RAIB

Rail Accident Investigation Branch

Rail Accident Report

Two trains in the same signal section at South Wingfield, Derbyshire
26 October 2022

Report 11/2023
October 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.

Any enquiries about this publication should be sent to:

RAIB
The Wharf
Stores Road
Derby UK
DE21 4BA

Email: enquiries@raib.gov.uk
Telephone: 01332 253300
Website: www.raib.gov.uk

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

Preface

The purpose of a Rail Accident Investigation Branch (RAIB) investigation is to improve railway safety by preventing future railway accidents or by mitigating their consequences. It is not the purpose of such an investigation to establish blame or liability. Accordingly, it is inappropriate that RAIB reports should be used to assign fault or blame, or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

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.

This page is intentionally left blank

Two trains in the same signal section at South Wingfield, Derbyshire, 26 October 2022

Contents

Summary

At about 07:02 hrs on 26 October 2022, a train travelling between Derby and Chesterfield unexpectedly encountered a signal displaying a red (stop) aspect. The previous signal had displayed a green (proceed) aspect. As the train was travelling at 100 mph (161 km/h), it was unable to stop before the red signal and passed it by about 760 metres. The train's driver called the signaller straight away to report the incident. About 17 minutes later, the following train approached the signal which was now displaying a yellow (caution) aspect. After passing the signal, while travelling at about 20 mph (32 km/h), the driver of the second train saw the taillights of the first train stationary ahead of it and braked to a controlled stop. The second train stopped about 75 metres from the rear of the first train, with both trains now in the same signal section. There were no significant consequences and both trains were able to continue their journeys after obtaining permission from the signaller.

The signal had displayed incorrect aspects to the drivers of the two trains as the wiring controlling its red and yellow aspects was crossed on two terminals in a nearby equipment cabinet, which was where a cable running to the signal was connected to the rest of the signalling system. This cable had been disconnected and reconnected during track engineering work the previous night and this work had introduced the wiring cross, which was not identified when the signal was tested afterwards. The testing was affected by a combination of time pressure, tester workload and possibly by unfamiliarity with the configuration of the signalling equipment. An underlying factor was that Network Rail had taken steps to assure the signal maintenance testing carried out by its own staff but had not yet included testers employed by contractors. A second underlying factor was that no one was carrying out any signalling related assurance activities when this type of track engineering work was taking place.

RAIB noted that the potential for a collision between the two trains was reduced by the actions taken by the signallers at East Midlands Control Centre and the second train driver. RAIB observed four issues with the testing work covering test records, tester licensing, deficiencies with drawings, and the omission of tests the previous night. RAIB also observed that while initial welfare checks were carried out for both drivers, follow-up post-incident welfare checks were only carried out for one of the drivers involved.

As a result of the investigation, RAIB has made five recommendations. The first two are addressed to Bridgeway Consulting and Randstad Solutions and seek to enhance the non-technical skills among the staff working for them, with specific emphasis on effective communication, safe decision-making, and safe behaviours when placed under time pressure. The third is for Network Rail to better manage the workload on lead testers. The fourth is for Network Rail to implement measures to better assure itself that signal maintenance testing by contractors on this type of track engineering work is to the required standard. The fifth, also addressed to Network Rail, is to provide testers with a means of recording the test steps when a signal's aspects are tested.

RAIB has also identified six learning points. The first highlights the importance of signal maintenance testers following the required testing process and the second is about staff working in management or supervisory roles not placing testers under undue time pressure to complete their work, even when they are under time pressure themselves due to work overrunning. The third and fourth highlight the importance of communication between signallers and train drivers when an incident occurs. The fifth is a reminder about testing signalling equipment, particularly track circuits, after engineering work has taken place on the track, and the sixth is a reminder to carry out follow-up post-incident checks with all drivers involved in a signalling irregularity.

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 incident

Summary of the incident

3 At about 07:02 hrs on 26 October 2022, an empty coaching stock train was travelling on the Down Main line between Derby and Chesterfield after passing a series of signals showing green (proceed) aspects, when it unexpectedly encountered a signal in the vicinity of South Wingfield, Derbyshire (figure 1), displaying a red (stop) aspect. As the train was travelling at 100 mph (161 km/h), it was unable to stop before the signal and passed it by about 760 metres. The driver called the signaller on the Chesterfield workstation at East Midlands Control Centre (EMCC) straight away to report the incident.

