue can result from sleep loss, periods of extended wakefulness, disrupted circadian phase and/or workload. ORR's guidance details other causes of fatigue, including:

- Work-related factors, including the timing of working and resting periods, length and number of consecutive work duties, intensity of work demands (work-related factors are generally about providing adequate opportunity for sleep).
- Individual factors including lifestyle, age, diet, medical conditions and drug and alcohol use, which can all affect the duration and quality of sleep.
- Environmental factors, including family circumstances and domestic responsibilities, and adequacy of the sleeping environment.

Fatigue can cause impaired decision-making, degraded task performance, and an increased risk of errors and accidents.[9] Consequently, safety-critical work involving shift work, including that carried out by certain railway staff, is undertaken with a risk of fatigue-related incidents occurring. An RSSB[10] research report[11] identified fatigue as a factor in 21% of incidents examined (most of which were signals passed at danger).

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[7] ORR, Managing Rail Staff Fatigue, 2012. https://www.orr.gov.uk/media/10934.

[8] Ingre M, Van Leeuwen W, Klemets T et al, Validating and extending the three process model of alertness in airline operations, 2014. Available from www.plos.org.

[9] Raslear TG, Gertler J and DiFiore, A, Work schedules, sleep, fatigue, and accidents in the US railroad industry, 2013. Available from https://www.transportation.gov/.

[10] RSSB is a not-for-profit company owned and funded by major stakeholders in the railway industry, and which provides support and facilitation for a wide range of cross-industry activities. The company is registered as 'Rail Safety and Standards Board', but trades as 'RSSB'.

[11] RSSB, Fatigue and its Contribution to Railway Incidents, 2019. Available from www.rssb.co.uk.

77 Both ORR and RSSB[12] provide guidance on managing fatigue. Of relevance to this accident is the guidance on night shifts, where there is an increased risk of errors being made. As such, guidance suggests that the maximum shift duration is reduced to eight hours (for shifts starting before 05:00 hrs), that the maximum number of consecutive night shifts is three and that the minimum rest period between night shifts is 14 hours. Guidance also recommends that where shift start times vary, this should be in a forward (clockwise) rotation - that is subsequent shifts should not start earlier than previous shifts. Guidance details the importance of rest between shifts and of rest days after continuous shifts worked, which includes the need to assess proposed changes to work patterns, such as rest day working. This guidance reflects good practice in other industries and further illustrates how fatiguing the driver's shift pattern potentially was.

The quality and quantity of the driver's rest

78 On Sunday 03 July 2022 the driver worked a shift lasting 9 hours and 59 minutes (paragraph 68). After finishing work at 21:00 hrs, the driver completed their normal one-hour commute (paragraph 21) before reaching home and going to sleep soon after. The driver had a full night's sleep although they reported that the quality of sleep was negatively affected by getting accustomed to a new pillow.

79 On Monday 4 July 2022, the driver woke at around 09:00, had breakfast with their family and did not take any further sleep before departing for Doncaster at around 19:00 hrs. Although the driver usually tried to have a couple of hours of sleep before the start of a late shift when transitioning from a day shift, they were only able to rest on the sofa on this day, due to work being undertaken in their house. The driver had been awake for approximately 11 hours when they booked on (see paragraph 87) to start their shift (at 20:09 hrs, table 1).

80 During the shift on Tuesday 5 July 2022, the driver had a period of approximately three hours waiting in the GBRf staff facilities at Peterborough for their train to arrive (paragraph 29). During this time the driver was not able to take meaningful rest as the environment of the room was not conducive to sleep. Although drivers should be well rested and fit for duty, industry guidance[13] highlights that napping is a useful countermeasure for fatigue. Although napping should not be relied upon to control fatigue, research also shows that there is a clear benefit of napping for relieving fatigue and improving performance.[14]

81 GBRf has no formal policy on napping. Drivers had not been briefed on napping as an effective short-term mitigation for fatigue, nor are there any facilities to help napping. This has led to an inconsistent understanding between staff and managers regarding GBRf's position on napping where work scheduling permits it. The driver's understanding was that napping was not permitted at any point during their shift.

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[12] RSSB, Fatigue Management – A Good Practice Guide, 2012. Available from www.rssb.co.uk.

[13] RSSB, Guidance on fatigue control options for first night shifts (T1084 Report), 2016. Available from www.rssb.co.uk.

[14] Driskell, J. E. and Mullen, B, The efficacy of naps as a fatigue countermeasure: A meta-analytic integration, 2005. Available from https://www.hfes.org/.

Working rostered rest days

82 ORR's guidance for managing fatigue risk recommends a maximum block of four early starts (before 07:00 hrs) and that this should be followed by two days' rest. The driver of train 4E11 had worked four early shifts and, on the base roster (see paragraph 133), was scheduled to have two rest days. However, on the actual roster these rest days were booked to be worked instead, meaning that no rest days were taken by the driver after the four early shifts worked between 29 June and 2 July and that shifts five and six became rest days worked (table 1).

83 GBRf has experienced an increase in business in recent years, which has resulted in it operating more freight services. Consequently, there are more shifts to roster out to drivers. Although more train drivers have been recruited, there is still a reliance on rest day working to fill the shifts.

84 Rest days recorded on the base roster are worked by many drivers in GBRf (see paragraph 134). The driver of 4E11, in the months leading up to the accident, had taken the decision to avoid working rest days at weekends, but they would often be approached to do extra shifts due to having wider route knowledge than many of the other drivers. However, as they had taken a week's leave shortly before the start of this roster, the driver agreed to work their rest days (shift 5, Sunday 3 July, and shift 6, Monday 4 July, table 1).

Individuals identifying and reporting fatigue, and the driver's perception of their own fatigue

85 Within GBRf processes, there are three opportunities to identify whether a driver is fatigued:

- Before the start of their shift (driver self-reporting).
- At the point of signing-on at the start of their shift by means of a triggered call to the driver from control. Such fatigue calls are only triggered in response to a specific circumstance in the roster (see paragraph 140).
- During their shift (driver self-reporting).

86 The GBRf General Operating Appendix (comprising numerous documents acting as a handbook for drivers) states that drivers should be rested, not under the influence of drugs or alcohol, have informed their line manager of any medication they have to take and to have items such as glasses with them should they be needed to drive safely.

87 GBRf drivers are assigned a specific location to start their shifts. For the driver of 4E11 this was the GBRf Doncaster offices. At Doncaster, drivers sign on for duty by telephone using a remote signing-on system (paragraph 21). Instead of a face-to-face fitness for duty check, it is the driver's responsibility to report by telephone to their control office if they feel unfit for duty for any reason, including fatigue.

88 On Monday 4 July, the driver was required to contact the GBRf control office when signing on (paragraph 27). This was not usually part of the process and was triggered by the remote signing-on system so that the GBRf control staff could confirm the driver's understanding of the work to be carried out during the forthcoming shift. The driver had made no report of feeling fatigued.

89 The Karolinska Sleepiness Scale (KSS)[15] measures the subjective level of situational sleepiness. RAIB used the KSS to assess the driver's experience on the day of the accident. The driver reported feeling 'very alert' (KSS scale 2) at the point of signing on at 20:09 hrs (having been awake for around 11 hours). However, by the time the driver departed from Peterborough at 05:00 hrs, they rated themselves as 'sleepy, but some effort to keep awake' (8). At this point the driver had been awake for around 20 hours. When train 4E11 passed the signal D197 at danger, the driver had been awake for more than 21 hours.

90 ORR's guidance for managing fatigue risk (paragraph 75) states that: *'Being awake for around 17 hours has been found to produce impairment on a range of tasks equivalent to that associated with a blood alcohol concentration above the drink driving limit for most of Europe. Being awake for 24 hours produces impairment worse than that associated with a blood alcohol concentration above the legal limit for driving on the UK's roads.'*

91 The driver of 4E11 had never self-reported as being fatigued, due to a reluctance to cause trains to be cancelled or their awareness of the impact on colleagues who would then have to cover their duties.