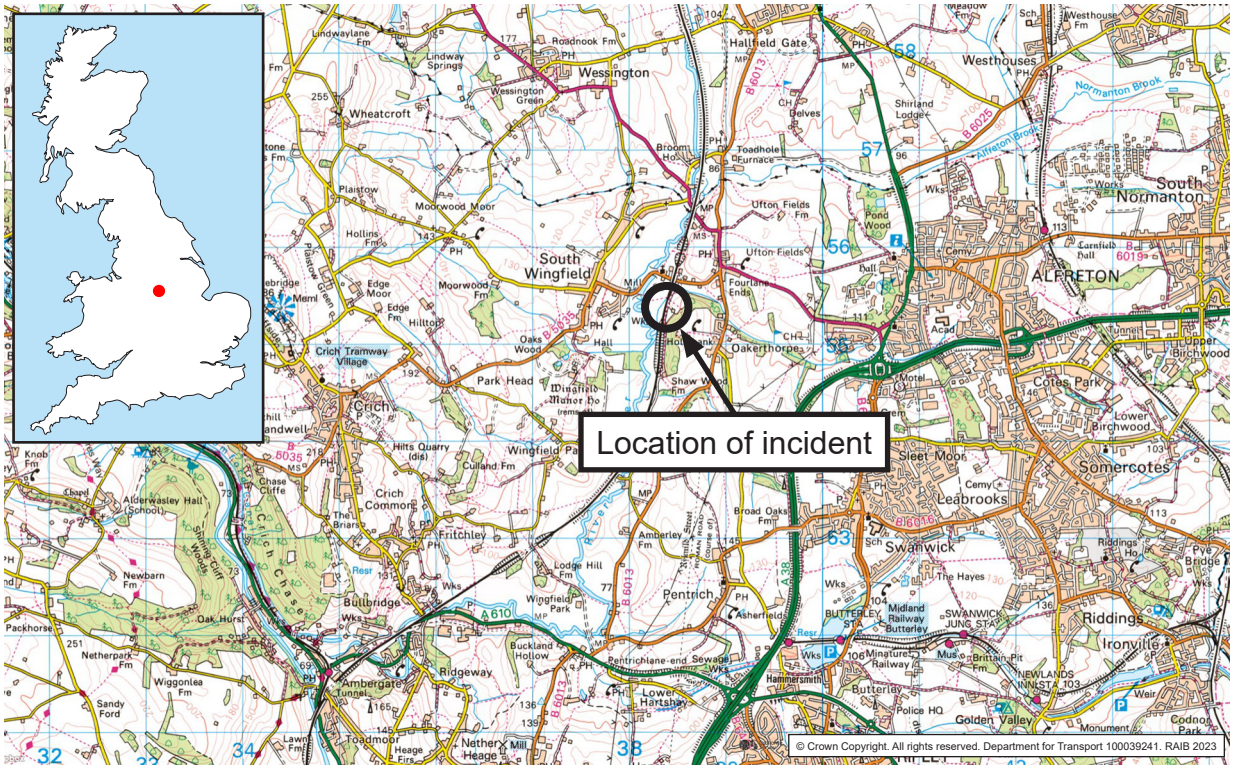

Figure 1: Extract from Ordnance Survey map showing the location of the incident at South Wingfield.

4 Shortly afterwards at 07:07 hrs, the signaller on the Derby workstation at EMCC contacted the driver of the following train on the Down Main line, which was a passenger train that had just departed from Belper station. The Derby workstation signaller advised the driver of this train to proceed at a reduced speed as the train ahead had passed a red signal in the Wingfield area.

5 At about 07:19 hrs, the passenger train approached the signal that the previous train had passed at red. The signal was now displaying a yellow (caution) aspect. After passing this signal at a speed of about 20 mph (32 km/h), the passenger train driver saw the taillights of the first train, which was stationary on the line ahead (figure 2). The driver brought the passenger train to a controlled stop about 75 metres from the first train, with both trains now in the same signal section (figure 3). There were no significant consequences and both trains were able to continue their journeys.

Figure 2: Image from the forward-facing closed-circuit television (CCTV) footage recorded by the second train showing the first train ahead of it (courtesy of East Midlands Railway).

6 There was disruption to train services between Derby and Chesterfield throughout the rest of the morning as the wrong side failure[1] of the signal, which had allowed the two trains to be in the same signal section, was investigated by a local Network Rail signalling maintenance team. The team found a problem in the wiring associated with the signal, some of which had been disconnected and reconnected the previous night as part of planned track renewals work. The team corrected the problem, tested the affected equipment and, having confirmed that it was now functioning correctly, placed it back into service.

[1] A failure of railway signalling equipment that results in an unsafe condition.

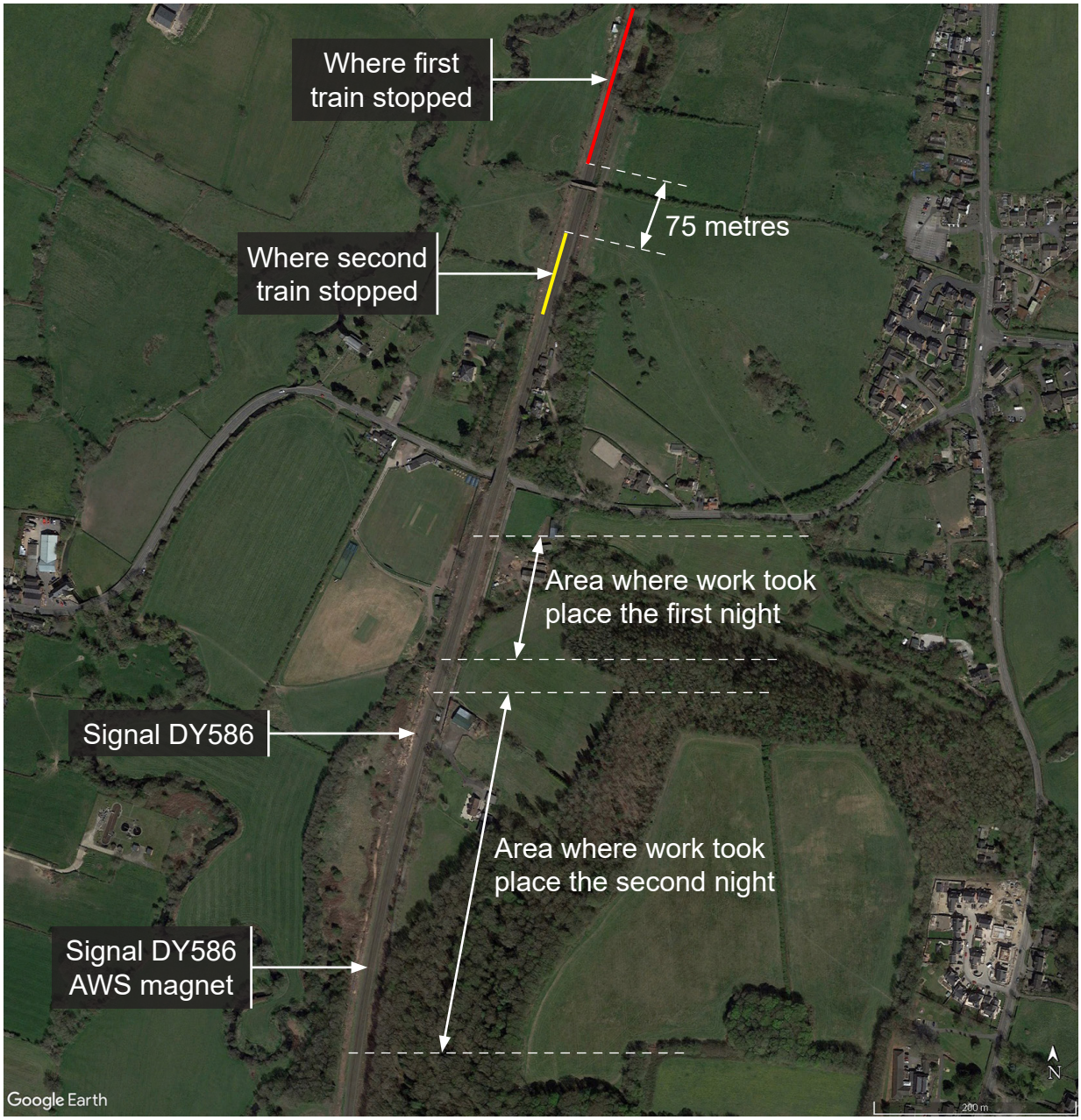

Figure 3: Overview of the location where the two trains stopped.

Context

Location

7 The incident happened in the South Wingfield area, on the railway line between Derby and Chesterfield, which is part of Network Rail's East Midlands route[2] within its Eastern region.[3] This is often referred to as the Wingfield area by railway staff due to the nearby Wingfield Tunnel and former Wingfield station which closed in 1967. The signal which allowed the two trains to be in the same section was signal DY586. It is located at mileage 141 miles 967 yards (from a reference point at London St Pancras). At this location the railway comprises two tracks, designated the Up Main line towards Derby, and the Down Main line towards Chesterfield (figure 4). Both lines have a permissible speed of 110 mph (177 km/h) for high speed trains[4] and 100 mph (161 km/h) for all other trains.

8 The approach to signal DY586, when travelling in the down direction, starts as a long left-hand curve and then changes into a short right-hand curve, with the signal located at the start of a long straight which lies beyond this shorter curve. The track curvature means the signal is first visible to train drivers from about 400 metres away.

Organisations involved

9 Network Rail is the owner and maintainer of the infrastructure at Wingfield. It is the employer of the signallers at EMCC. Network Rail was the lead organisation for the overnight track renewals work. This work was part of a programme of work delivered by the high output track renewals (HOTR) project which carries out work, often overnight, using specialised trains[5] to replace either the ballast, rails or sleepers. It employs the staff who planned this work at Wingfield and the staff who had overall responsibility for delivering it.

10 East Midlands Railway was the operator of both trains and is the employer of both train drivers. The driver of the first train was based at its Derby train crew depot, while the driver of the second train was based at its Nottingham depot.

11 Bridgeway Consulting Limited (referred to as Bridgeway) is the employer of four of the staff (in a group of six) working on the signalling equipment at Wingfield to facilitate the track renewals work. Randstad Solutions Limited (referred to as Randstad) is the employer of the other two staff in the signalling group.

12 Network Rail, East Midlands Railway, Bridgeway and Randstad all freely co-operated with the investigation.

---

[2] Part of Network Rail's organisation which manages, operates and maintains the railway from London St Pancras to Chesterfield and a number of routes that branch off main lines to Northamptonshire, Rutland, Leicestershire, Derbyshire, Nottinghamshire and Lincolnshire (but does not include the East Coast Main Line).

[3] Part of Network Rail's organisation which supports four of its routes: Anglia, East Coast, East Midlands and North & East.

[4] Details of the classes of train that can run at the higher speed are defined in the London North Eastern Sectional Appendix, which is an operating publication produced by Network Rail that includes details of running lines, permissible speeds, and local instructions.

[5] The specialised trains used by the HOTR project either replace the ballast (this train is called the ballast cleaning system) or renew rails and sleepers (this train is called the track renewal system). When the track is handed back after work by an HOTR train is finished, it is settled enough for train services to run at normal speeds straight away. The ballast cleaning system train was in operation at Wingfield the night before this incident.