Sleep apnoea and medical examinations

92 After the accident, GBRf arranged for the driver to take part in a sleep study, which produced a report in August 2022. The sleep study identified that the driver had a previously undiagnosed condition, severe Obstructive Sleep Apnoea (OSA), noting that the OSA '*may have been responsible for the incident*'. OSA is a condition in which breathing stops and starts during sleeping, reducing the oxygen levels within the body. This disordered breathing can result in disrupted sleep and common symptoms such as people feeling very tired and finding it hard to concentrate during the day.

93 In 2006, RSSB published a report of a study to investigate the prevalence of OSA in the rail industry.[16] The study found that:

- The prevalence of OSA in the rail sector based on strict criteria was 7.3%, which is approximately twice the amount expected in the general population.
- Unrecognised OSA is present in individuals working in safety-critical roles in the rail industry.

94 The driver was not taking any medication at the time of the accident and had no known medical conditions. The driver's previous routine medical examination was in September 2021 when they had been assessed as medically fit to continue to drive trains by GBRf's occupational health provider. The driver did not recall being asked any questions regarding sleep. The assessment followed Railway Industry Standard RIS-3451-TOM '*Train Drivers – Suitability and Medical Fitness Requirements*'.[17]

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[15] High levels of fatigue are values of eight or nine on the Karolinska Sleepiness Scale (KSS), a nine point scale ranging from one - extremely alert to nine - extremely sleepy and fighting sleep. A. Shahid et al. (eds.), STOP, THAT and One Hundred Other Sleep Scales, 2012 © Springer Science+Business Media, LLC.

[16] RSSB, Obstructive Sleep Apnoea Syndrome in Train Drivers (T299 Report), 2019. Available from www.sparkrail.org.

[17] RSSB, Railway Industry Standard RIS-3451-TOM 'Train Drivers – Suitability and Medical Fitness Requirements', 2016. Available from www.rssb.co.uk.

95 RIS-3451-TOM sets out the general medical requirements for train drivers including requirements for visual acuity and frequency of medicals. It states that drivers must not be suffering from any medical conditions or be taking any medication, drugs or substances which are likely to cause:

- a sudden loss of consciousness
- a reduction in attention or concentration
- sudden incapacity
- a loss of balance or co-ordination
- significant limitation of mobility.

96 Additionally, the Train Driving Licences and Certificates Regulations 2010[18] sets out the minimum content for periodic medical examinations, with Schedule 1 stating that these examinations must include:

- a general medical examination
- an examination of sensory functions (vision, hearing, colour perception)
- blood or urine tests to detect diabetes mellitus and other conditions as indicated by the clinical examination
- tests for drugs where clinically indicated.

97 Neither the Train Driving Licences and Certificates Regulations 2010 nor RIS-3451-TOM mention sleeping disorders. However, RSSB document GO/GN3655 'Guidance on Medical Fitness for Railway Safety-critical Workers'[19] details sleep apnoea and acknowledges that sleep apnoea is related to increased accident rates, depending on its severity. GO/GN 3655 states that '*Sleep disorders such as OSA will have an increased likelihood of impairment of awareness or concentration, or even falling asleep, while performing safety-critical work'.*

98 GO/GN 3655 advises organisations to proactively share information about sleep disorder symptoms with employees, to consult with their occupational health provider regarding suspected or identified sleep disorder/s, and to check that their provider routinely considers sleep disorders including OSA '*when assessing the medical fitness of safety-critical workers*'. There was no evidence of GBRf following this guidance.

99 GO/GN 3655 also details that managers should '*arrange for the medical status of individuals involved in sleep related accidents and Signals Passed at Danger to be established, in order to exclude sleep disorders as an underlying cause*'. Such a post-accident examination was carried out on the driver of 4E11 by GBRf (paragraph 92).

100 The driver of 4E11 could not recall having been asked any sleep-related questions or undergone an assessment of possible indicators of sleeping disorders, such as sleep apnoea, during any previous periodic medical exams.

[18] The Train Driving Licences and Certificates Regulations, 2010. Available from www.legislation.gov.uk.

[19] RSSB, Rail Industry Guidance Note GO/GN3655 Medical Fitness for Railway Safety Critical Workers, 2014. Available from www.rssb.co.uk.

101 The National Institute for Health and Care Excellence (NICE)[20] identifies two screening questionnaires to assess the extent and severity of a sleep condition such as apnoea. These are the 'STOP-Bang' questionnaire and the Epworth Sleepiness Scale. Although the standards do not require these questionnaires to be used during a medical assessment, GO/GN 3655 provides guidance that organisations should check that their health service provider routinely considers obstructive sleep apnoea when assessing the medical fitness of safety-critical workers. However, sleep conditions are not formally assessed by GBRf's occupational health provider, and GBRf did not verify that this was done.

102 GBRf's policies did not specify the contents of the periodic medical for their safety-critical staff, instead referring to compliance with a railway standard 'GO/RT 3353 Personal Track Safety'.[21] This standard was withdrawn in 2002.

The driver's workload and expectation of D197 aspect

103 The driver's awareness was possibly affected by low workload and their expectation of the aspect which would be displayed at signal D197.

104 After leaving Peterborough, all the signals encountered by train 4E11 displayed green aspects until the train approached Loversall Carr Junction (paragraph 31). This meant that there was very little stimulus for the driver during the approximate 78-minute journey to this point. A sustained period of low workload can result in a state of mental 'underload' in which a driver's attention to the driving task is diminished due to a lack of stimulation.[22] Underload can affect performance on its own or can interact with fatigue to exacerbate its effects on performance.

105 The period of low workload continued until the driver encountered signal D187, exhibiting a flashing double yellow aspect (paragraph 10).

106 Although the driver was very familiar with the route taken by 4E11 (paragraph 22), they could not recall any previous instances of being stopped at either signal D197 or D207. The driver's normal experience was to be signalled off the ECML at Loversall Carr Junction and straight through to Doncaster Decoy yard without being stopped at either signal. Therefore, the driver had always experienced signal D187 showing a double flashing yellow aspect and signal D189 showing a flashing single yellow aspect. This was then always followed by signal D191 initially displaying a steady single yellow aspect and then changing (stepping up), as the train approached, to a less restrictive steady double yellow aspect (paragraph 60).

107 Stopping trains at signal D197 was an unusual event, although one permitted by the relevant operating rules. Analysis of signalling data for trains routed from the ECML at Loversall Carr Junction for the five days before the accident showed that no train received a red aspect at D197 within that period. The fact that GBRf was unable to identify OTDR records for any trains which had been stopped at D197 (paragraph 53) alongside witness evidence, further supports the conclusion that this was an unusual event.

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[20] NICE, How should I assess a person with suspected obstructive sleep apnoea syndrome?, 2021. Available from www.nice.org.uk.

[21] RSSB, Railway Group Standard GO/RT3353 Personal Track Safety, 1998. Available from www.rssb.co.uk.

[22] RSSB, Evaluating prevention and mitigations to manage cognitive underload for train drivers (T1133), 2019. Available from www.rssb.co.uk.

108 The driver knew that the flashing yellow signal sequence was indicating that they were taking the diverging route. Although they were aware that it was possible for signal D197 to display a red aspect, this was not their normal experience of this route. The driver's loss of awareness occurred at some point after they had seen the single yellow aspect at D191. If they had been aware that this signal remained displaying a single yellow aspect, then they could have recognised that their approach to the junction on this occasion was deviating from their normal experience and expectation and taken appropriate action (paragraph 58).