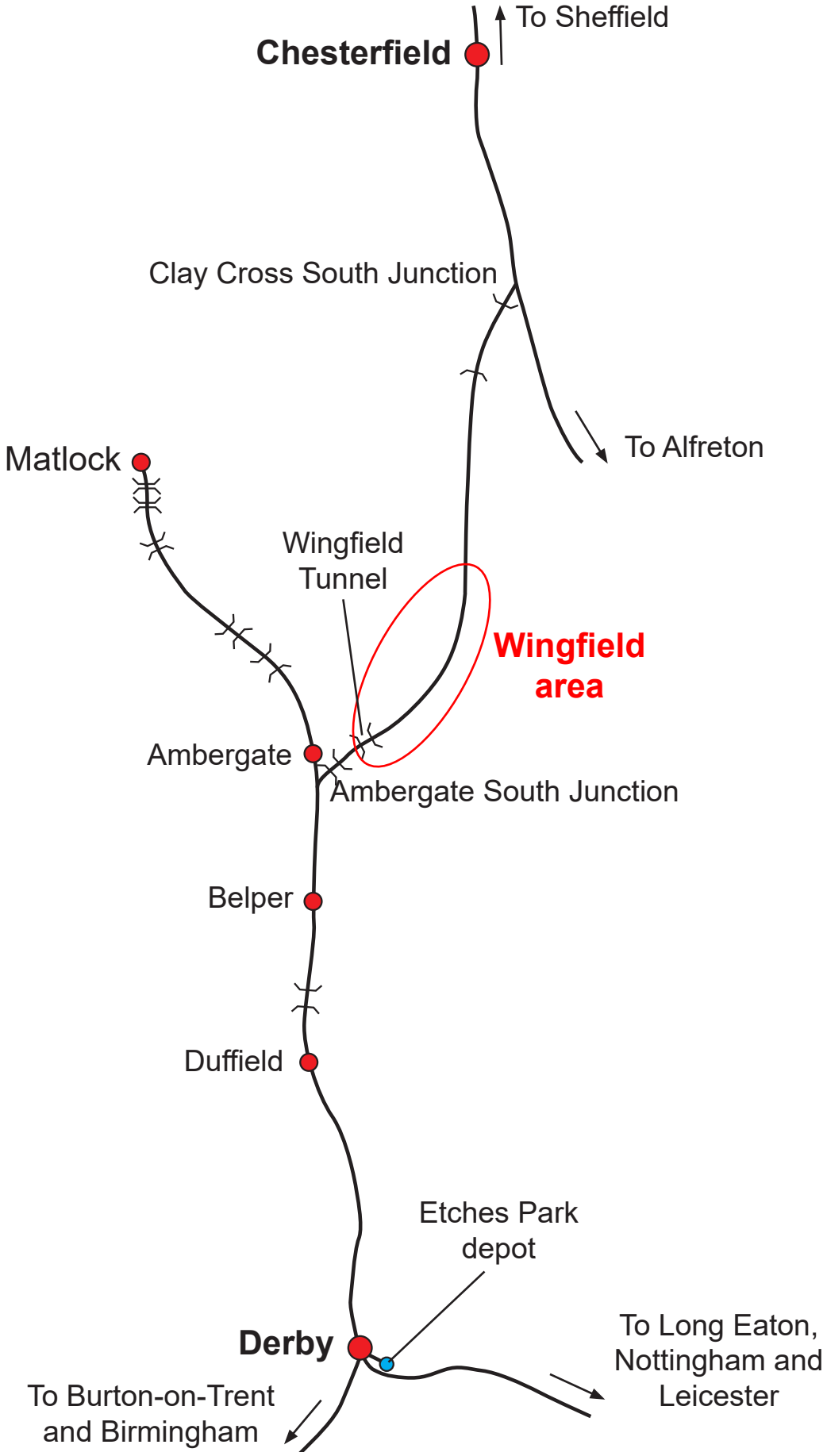

Figure 4: Layout of the railway in the Wingfield area.

Trains involved

13 The first train, which passed signal DY586 showing a red aspect, was the 06:45 hrs empty coaching stock service from Derby Etches Park depot to Sheffield. Its reporting number was 5C23 and it comprised a seven-car, class 222 diesel electric multiple unit, number 222002.

14 The second train, which passed signal DY586 showing a yellow aspect, was the 06:55 hrs passenger service from Derby to Sheffield. Its reporting number was 1F02 and it comprised a pair of two-car, class 158 diesel multiple units, numbers 158854 and 158857.

Signalling equipment involved

15 Signal DY586 is a three aspect, colour light signal (figure 5), meaning it can display a red, yellow or green aspect. It has a light emitting diode (LED) signal head so it can display all three colours through a common single aperture.

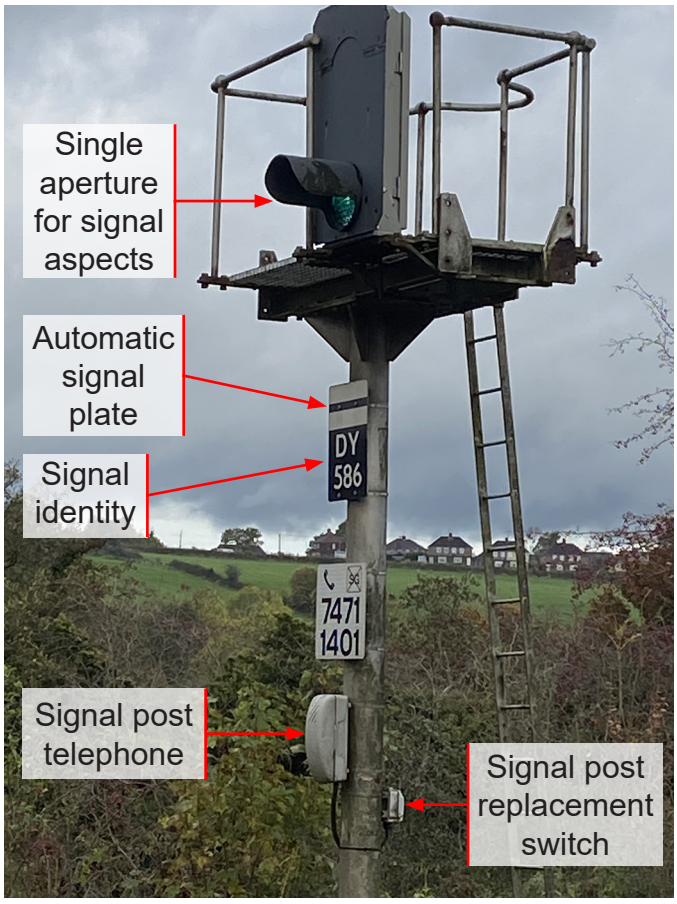

Figure 5: Signal DY586.

16 Signal DY586 is located next to the Down Main line. The cabling for the signal runs under both tracks to an equipment cabinet, known as a location case. It is numbered 141/2 and is on the opposite side of the railway to the signal (figure 6). The location case contains terminal bars that the external cables running to and from trackside signalling equipment and other location cases further along the railway are connected to. Also connected to the terminal bars is the wiring inside the case, going to equipment such as relays, transformers, power supply busbars and fuses.

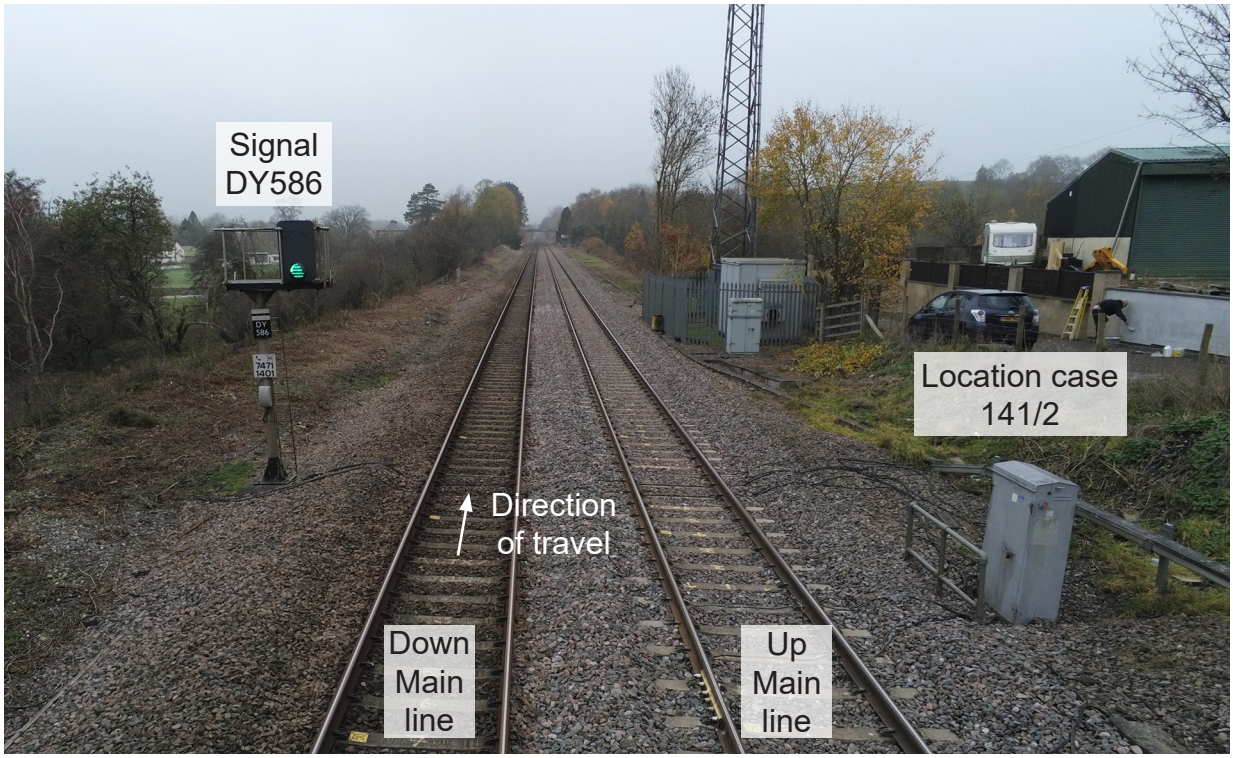

Figure 6: Location case 141/2 in relation to signal DY586.

17 Signal DY586 is an automatic signal, so it changes its aspect with the passage of a train without intervention by a signaller. The colour of the aspect displayed is based on the occupation and clearance of defined track sections, and the aspects shown by the signals beyond it. It has a rectangular plate fitted to it (figure 5) to identify it as an automatic signal. The signal is fitted with a signal post replacement switch (SPRS) that prevents the signal from showing any aspect other than red when operated with a special key (figure 5).

18 The signal is fitted with automatic warning system (AWS) equipment. This is a safety system that uses permanent magnets and electromagnets placed between the rails and which alerts train drivers about the aspect displayed by a signal ahead. The magnets for signal DY586 are located 233 metres on the approach to the signal. When a train passes over the magnets, and a red or single yellow aspect[6] is displayed by the signal, a horn sounds in the driving cab. The driver must acknowledge the horn sound by pressing a button in the cab, or the train's brakes will automatically apply. A black, yellow and white indication is then shown to the driver. When a green aspect is displayed by a signal, a bell sounds in the cab, and a black indication is shown to the driver.