Engineered systems

109 The engineered systems in place did not mitigate the loss of driver awareness.

110 The railway infrastructure in the area of the accident and the class 66 locomotive involved were fitted with a number of safety systems. These included:

- Driver's Safety Device (DSD); this incorporates a vigilance feature
- Automatic Warning System (AWS)
- Train Protection and Warning System (TPWS).

AWS and DSD system and driver awareness

111 The DSD system is intended to apply the train's emergency brakes should the driver become incapacitated. The driver must maintain downward pressure on a foot pedal while driving. A periodic audible vigilance alarm requires the driver to release and reapply the DSD pedal at set time intervals. If the driver does not respond then an emergency brake demand is triggered. The locomotive OTDR does not specifically record the operation of the DSD system but it will record any brake demands which result from it.

112 The AWS system provides an audible and visual warning to a driver on the approach to certain infrastructure features, such as signals and selected speed restriction changes. It uses track-mounted magnets which are detected by receivers fitted to trains. The system on the train sounds a bell (or electronic equivalent) when approaching a signal displaying a green aspect, and a horn when approaching a signal displaying any other aspect, or a change in permissible speed. This warning is intended to alert the driver to the upcoming signal or speed change. When receiving a warning, a driver must acknowledge this by pressing the 'AWS Reset' button on the driving desk. If the driver does not acknowledge the warning within 2.5 seconds, the train's emergency brakes will be applied. The driver's acknowledgement causes the AWS visual indicator in the cab to show a yellow and black 'sunflower' indication as a reminder of the warning (figure 9).

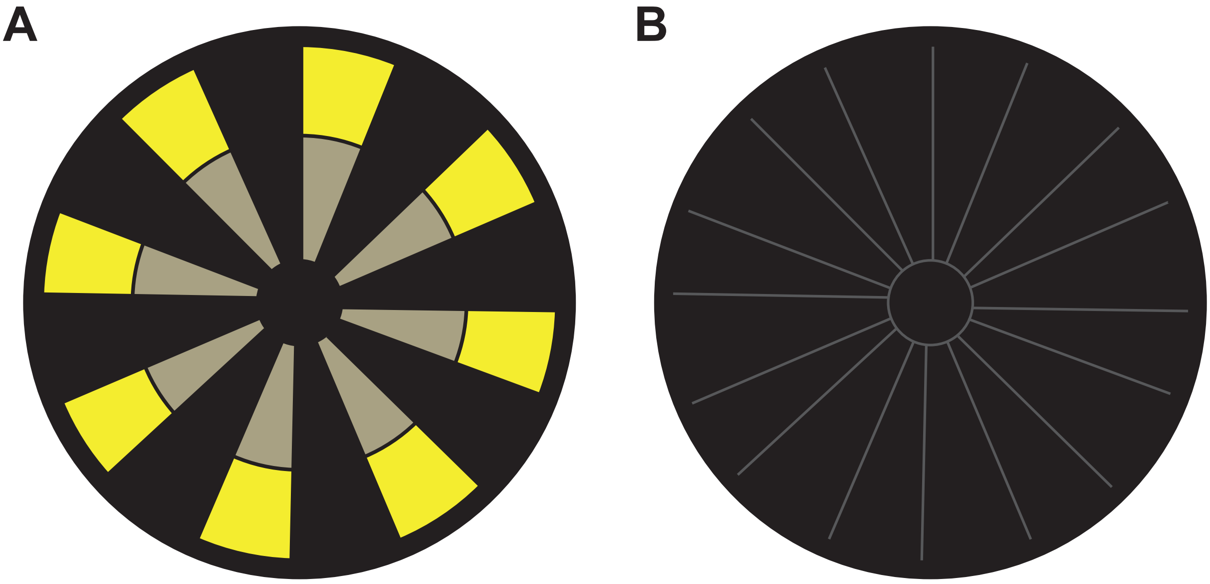

Figure 9: Automatic Warning System 'sunflower' visual indicator as displayed in the driving cab, showing [A] activated, and [B] not activated.

113 During the approach to Loversall Carr Junction, the driver received four AWS warnings, the first of which was for signal D187 (showing a flashing double yellow aspect). The driver pressed the AWS reset button for all four of these warnings (table 2).

AWS reaction time (seconds) from the OTDR download	
AWS signal D187	0.3
AWS signal D189	1.2
AWS signal D191	1.1
AWS signal D197	0.5

Table 2: Reaction times of the driver of train 4E11 to AWS reset for signals approaching D197.

114 Relevant previous RAIB investigations (see paragraph 174) and academic research[23] show that drivers can respond to AWS and DSD warnings in an automatic manner, even while fatigued, becoming habituated to cancelling AWS warnings without it drawing their attention to the driving task as a whole (paragraph 61). In this case, the warnings sounded did not serve to alert the driver or raise their awareness, and the driver continued to operate the DSD foot pedal and AWS reset button.

The Train Protection and Warning System (TPWS)

115 TPWS was developed in the mid-1990s to address the risk arising from trains passing signals at danger. It is fitted at signals which can show a stop aspect to protect crossing or converging movements on passenger lines and certain other conflicting movements. TPWS is not a failsafe protection system; it is designed to reduce the likelihood and consequences of an undesirable event. It is also not intended to intervene across the full range of train speeds.

[23] RSSB, Extended use of AWS (T021 Report), 2003. Available from https://www.sparkrail.org/.

116 TPWS uses radio frequency transmitters (known as 'loops') placed between the rails. When used at signals, a pair of loops are placed at the signal itself. This is known as a train stop system (TSS). These are energised when the signal is at danger (showing a red aspect). The TPWS equipment installed on the train consists of a TPWS receiver, a combined AWS/TPWS control unit and a TPWS visual indicator in the cab. Should a train pass over the loops when they are energised, the TPWS equipment on the train will detect this and generate an emergency brake demand. The driver will receive a visual indication that the brake demand has occurred and will be required to acknowledge the demand as part of resetting the system.

117 An overspeed sensor system (OSS) can be fitted at signals fitted with TPWS and on the approach to speed changes or buffer stops. An OSS involves another pair of loops being placed at a specified distance on the approach to the signal, speed change or buffer stop. The distance between the OSS and the signal, speed change or buffer stop is calculated to stop an approaching train wherever possible, or to at least reduce its speed, before any conflict point is reached. The OSS loops are activated if the associated signal is showing a danger aspect or are permanently activated at speed changes and on approach to buffer stops.

118 The Railway Safety Regulations 1999[24] came into force on 30 January 2000. Regulation 3 of these regulations originally required railway organisations to fit an appropriate train protection system before 1 January 2004 to mitigate the risks due to trains passing signals at danger and overspeeding at speed restrictions. Following the 1999 Ladbroke Grove accident in which 31 people died,[25] the deadline for fitment of such systems was brought forward to 2003 by the Health and Safety Executive (HSE) which was at that time the safety authority for the mainline railways in Great Britain.[26]

119 During the mid-1990s, the infrastructure managers of the mainline railway in Great Britain (British Rail and subsequently Railtrack) developed and tested the system which would become TPWS. As this was the only system available which could be implemented on the scale required before the compliance date contained in the regulations, fitment of TPWS was rolled out across the mainline rail network in Great Britain.

120 In 2003, Network Rail requested, and was granted by HSE, an exemption from the regulations for certain situations. The different types of exclusion are currently listed within Network Rail Standard NR/SP/SIG/10137 '*TPWS – Selection of Signals and Other Locations for Provision of Track Sub System'*. Exclusion C of this standard applies to signal D197 due to its categorisation as a 'plain line signal' that does not protect a conflict point (such as converging junctions or cross overs). Signal D197 is, therefore, not legally required to be fitted with a protection system such as TPWS and was not so fitted.

[24] Railway Safety Regulations, 1999. Available from www.legislation.gov.uk.