19 The signal is not fitted with the train protection and warning system (known as TPWS). The purpose of TPWS is to automatically apply the brakes on a train that has passed a signal displaying a red aspect without authority, or approached a signal displaying a red aspect too fast. TPWS is not designed to prevent the train from passing the red signal, but to mitigate against the consequences of it doing so, by preventing the train from reaching a conflict point ahead of the signal. It is typically fitted at signals that protect conflicting movements, such as at a junction where crossing or converging movements can take place. Signal DY586 has no conflict points ahead of it and hence is not fitted with TPWS.

[6] For a double yellow aspect too when a signal can display this aspect.

20 Signal DY586 is the last signal before the boundary of two interlockings[7] and two control areas. It is the last signal in the down direction within the Ambergate interlocking area, and it falls within the control area of the Derby workstation signaller. The next signal in the down direction, signal DC4833, is in the adjacent Clay Cross interlocking and the control area of the Chesterfield workstation signaller. Signal DY586 is shown on both signaller workstations.

21 Signalling design practices in 1969, around the time the Ambergate interlocking was commissioned, did not require signallers to have any controls to change the aspect displayed by automatic signals. Therefore, the Derby workstation signaller was not able to command signal DY586 to display a red aspect. These practices also limited what information the signalling system needed to provide to signallers, so information about what aspect the signal is displaying is not passed back to either the Derby or Chesterfield workstations. On the workstations, the signallers can see a symbol providing the location of signal DY586 but, while other signals might indicate the aspect being displayed, this is greyed out for signal DY586 (figure 7). It is the same on the Chesterfield workstation.

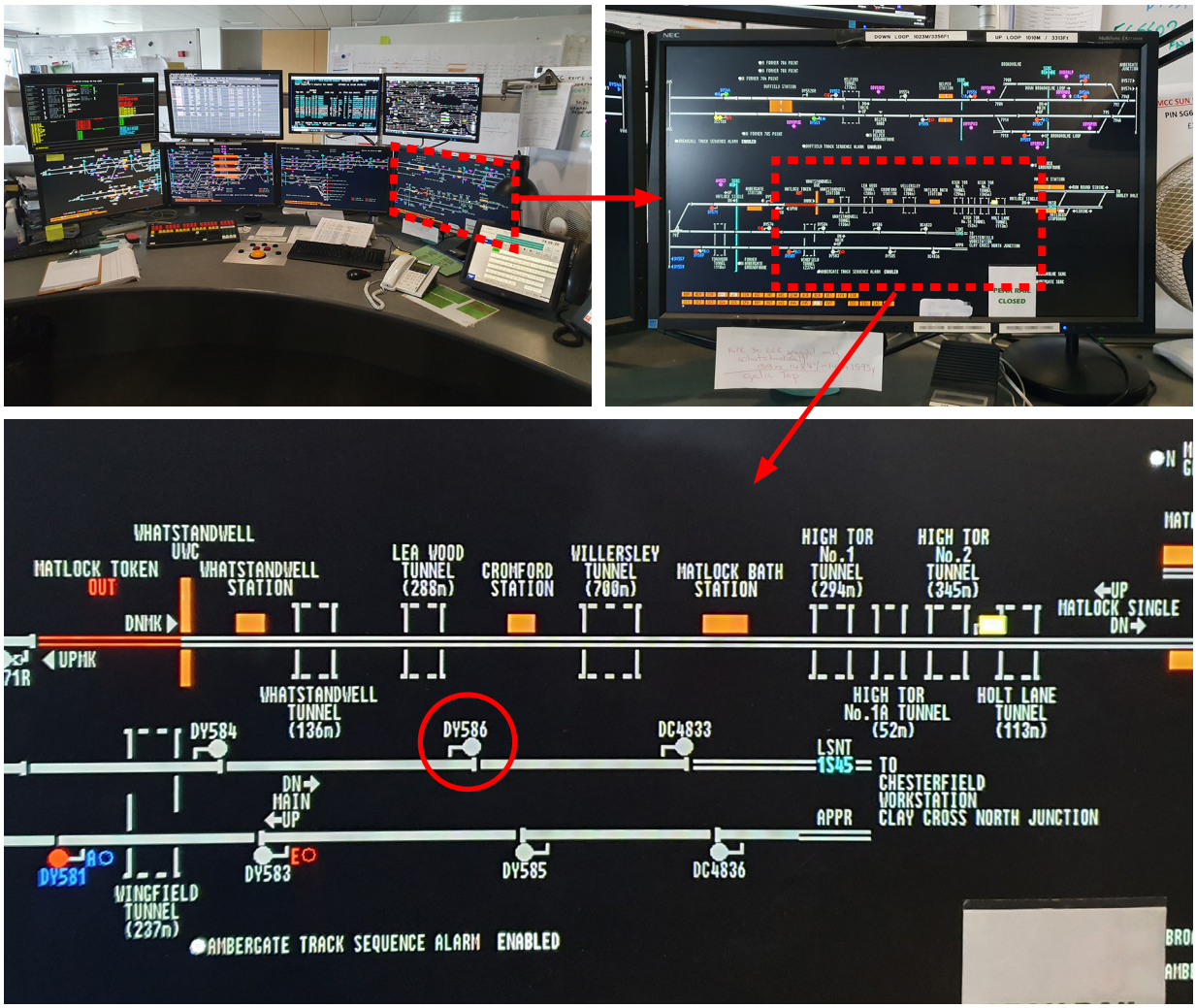

Figure 7: The Derby workstation (top left image), a workstation display screen showing the Wingfield area (top right image), and a closeup of signal DY586 greyed out on the workstation display.

[7] A general term applied to equipment that controls the setting and releasing of routes, signals, points and other apparatus to prevent an unsafe condition of the signalling system arising during the passage of trains.

Staff involved

22 The group of six staff that worked on the signalling equipment at Wingfield during the night before the incident comprised three signal maintenance testers and three technicians.

23 The role of a signal maintenance tester is to test signalling equipment in accordance with the processes and test plans that are documented in Network Rail's signal maintenance testing handbook[8] (SMTH). The processes in SMTH are used when the work being carried out on the signalling equipment does not change its configuration or functionality. Design documents and drawings that describe the engineering details of the work are not provided, and instead the existing infrastructure records are used as the reference documents. Typically, local Network Rail maintenance teams follow the SMTH process for the replacement or repair of defective or life-expired equipment. This can involve replacing the original failed item with a newer version as long as it is functionally the same. The SMTH process can also be used for like-for-like renewals of equipment, or when signalling equipment needs to be disconnected and moved aside for other work to take place, before being reconnected and tested to ensure correct operation (as was the case in this instance).

24 All three signal maintenance testers were familiar with working on the HOTR project. Their role at the start of the work was to identify any differences between the on-site drawings and the affected signalling equipment before it was disconnected. After the HOTR work was completed, their role was to test the functionality of the affected signalling equipment after reconnection. The role of the three technicians was to disconnect and reconnect the cables, under instruction from the testers.

25 The signal maintenance tester who was carrying out the role of lead tester for this work (referred to as SMT1) is employed by Bridgeway. SMT1 had seven years' experience working on signalling equipment and had been working full-time on the HOTR project in the months before the incident.

26 The second signal maintenance tester (referred to as SMT2) is employed by Bridgeway and had seven years' experience working on signalling equipment. SMT2's working time was split between carrying out maintenance work on signalling equipment at private sidings and working on the HOTR project.

27 The third signal maintenance tester (referred to as SMT3) is employed by Randstad. SMT3 had 21 years' experience working on signalling equipment, including 16 years carrying out signal maintenance testing and had been working full time on the HOTR project in the months before the incident.

28 The three technicians, two from Bridgeway and one from Randstad, worked under the instruction of the signal maintenance testers. Their roles were primarily limited to installation activities which involved disconnecting and reconnecting the affected cables. None of the technicians disconnected or reconnected the signal's cable and none were involved in testing the signal.

[8] The version of the SMTH current at the time of the incident was Network Rail company standard NR/L3/SIG/11231, issue 17, dated 4 June 2022.

29 A supervisor, who was carrying out the works manager role, had overall responsibility for delivering the site phase of the HOTR project work at Wingfield. The works manager is employed by Network Rail and had ten years' experience working in the rail industry. They had been working on the HOTR project since 2019 and was usually based at the HOTR project's Newcastle depot. At the time of this incident, they had been seconded to the Central depot (based at both Crewe and Doncaster) that was delivering the work at Wingfield.

External circumstances

30 It was dark when the signalling group carried out its work. The signalling group did not use any site lighting for its work at the signal or location case and there were no external light sources from nearby buildings and roads to illuminate the area.

31 Witness accounts reported that it was raining at times during the night and four local weather stations, located between 2.2 miles (3.5 km) and 3.6 miles (5.8 km) away, recorded data showing rain showers between 00:00 hrs and about 04:00 hrs on 26 October. The weather stations reported that, while the signalling group was working at Wingfield, the air temperature in the area rose from about 11°C (at 23:00 hrs on 25 October) to about 14°C (at 06:00 hrs on 26 October).

The sequence of events

Events preceding the incident

Signal DY586 maintenance activities

32 According to maintenance records, the last time any significant maintenance work took place on the signal was in August 2015 when its filament lamp signal head was replaced with an LED version. The work to install and test the new signal head was carried out by staff from the local signalling maintenance team based in Derby. The team tested the signal with its new head using the SMTH process as it was functionally the same as the old one (paragraph 23). This change also required some of the drawings to be updated. The local signalling maintenance team made some of the updates and placed copies of the revised drawings on site in location case 141/2. However, not all of the required updates were made leaving some deficiencies (see paragraph 183).

33 After August 2015, the maintenance records for signal DY586 show that routine maintenance activities took place at the frequencies required by the relevant signalling maintenance specifications.[9] There were no failures or out-of-course maintenance activities recorded for the signal between August 2015 and the time of the incident.

34 The last routine maintenance on signal DY586 before the incident was on 16 August 2022. No issues were noted by the local signalling maintenance team that carried out the required maintenance checks. These checks included testing the operation of the SPRS (paragraph 17).

HOTR project activities

35 Network Rail staff from the local track maintenance team had identified that the track quality on the Up Main line in the Wingfield area was deteriorating. It requested, through the route engineer (track) team,[10] that work was carried out to refresh or replace the ballast. Over time, the sharp edges of the ballast will start to round off so it will not lock together to support the track as it should. This also creates dust that contaminates the ballast and affects the drainage of water through it. Carrying out HOTR work replaces this ballast with new and/or recycled stone that locks and aids drainage.

[9] These are defined in Network Rail company standard NR/L3/SIG/10663, 'Signal Maintenance Specifications'. Issue 15, dated June 2022, was current at the time of the incident.

[10] In Network Rail's Eastern region, this is the team with the roles and responsibilities associated with the custodianship of the track infrastructure on a Network Rail route. This team was previously known as the route asset management (track) team.