[25] The Rt Hon Lord Cullen PC, HSE, 'The Ladbroke Grove Rail Inquiry Report', 2001. Available from www.railwaysarchive.co.uk.

[26] The Railways Act 2005 transferred responsibility for railway-related health and safety matters from HSE to ORR.

121 Using the braking data from the OTDR fitted to 4E11's locomotive, RAIB analysed the potential effect of TPWS if it had been fitted at signal D197. RAIB's analysis showed that a TPWS OSS installation[27] at the signal would have reduced the speed, and therefore the severity of the collision, but would not have prevented it. RAIB's analysis also showed that if a TSS had been fitted at the signal, then it would have applied the emergency brake around four seconds earlier than the point where the driver applied it during the accident. This suggests that a TSS fitment alone would have had little effect on the collision.

Identification of underlying factors

Management of fatigue

122 GBRf management systems did not detect that the driver was at risk of fatigue. This is a probable underlying factor.

123 ORR and RSSB guidance documents (paragraph 75) describe the elements of a fatigue risk management system (FRMS). An FRMS is defined in ORR guidance as a system which '*identifies and draws together all the preventive and protective measures which help an organisation control risks from fatigue*'.

124 RSSB guidance states that an FRMS should include:

- evidence of a supportive company culture, including policy commitment and the establishment of a consultation process supported by senior management, effective resourcing, education and training
- a dedicated fatigue risk identification, assessment, control, and evaluation process
- documented arrangements to enable systematic monitoring, review and audit as part of a cycle of continual improvement.

The guidance documents emphasise the importance of both work-related and non-work-related fatigue, as well as the responsibilities of both employer and employee in managing fitness for work relating to fatigue.

125 RSSB's Fatigue Coordination Group (FCG) is a platform for information sharing and cross-industry collaboration. FCG brings together the activities of the individual Fatigue Working Groups from train operating companies, Infrastructure Safety Leadership Group and National Freight safety Group (NFSG).

126 NFSG, of which GBRf is an active member, has published a Code of Practice called 'Managing Freight Fatigue'.[28] This sets out common principles for managing fatigue in the freight sector. The document refers to the guidance from ORR and RSSB, and RSSB's health and safety strategy. It also highlights the requirements and guidance for the UK rail freight sector.

[27] The set speed for this hypothetical TPWS OSS was 34 mph (54 km/h) as per comparable signals in the area.

[28] RSSB, Common Principles for Managing Fatigue in the Freight Sector, 2018. Available from rssb.co.uk.

127 GBRf has a Fatigue Policy Statement which is endorsed by the managing director (appendix C). This document demonstrates the company's awareness of legal requirements and guidance in relation to fatigue and summarises the company's primary commitments to fatigue controls, with specific reference to first night shifts. Within the document, GBRf says it '*will take all measures as far as is reasonably practicable to ensure that all safety-critical workers and contractors are aware of and adhere to the guidelines for the hours of work and managing fatigue'.*

128 GBRf did not have a specific FRMS. Its processes for managing fatigue are covered within a number of documents, including its Safety Management System (SMS), standards manual, Control and Planning Manual, Health & Safety Policy and GBRf General Operating Appendix.

129 These documents record basic processes for managing fatigue related to specific elements of safety-critical roles, such as drivers' rosters. Processes detailed include:

- working time limits and requirements for designing and evaluating rosters for fatigue considerations in base roster creation
- how GBRf manages exceedances in fatigue risk index scores (see paragraph 137) and hours worked in actual rosters through individual risk assessments
- when fatigue should be reported and guidance on lifestyle and fitness for duty, including how drivers should prepare for work to reduce fatigue.

130 These processes, although referenced as part of its SMS, have also not been formalised within an FRMS (paragraph 123). An FRMS should guide GBRf through the implementation of the ROGS 'Nine-Stage' approach (illustrated in figure 10) which outlines the arrangements for managing the risk arising from fatigue in safety-critical workers. Without an FRMS to centralise its approach to managing fatigue risk, there was an absence of clarity within GBRf of how the fatigue risk was being identified and controlled. There was also a scarcity of assurance processes to continuously monitor, develop and improve GBRf's management of fatigue.

Figure 10: Summary outline of the ROGS 'Nine-Stage' approach for managing the risks arising from fatigue in safety-critical workers (ORR, 2012).

The process for creating drivers' rosters and evaluation of fatigue risks

131 GBRf's fatigue management is centred around the rostering and planning process for safety-critical staff (including drivers and ground staff). A summary of the principles of this process is included within the Fatigue Policy Statement. These are:

a. A maximum rostered turn length of 12 hours
b. At least 12 hours rest between safety-critical turns excluding first night in lodge[29]
c. No more than 13 consecutive shifts without a 48-hour break
d. At least 32 hours of rest after a block of consecutive nights
e. No more than 5 consecutive shifts in a permanent base rostered pattern
f. No more than 60 hours worked in a period of available days
g. Very early shifts starting before 05:00 will be minimised if possible
h. Risk evaluating all base rosters in conjunction with the ORR fatigue guidance and the Fatigue Index model
i. Weekly and daily fatigue monitoring throughout the planning and control progress
j. Review of the ORR Fatigue Risk Management System document periodically
k. Note: Any deviation from the above limits will require a risk assessment to be carried out.

132 When reviewing these commitments in reference to GBRf's management of fatigue of the driver of 4E11, one of those listed was identified as not being followed (clause g). However, the requirement to complete a risk assessment (clause k), should there be any deviation, was not carried out as the fatigue risk assessment was only used by control, and then only in reaction to a high Fatigue and Risk Index (FRI) score (see paragraph 140).

133 GBRf train drivers' rosters are created by the timetabling and resources functions of the planning team. The base roster is developed using information from longer-term planning and is issued on a six-monthly basis. The actual roster takes this base roster and further develops it, using short-term planning information. The actual roster is issued to the drivers every week on a Thursday and starts the following Sunday. Drivers need to inform the planning team, by the Sunday before roster publication, of any rest days (as stated in the base roster) that they do not want to work. Unless the planning teams are specifically told by a driver that they do not want to work a rest day, a working shift may be assigned to a driver on a nominal rest day. This means that there can be significant differences between the base roster and the roster actually worked. As such, the base roster is mainly used by drivers for scheduling annual leave.

[29] 'In lodge' refers to a driver staying overnight between shifts in hotel accommodation.

134 RAIB analysed the number of rest days worked by GBRf drivers based at Doncaster depot where they have three rest days per week in their base roster as a requirement of their contractual terms and conditions. This analysis reviewed the eight weeks leading up to the accident (figure 11). The driver of 4E11 was in the top 25% of drivers in terms of the number of rest days worked, having worked 10 rest days within the period.

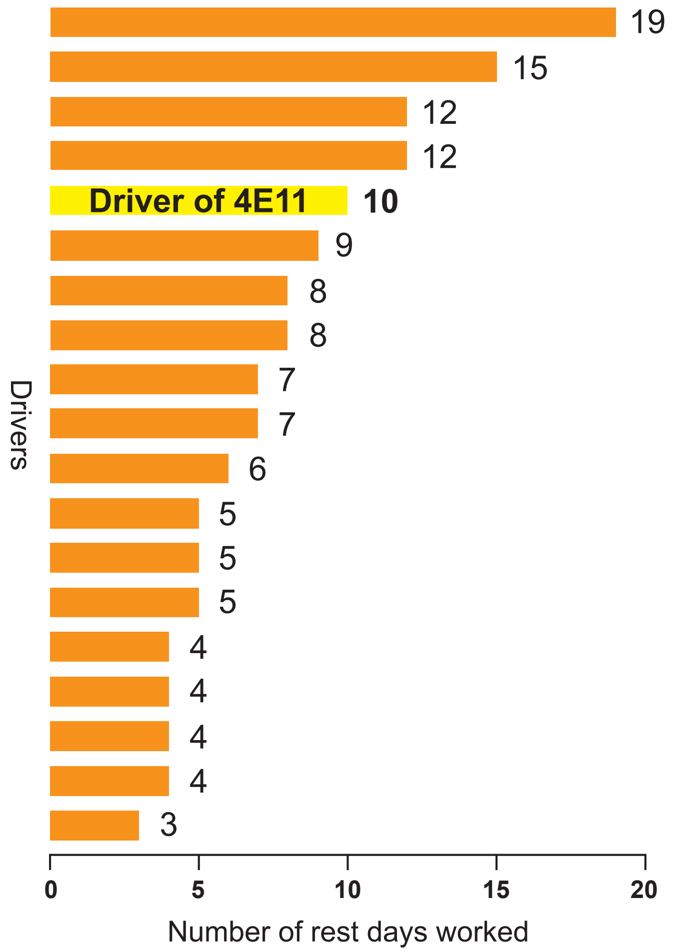

Figure 11: Doncaster depot rest day working for the 8 weeks before the accident showing the driver of 4E11 compared to the other drivers in the depot.

135 There is a different approach to fatigue management between the base roster and actual roster. The base roster was constructed with consideration of ORR's fatigue factors (paragraph 71), whereas attempts to address those factors relating to the actual roster were reactive, based solely on the use of the FRI (see paragraph 137).

136 To address the risk of first night shifts, the Fatigue Policy Statement (appendix C) states that they are to be identified and mitigated through educational programs, targeted fitness for duty discussions, and that checks will be made during a shift to reduce exposure to monotonous routes and hazardous activities. The driver of 4E11 had never received a fatigue-related check during a shift and was on their first night shift when the accident took place. Before the accident, the last briefing on fatigue they received was during the summer 2021 safety briefing (see paragraph 151).

137 GBRf's rosters are evaluated using a fatigue assessment tool called the FRI (Fatigue Risk Index), developed by HSE.[30] The FRI is a mathematical model designed to predict fatigue and risk arising from shift patterns. It constructs its predictions from three separate components: a cumulative component associated with the pattern of work and rest; a duty timing component associated with the shift start time, the time of day throughout the shift and the shift length; and a job type/breaks component associated with the intensity of the work being carried out, the timing of breaks and their duration.

138 The FRI produces two numerical outputs for a given roster pattern. These are:

a. A fatigue score, from 0 to 100, representing the probability that a person is experiencing high levels of fatigue.[31] A score of 50 is the probability that one in every two people would be fatigued to this extent.

b. A risk score, representing the relative risk of a fatigue-related event. A score of one represents the average risk on a two-day, two-night, four-off schedule of 12-hour shifts starting at 08:00 hrs and 20:00 hrs; a score of two represents a doubling of risk.

139 For each base roster created by GBRf, an FRI is calculated, producing fatigue scores for every shift. GBRf standards are followed to assess whether further action needs to be taken to manage fatigue. Fatigue scores between 40 and 45 are considered 'medium to high risk' within the base roster. When creating the base roster, fatigue scores are proactively managed to keep them below 40 and 45. Since the actual roster (including rest days worked) is likely to be more fatiguing than the base roster, any base roster which generates a fatigue score indicating medium-to-high risk will be likely to produce higher fatigue score values when the actual roster is created.

140 GBRf uses a 10-day prediction tool, which generates an email every four hours to all control and planning staff. The tool identifies which drivers may breach the FRI score of 45. The GBRf Control and Planning Standards Manual requires mitigation for any shifts with an FRI score of 45 or over.

141 Actual rosters featuring fatigue scores of 45 or above are managed reactively through GBRf control. Control will apply a 'trigger' to the remote signing-on system, requiring the driver to call them before they start their shift. The controller will then work through a fatigue risk assessment template with the driver to assess whether it is safe for them to continue their shift. Once control have completed a fatigue risk assessment, the scores then drive any risk mitigations for the individual concerned, such as later start times, longer rest periods, or reminding the individual how they can manage their own fatigue risk. If the risk is perceived as not being adequately managed, the duty control manager will work with the operations manager (the driver's line manager) to inform the decision on whether that individual driver should complete their shift or not.

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[30] The HSE has now withdrawn access to the Fatigue and Risk Index, due to developments in software, and the need to improve the model and its implementation, as detailed on its website https://www.hse.gov.uk/research/rrhtm/rr446.htm.

[31] The Fatigue and Risk Index considers high levels of fatigue to be values of eight or nine on the Karolinska Sleepiness Scale (KSS), a nine point scale ranging from one - extremely alert to nine - extremely sleepy and fighting sleep. The KSS is one of several methods used to subjectively estimate sleepiness.

142 Although Control spoke with the driver when they signed-on (paragraph 27) a fatigue risk assessment was not conducted. This was because the driver's FRI fatigue score was 19.38, and therefore less than the 45 required to initiate such an assessment. This fatigue score at the start of the shift represented a 19.38% chance that fatigue would be experienced to the extent that the driver may struggle to stay awake on that particular shift. Although the driver had no knowledge of the FRI and its use within GBRf to trigger fatigue risk assessment phones calls with Control, the driver could predict when one of these calls would be triggered based on their shift patterns.

143 Witness evidence indicates that the fatigue risk assessment process conducted by GBRf Control is seen as a 'tick box' exercise, with little confidence expressed in how the process aids the management of fatigue. Witness evidence also identified that the process very rarely results in a driver being removed from their shift.

144 The completed paper fatigue risk assessments are filed within GBRf control. A GBRf audit after the accident identified that nothing else in terms of monitoring and useful data collection takes place once these assessments are filed. In addition to the paper assessments, a record of the triggered call is emailed to the appropriate managers. Typically, a manager receives around two such emails per day. Managers are not required to undertake any action in response to these emails. This represents a lost opportunity to seek assurance of the effective operation of the fatigue management process.

145 RAIB identified that the teams using the FRI within rostering and control did not have a detailed understanding of what the FRI scores meant and how they should be used. This absence of training and knowledge extended to the line managers and the wider staff within GBRf who were affected by the FRI calculations.

146 This lack of understanding meant that GBRf did not include the commuting time of a driver when calculating the FRI score. The driver had to travel for an hour at the start and end of each shift (due to the relocation of their signing-on point, paragraph 21), thus adding two hours onto each shift and removing two hours from the available rest between shifts. Managing Rail Staff Fatigue (ORR, 2012) suggests that the time spent travelling associated with work can contribute to fatigue and should therefore be considered in the effective management of the risk of fatigue.

147 Witness evidence suggests that, although the driver had been informed that the change in their signing-on point from Immingham to Doncaster would be considered during rostering after concerns were raised about the increased travel time, there had been no changes made to shift patterns.

148 As well as these specific issues with FRI calculations, the reliance on FRI thresholds is not in line with industry good practice. Neither HSE nor ORR advocate the use of FRI thresholds to determine if a roster is satisfactory or otherwise. The intended purpose of using models of this nature is to reduce the scores to as low as reasonably practicable. ORR states that users should carefully consider what the FRI values actually mean, rather than assuming that the tool provides an authoritative decision as to whether a roster is acceptable or not, such as relying on a fatigue score below 45. ORR strongly advises that such 'hard limits' should be treated with caution.

149 In June 2021, HSE removed the FRI calculator from its website, citing among other concerns '*cases of the FRI being misused in order to justify work patterns that clearly require further action to reduce fatigue-related risk*'. Current guidance from ORR, RSSB and NFSG specifies the importance of an FRI not becoming a target and instead being used as part of a wider FRMS.

150 Although previous RAIB investigations (see paragraph 174) and industry good practice guidance emphasise an integrated approach to managing fatigue, GBRf still relied heavily on FRI scores and working hours as a primary fatigue control measure.

Individual fatigue management

151 Lifestyle guidance can make an important contribution to safety by helping staff balance home and work life, including recognising and managing fatigue issues. The General Operating Appendices (GBRf's driver handbook) include basic guidance for drivers on managing their own fatigue within sections entitled 'Effective Personal Preparation' and 'Lifestyle and Drugs and Alcohol'. Although the documents detail how sleep health can affect performance, there was no reference or guidance about sleep-related medical conditions such as sleep apnoea. GO/GN 3655 explicitly advises sharing such information with drivers and other safety-critical staff (paragraph 98).

152 GBRf drivers receive a safety briefing delivered via an online platform twice per year. Briefings are either delivered face-to-face, via a short video on an online platform, or by a presentation document. The systems are checked to give assurance that the drivers have received and opened the briefing.

153 The contents of the briefing varied based on observed trends, issues, and seasonal risk. Before the accident, the last safety briefing to drivers on fatigue was during the summer of 2021. The briefing identified that working 14 hours or more including driving, shunting or road driving was considered high risk, and encouraged drivers to 'speak up' if they didn't feel safe. Although no evidence of drivers speaking up in such a way could be provided, GBRf stated to RAIB that drivers spoke up about fatigue informally. This was an approach which GBRf recognised had weaknesses.

154 Additionally, GBRf has a Fatigue Focus Group, formed in 2017. The aim of the group is to provide a forum for management and trade union representatives to discuss and address fatigue within GBRf. However, the last meeting before the accident was during the COVID-19 pandemic (July 2020). GBRf has recently restarted these meetings under the name of the Fatigue Risk Action Group (FRAG).

155 The main GBRf forum in which fatigue is monitored is through a fatigue Key Performance Indicator (KPI) presented to the Executive Safety Standards Group (ESSG). ESSG is formed of directors, senior managers and trade union representatives with responsibility for safety within GBRf. The fatigue KPI looks at the number of exceedances on a month-by-month basis for both shifts exceeding 12 hours worked and fatigue scores of 45 and over. The KPI is calculated using a moving annualised average approach to 'normalise' figures otherwise distorted during the COVID-19 pandemic. A positive trend for this KPI would therefore be downwards, indicating a reduction in fatigue exceedances.

156 ORR guidance on fatigue KPIs[32] states ‘*Good fatigue KPIs help measure the presence and effectiveness of fatigue defences, providing an early warning of weaknesses in fatigue controls*’. Over the last year, although there have been fluctuations, both positive and negative, the KPI has not demonstrated a sustained reduction in fatigue exceedances.

157 In response to the fatigue KPI, and before the accident, GBRf trialled a driver attention device by installing it in its driving simulator located at Peterborough. GBRf is working with drivers, union representatives and the manufacturer to trial the device within operational driving cabs. However, at the time of the accident, no such equipment had been fitted to any driving cab.

158 There were no other actions recorded by ESSG in response to the fatigue KPIs and no clear identification of the degree to which GBRf is aiming to improve its performance. This monitoring was also entirely retrospective. RAIB found little evidence of proactive monitoring, target setting or use of management controls to prevent staff working excessive hours.

The driver’s line management and employment record

159 Drivers employed by GBRf have two line managers:

- an operations manager responsible for human resources matters and development
- an operations standards manager, responsible for competency management and assessment.

160 Each role has opportunities to identify fatigue or distraction concerns arising from conversations, assessments and investigations relating to the driver they are collectively managing. However, although based in the same office, the line managers work separately and with limited communication, meaning that shared concerns are not identified.

161 GBRf provided RAIB with the driver’s employment record, which showed that there had been two personal support plans (PSP) written for the driver in the last four years. The first PSP was created following an operational incident while the second PSP was created after the results of driving assessments required over 12 months as part of the first PSP were found to be below the standard required by GBRf. The PSP process included a post-accident in-cab assessment of the driver’s behaviour (replaced by OTDR downloads during COVID-19 restrictions), and the analysis of OTDR downloads to check driving techniques. GBRf stated that the second PSP was signed off as being complete in December 2021 after improvements were noted.

162 As part of the GBRf competency management cycle, the last OTDR download to be analysed before the accident was in April 2022. The assessor noted that the driver braked heavily approaching a red aspect, and asked the driver whether this was due to a loss of situational awareness. The driver’s response was that they didn’t know what happened and that they may have been tired. Although this event did not result in an incident, it was a missed opportunity, as there was then no further examination into factors associated with fatigue.

[32] ORR, Fatigue – Key Performance Indicators, 2017. Available from www.orr.gov.uk.

Train driver risk assessments

163 Risk assessments undertaken by GBRf did not identify hazards caused by train drivers being fatigued. This is a possible underlying factor.

164 As an employer, GBRf has a responsibility to the people within its employment and those affected by their operations to identify, assess and control risks to health and safety.[33] Regulation 19 of ROGS[34] details the requirement of transport operators to conduct suitable and sufficient assessment of the risks '*for the effective planning, organisation, control, monitoring and review of the measures identified'.*

165 Additionally, regulation 25 of ROGS specifically refers to fatigue, and the requirement for employers of safety-critical staff such as GBRf to have arrangements in place to ensure '*that a safety-critical worker under his management, supervision or control does not carry out safety-critical work in circumstances where he is so fatigued or where he would be liable to become so fatigued that his health or safety or the health or safety of other persons on a transport system could be significantly affected*'.

166 GBRf has a generic risk assessment for train driving duties entitled Driver Role Risk Assessment. RAIB reviewed the version that was valid at the time of the accident (February 2021) which had been modified to include risks associated with COVID-19. However, the risk from fatigue and other human factors that would detrimentally affect the safe completion of the driving task was not included within the risk assessment for drivers. While GBRf had a number of processes and policies intended to control fatigue risk, there is no evidence that these were based on an assessment of risk. If this risk had been more formally considered, it is possible that GBRf's driver fatigue management would have become more effective.

Observations

The use of flashing aspects at signals approaching D197

167 The design principles governing the application of the flashing yellow signals approaching D197 pre-date current signalling practice.

168 Flashing yellow signals were introduced during the mid-1970s to provide train drivers with advanced notification of a diverging junction. Drivers combine this notification with their route knowledge and control the speed of their train on the approach to the divergence before receiving the route indication at the junction signal itself. Flashing yellow aspect signal controls were added to Loversall Carr Junction in 1978.

[33] Management of Health and Safety at Work Regulations, 1999. Available from www.legislation.gov.uk.

[34] Railways and Other Guided Transport Systems (Safety) Regulations (ROGS), 2006. Available from www.legislation.gov.uk.

169 In 1986, a collision occurred at Colwich in which a driver passed a signal at danger. On the approach to the junction, the driver received flashing yellow aspects, followed by a single yellow aspect before reaching and passing the signal at red. This signal was at red to protect a train approaching on a converging route. The collision between the two trains resulted in one death and 75 injuries.[35] The driver had misunderstood the meaning of the flashing yellow signals and thought that they indicated that the route had been cleared fully across the junction where the collision occurred. This misunderstanding occurred because, at Colwich, the junction had been split into two. The signal beyond the first divergence was itself a junction signal. The flashing yellow sequence exhibited was for a route up to the first signal beyond the divergence only. Following the Colwich accident, additional controls were recommended requiring that, if the first signal on the diverging route is also a junction signal, flashing yellow aspects would be inhibited if the diverging route junction signal is held at red.

170 D197 at Loversall Carr is not a junction signal, and so it would not require the flashing yellow controls to be applied as recommended after the Colwich accident. However, drivers could still be mistaken in thinking the signal ahead will be clear even though the junction protecting signal does not step up from single yellow. In 2002 railway signalling standard GK/RT 0032[36] was updated to include similar controls to be applied to inhibit flashing yellow signals in those circumstances where the first signal on a diverging route is at red including when this is caused by a train in the section ahead. If this control had been applied, the train ahead of signal D197 would have prevented the flashing yellow aspect sequence being given to train 4E11. It is unlikely that this would have influenced events because the driver would still see a yellow aspect at signal D191, as they had done on 05 July 2022, and would not have needed to take any different action to control the speed of their train.

[35] Railway Inspectorate, Report on the Collision that occurred on 19th September 1986 at Colwich Junction, 1988. Available from www.railwaysarchive.co.uk.

[36] RSSB, Railway Group Standard GKRT0032 issue two Provision of Lineside Signals, section B10.6.5, 2002. Available from www.rssb.co.uk.

Summary of conclusions

Immediate cause

171 Train 4E11 passed signal D197 at danger and did not stop before the collision (paragraph 48).

Causal factors

172 The causal factors were:

a. The driver did not control the speed of train 4E11 on approach to signal D197 to enable it to stop before passing the signal at red. This was due to the driver losing awareness of the driving task (paragraph 51, **Learning point 1**). This causal factor arose due to a combination of the following:

   i. The driver was probably experiencing the effects of fatigue when train 4E11 approached signal D197 (paragraph 67, **Recommendations 1 and 2**).

   ii. The driver's awareness was possibly affected by low workload and their expectation of the aspect which would be displayed at signal D197 (paragraph 103).

b. The engineered systems in place did not mitigate the loss of driver awareness (paragraph 109, **Recommendation 1**).

Underlying factors

173 The underlying factors were:

a. GBRf management systems did not detect that the driver was at risk of fatigue. This is a probable underlying factor (paragraph 122, **Recommendations 1 and 2**).

b. Risk assessments undertaken by GBRf did not identify hazards caused by train drivers being fatigued. This is a possible underlying factor (paragraph 163, **Recommendation 1**).

Additional observation

174 Although not linked to the accident on 5 June 2022, RAIB observes that the design principles governing the application of the flashing yellow signals approaching D197 pre-date current signalling practice (paragraph 167, **Learning point 1**).

Previous RAIB recommendations relevant to this investigation

175 The following recommendations, which were made by RAIB as a result of previous investigations have relevance to this investigation.

176 At 05:31 hrs on 9 February 2006, an English, Welsh and Scottish Railway (EWS) freight train derailed at Brentingby Junction, near Melton Mowbray after the train had passed a red signal at the end of a goods loop (RAIB report 01/2007). RAIB identified that a cause of the accident was fatigue. Although there was no evidence that the driver suffered from sleep apnoea, their build and age increased the likelihood of sleep-related conditions. RAIB's investigation found that the train operator's processes did not include routine screening for sleep disorders. RAIB made a recommendation to investigate and if reasonably practicable instigate a change to Railway Group Standard GO/RT 3251 to make screening for sleep disorders a requirement in periodic medical surveillance applied to train drivers and following incidents/accidents where fatigue has been identified as a possible causal or contributory factor. At the time, RSSB suggested that the process of adding sleep disorder screening to periodic medicals could not be implemented objectively. This recommendation has been closed by ORR.

177 In the early hours of 17 August 2010, a northbound freight train was travelling uphill on the West Coast Main Line between Tebay and Shap Summit in Cumbria. At 02:04 hrs, the train slowed to a stop and then ran back until the driver braked and the train came to a stand at 02:09 hrs (RAIB report 15/2011). The investigation found that DB Schenker's train driver, who was working the first of a series of night shifts, was probably fatigued and not sufficiently alert at the time of the incident. It also found that although DB Schenker had used a recommended mathematical model and industry guidance to plan the shift, the driver had been exposed to a work pattern that was likely to induce high levels of fatigue. The report concludes that the mathematical model adopted by most of the rail industry was likely to under-predict the probability of high levels of fatigue experienced by people working a first night shift. The resulting recommendation led to the creation of ORR's Fatigue Management Guidance (2012) (paragraph 75).

178 At around 21:43 hrs on Sunday 21 June 2020, a near miss occurred between two passenger trains at London Underground's Chalfont & Latimer station on the Metropolitan line (RAIB report 04/2021). A Chiltern Railways train had passed a signal at danger (SPAD). This resulted in the train being automatically stopped by a safety system, known as a tripcock, which had applied the train's emergency brake. Without seeking the authority required from the signaller, the driver reset the tripcock before continuing towards Chalfont & Latimer station, where the train was routed towards the northbound platform, which was occupied by a London Underground train. The probable cause of the SPAD was that the driver of the Chiltern Railways train was fatigued. A medical examination after the incident identified undiagnosed sleep apnoea. Recommendation 1 focused on Chiltern improving its driver management and included identifying conditions such as sleep apnoea during periodic medical examinations. This recommendation has been closed by ORR. A learning point was also made to highlight the importance of organisations checking that periodic medical examinations include consideration of sleep disorders when assessing the medical fitness of safety-critical workers.

Recommendations that are currently being implemented

Incidents at Reading Westbury Line Junction, 28 March 2015 and Ruscombe Junction, 3 November 2015, RAIB report 18/2016, Recommendations 1, 2, 3

179 At 08:22 hrs on 28 March 2015, a freight train running from Acton to Westbury, operated by DB Schenker Rail (UK), passed a signal at danger at Reading Westbury Line Junction, to the west of Reading station (RAIB report 18/2016). A similar incident occurred at 06:11 hrs on 3 November 2015 when another freight train forming the same service from Acton to Westbury, and operated by the same company, passed a signal at danger at Ruscombe Junction, about seven miles east of Reading. Both incidents occurred because the train drivers were too fatigued to properly control their trains with both of them stating that they momentarily fell asleep on the approach to the signals concerned. The drivers were nearing the end of a long night shift and were also suffering from fatigue because they had not obtained sufficient sleep. This was in part due to the rest facilities at Acton not being fit for purpose. The investigation also identified underlying factors associated with the general approach to the management of fatigue within the company. RAIB made three recommendations on fatigue looking at reducing the risk of fatigue through rostering and improving the management of fatigue in accordance with contemporary research and good practice. The third recommendation was for freight operating companies and RSSB to improve the industry's understanding of fatigue risk through deeper analysis of available data sources, providing more intelligence on fatigue risk precursors which could feed into fatigue risk management systems. Learning points focused on drivers managing fatigue through rest, and awareness of fatigue reporting and napping as a countermeasure for fatigue. All recommendations are recorded as still being in progress.

Accident at Kirkby, Merseyside 13 March 2021, RAIB report 07/2022, Recommendation 1

180 At around 18:53 hrs on Saturday 13 March 2021, a Merseyrail train hit the buffer stop at Kirkby station, Merseyside (RAIB report 07/2022). The train was travelling at 41 mph (66 km/h) as it entered the platform. Soon afterwards, the driver applied the emergency brake, but there was insufficient distance remaining to prevent the collision, and the train struck the buffer stop at around 29 mph (47 km/h). The train came to rest under a bridge, around 28 metres beyond the original buffer stop position. The collision caused significant damage to the station infrastructure and the front of the train, with the station remaining closed for eight days. The accident occurred because the driver of the train did not apply the brakes in time, as they were distracted from the driving task by using their mobile phone, and by their bag falling onto the cab floor. No engineered systems automatically applied the train's brakes, as the conditions for their intervention were not met. The driver continued to operate the controls for two of these systems (AWS and DSD) preventing their activation, despite not being entirely engaged in the driving task. A third system (TPWS) did not activate until after the driver had already applied the emergency brake. This system was installed in compliance with the relevant standards but it did not protect against the particular scenario of this accident.

181 Recommendation 1 addressed one of the factors identified in this investigation regarding the absence of engineered systems to mitigate the loss of driver awareness. The recommendation was made less than 12 months ago, and RAIB has not received an update. Therefore, to avoid duplication, it is not remade in this report, but reproduced in full below.

Recommendation 1

The intent of this recommendation is that additional research be undertaken into systems which can detect and monitor driver alertness and awareness, and how these could be trialled in the industry.

RSSB, in consultation with relevant stakeholders and bodies representing staff, should undertake further research into how the detection and mitigation of a loss of alertness or attention in train drivers can be improved. This research should specifically consider the effectiveness of systems currently in operation and build on work already completed, such as the functional specification and proposed trials set out in the T1193 research report. It should also take into account relevant practice from other transport systems.

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

182 Since the accident, GBRf is reviewing its current drivers' rosters in line with ORR's working pattern fatigue risks and assessing each individual's travel distance between their home and their signing-on location.

183 GBRf is reviewing its procedures and training in relation to fatigue management and driver preparation. Information on fatigue and preparation for duty has been disseminated through safety briefs to all safety-critical staff. Due to their role in completing fatigue risk assessments with drivers, specific training on driver fatigue has been delivered to control office staff (paragraph 140).

184 GBRf is creating an FRMS, which considers ORR and RSSB guidance, in addition to researching best practice from outside the rail industry. This includes investigating alternative fatigue management technologies, such as the use of smartphone apps to assist fatigue management. GBRf is working with RSSB to receive support and advice on its approach to fatigue management.

185 Fatigue-related meetings within GBRf have been restructured. The agenda of the ESSG meeting (paragraph 154) has been revised alongside the fatigue and safety KPIs where leading measures have been introduced. The FRAG (paragraph 153) has been re-established under the lead of GBRf's production director, including the completion of a monthly exceedance analysis by the group.

Recommendations and learning point

Recommendations

186 The following recommendations are made:[37]

1 *The intent of this recommendation is to reduce the risk of fatigue affecting the performance of train drivers employed by GBRf.*

GBRf should review its existing policies and processes relating to fatigue management. This review should consider how the risks of driver fatigue are assessed and controlled, as well as relevant law, guidance and good practice from other industries that may be applicable. This review should include consideration of:

a. the incorporation of policy and process into an integrated fatigue risk management model

b. how the risk of fatigue is managed for the roster and how factors such as fatigue created by rest day working is assessed and controlled

c. the use of biomathematical fatigue models

d. reviewing and updating risk assessments for the driving task, including the identification and mitigation of any other hazards caused by train drivers being fatigued which are not otherwise addressed

e. how assurance and monitoring processes will ensure that fatigue risk control remains effective.

GBRf should develop a timebound programme for the implementation of any appropriate measures identified.

This recommendation may apply to other train, freight and rail vehicle operators.

(Paragraphs 172 and 173).

[37] 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 and Road 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 intent of this recommendation is that medical assessments identify safety-critical staff at risk of sleep disorders.*

RSSB, working in conjunction with relevant transport undertakings, should review current medical fitness standards for safety-critical staff. Where appropriate, these should be updated to include a requirement to identify sleep disorder indicators (paragraphs 101 and 173a).

Learning point

187 RAIB has identified the following learning point:[38]

1 Drivers are reminded that flashing yellow signal aspects indicate that a diverging route, with a lower speed, is set at the junction ahead. It is important that drivers carefully check the junction signal on approach to identify whether it is indicating that the relevant signal beyond the junction is showing a red aspect. Not doing so increases the risk of a signal passed at danger and collision at locations where drivers can become accustomed to the route being cleared beyond a junction, particularly where flashing yellow aspects have been displayed (paragraphs 166, 172 and 174).

[38] 'Learning points' are intended to disseminate safety learning that is not covered by a recommendation. They are included in a report when RAIB wishes to reinforce the importance of compliance with existing safety arrangements (where 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

AWS	Automatic Warning System
CCTV	Closed-circuit television
DSD	Driver’s Safety Device
DVD	Driver’s Vigilance Device
ECML	East Coast Main Line
FRI	Fatigue and Risk Index
FRMS	Fatigue risk management system
GBRf	GB Railfreight
HSE	Health and Safety Executive
KPI	Key Performance Indicator
NFSG	National Freight Safety Group
ORR	Office of Rail and Road
OSS	Overspeed sensor system
OTDR	On-train data recorder
PSB	Power signal box
PSP	Personal support plan
RAIB	Rail Accident Investigation Branch
ROGS	The Railways and Other Guided Transport Systems (Safety) Regulations 2006
RSSB	Trading name of Rail Safety and Standards and Board
SMS	Safety Management System
TPWS	Train Protection and Warning System
TSS	Train stop system

Appendix B - Investigation details

RAIB used the following sources of evidence in this investigation:

- information provided by witnesses
- information taken from the train's OTDR
- CCTV recordings from train 4E11
- voice communication recordings
- site photographs and measurements
- an examination of the train and wagons involved
- weather reports and observations at the site
- a report detailing relevant activity on the driver's mobile devices
- the driver's rosters, competence and medical records
- GBRf documentary evidence relating to rules and operating instructions, planning, processes and procedures, competency management and briefing and training
- signalling plans and electronic data relating to the movement of the trains
- a review of relevant research literature, railway standards, procedures and guidance
- a review of previous RAIB investigations that had relevance to this accident.

Appendix C - GBRf Fatigue Policy Statement

GB Railfreight
Pioneering the Digital Rail Freight Revolution

FATIGUE POLICY STATEMENT

We are committed to the management of fatigue of all our workers and the application of this policy which meets the requirements of Regulation 25 of ROGs, ORR and RSSB Fatigue Guidance, and is in line with the national health and safety strategy – 'Leading Health and Safety on Britain's Railway'.

Consideration during our planning process is also given to the NFSG (National Freight Safety Group) Code of Practice published in December 2018 which was agreed by all Freight Operating Companies under the Rail Freight Project Charter.

We recognise the importance of such a policy in its contribution towards ensuring the health and safety of our workers, contractors and those affected by our activities.

We will take all measures **as far as is reasonably practicable** to ensure that all safety critical workers and contractors are aware of and adhere to the guidelines for hours of work and managing fatigue.

GB Railfreight are committed to the following fatigue controls:

a) A maximum rostered turn length of 12hrs.
b) At least 12hrs rest between safety critical turns excluding first night in lodge.
c) No more than 13 consecutive shifts without a 48-hour break.
d) At least 32 hours of rest after a block of consecutive nights.
e) No more than 5 consecutive shifts in a permanent base rostered pattern.
f) No more than 60 hours worked in a period of available days.
g) Very early shifts starting before 05:00 will be minimised if possible.
h) Risk evaluating all base rosters in conjunction with the ORR fatigue guidance and the Fatigue Index model.
i) Weekly & Daily fatigue monitoring throughout the planning and control processes.
j) Review of the ORR Fatigue Risk Management System document periodically

First night shifts are identified and mitigated by the following:

a) Development of staff education packages on the performance effects of first nights, long hours awake and misaligned body clock
b) Creation of staff education on sleep hygiene and napping
c) Targeted fitness for duty discussions, led by managers, which specifically include a discussion on recent sleep and activity
d) Checks on staff during duty reducing exposure to monotonous or particularly hazardous routes/activities

Note: Any deviation from the above limits will require a risk assessment to be carried out.

GB Railfreight has developed internal procedures to prevent staff or contractors from working excess hours or shifts. Where applicable rosters shall be risk assessed using the Fatigue and Risk Index prior to implementation to evaluate whether proposed shift patterns place staff at risk of fatigue.

Measurement of the effectiveness of these control measures will be via continuous monitoring and audit. Should this reveal a deviation from the procedures then appropriate action will be taken at lead by the Fatigue Focus Working Group made up of Safety, Ops, Planning and Union Representatives.

Any deviations or concern will be treated under our Fair Culture and should be sent to [redacted] and [redacted]

[redacted]

[redacted] | GB Railfreight Ltd | January, 2022

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