36 The route engineer (track) team accepted the request and Wingfield was added to the work bank. The team, working alongside the HOTR project, then decided what HOTR jobs within the work bank would be delivered in control period 6 (from April 2019 to March 2024).[11] Further work was carried out by both the team and HOTR project to analyse and filter the jobs to be delivered in control period 6. As well as prioritising the order in which jobs needed to be done, this activity looked at when it would be best to deliver jobs based on when possessions[12] were planned to take place, and when the required HOTR equipment would be available to do the work. From these activities, the route engineer (track) team tasked the HOTR project with delivering the work at Wingfield in the 2022 to 2023 financial year (which runs from April 2022 to March 2023). The HOTR project next created a plan for that year's work, which is referred to as a 'campaign'. There can be up to 25 separate sites within a campaign. The work at Wingfield was planned for week 30, running from the evening of Monday 24 October to the morning of Friday 28 October.

37 In March 2021, about 84 weeks before the work at Wingfield was due to be delivered, the HOTR project team started work to define and plan what needed to be done. One of the first activities to be carried out took place in April 2021, when the HOTR project team undertook a walkout at Wingfield, in the vicinity of signal DY586, to scope the ballast cleaning to be done on the Up Main line. The walkout included a member of the HOTR project Central depot signalling team. Their role was to identify what signalling assets would be affected by the work.

38 The output from the walkout helped the project team develop what is known as a plain line specification. This specification identified the areas where the ballast was to be renewed. It also identified where work could not be carried out due to restrictions such as structures along the track. The specification also listed other requirements that the project team needed to be aware of, such as the affected signalling assets. Version one of the specification was issued in February 2022.

39 On 9 May 2022, the HOTR project team carried out a dilapidation survey at Wingfield. This survey included an assessment of the affected signalling equipment and recorded its condition. From this information, the HOTR project signalling team determined what level of signalling resource was needed to disconnect, reconnect and test the affected signalling equipment. On 16 September, it sent a request to Bridgeway for two signal maintenance testers and two technicians. It also sent a request to Randstad to supply a signal maintenance tester and a technician.

40 On 4 October 2022, Bridgeway provided the names of the four staff it would be supplying for this work. Randstad provided the names of its two staff on 13 October. Once the resources for the signalling work were confirmed, the HOTR project Central depot signalling team finalised the work pack which detailed the signalling work to be carried out at Wingfield. On 18 October, the team sent the work pack to Bridgeway and Randstad so it could be passed to the staff nominated for this work.

---

[11] A control period is a five-year period set by the economic and safety regulator of the mainline railway in Great Britain, the Office of Rail and Road (ORR), for the purposes of monitoring Network Rail's expenditure.

[12] Periods of time during which one or more tracks are blocked to normal service trains to permit work to be safely carried out on or near the affected railway lines.

41 At 21:40 hrs on 24 October, the first of four nights of HOTR work started at Wingfield. The HOTR train cleaned and replaced ballast on the Up Main line from 141 miles 1200 yards to 141 miles 1056 yards, completing the 144 yards (132 metres) it was planned to deliver. The possession was handed back on time at 05:40 hrs on 25 October. No signalling equipment was disconnected and reconnected during that night's work, but the six members of the signalling group were still all on shift at Wingfield while this work took place just in case they were needed.

Overnight work on signal DY586

42 At 20:45 hrs on 25 October, SMT1 arrived at Alfreton station. This was where everyone working at Wingfield that night was required to sign in before heading to the site. Soon after arriving, SMT1 was called into a briefing with the engineering supervisor.[13] Receiving this briefing meant that SMT1 could now sign in to the engineering supervisor's work site as a controller of site safety[14] (COSS).

43 The other members of the signalling group arrived to sign in at about 21:00 hrs. At 22:00 hrs, the group travelled to the access point at Wingfield. By 22:15 hrs, the possession was taken, and the engineering supervisor had set up the work site where the work was to take place. SMT1, as the COSS for the signalling group, signed in to the work site with the engineering supervisor. The group then went onto the railway at about 22:25 hrs. At 22:27 hrs, SMT1 called the Derby signaller and signed the affected signalling equipment out of use. The signalling group then began its work to disconnect and move the affected cables out of the way, including the cable for signal DY586. These cables are shown in figure 8.

44 By 23:20 hrs, the signalling group had finished disconnecting the cables and had moved them clear of the tracks. A short time later, the HOTR train moved into position on the Up Main line, and once the train's preparation activities were complete, it began its ballast cleaning work at 23:59 hrs.

45 At 01:50 hrs on 26 October, the HOTR train stopped ballast cleaning. It had worked from 141 miles 1032 yards to 141 miles 649 yards, a distance of 383 yards (350 metres). The train was then made ready for its movement from the site, and it moved clear of where the work had taken place at 02:45 hrs.

46 At 02:56 hrs, two on-track machines began their first pass. The first machine lifted and slued the track into the correct position and consolidated the new ballast under the track, while the second machine distributed the ballast along the track and shaped its profile relative to the sleepers. The first pass was completed at 04:00 hrs. After travelling back to the starting point, the on-track machines began a second pass at 04:07 hrs. This pass raised the track quality to a level that allowed the Up Main line to be handed back with an 80 mph (129 km/h) temporary speed restriction in place.

[13] The person nominated to manage the safe execution of works within a work site that is set up within a possession. This includes arranging the placement of the protection for the work site, authorising the movements of trains and on-track machines in and out of the work site, and managing access to the work site by each COSS that wants to bring their group into the work site.

[14] Defined by Network Rail as a person who is certified as competent to enable activities to be carried out by a group of persons on Network Rail infrastructure in accordance with the requirements of the Rule Book.

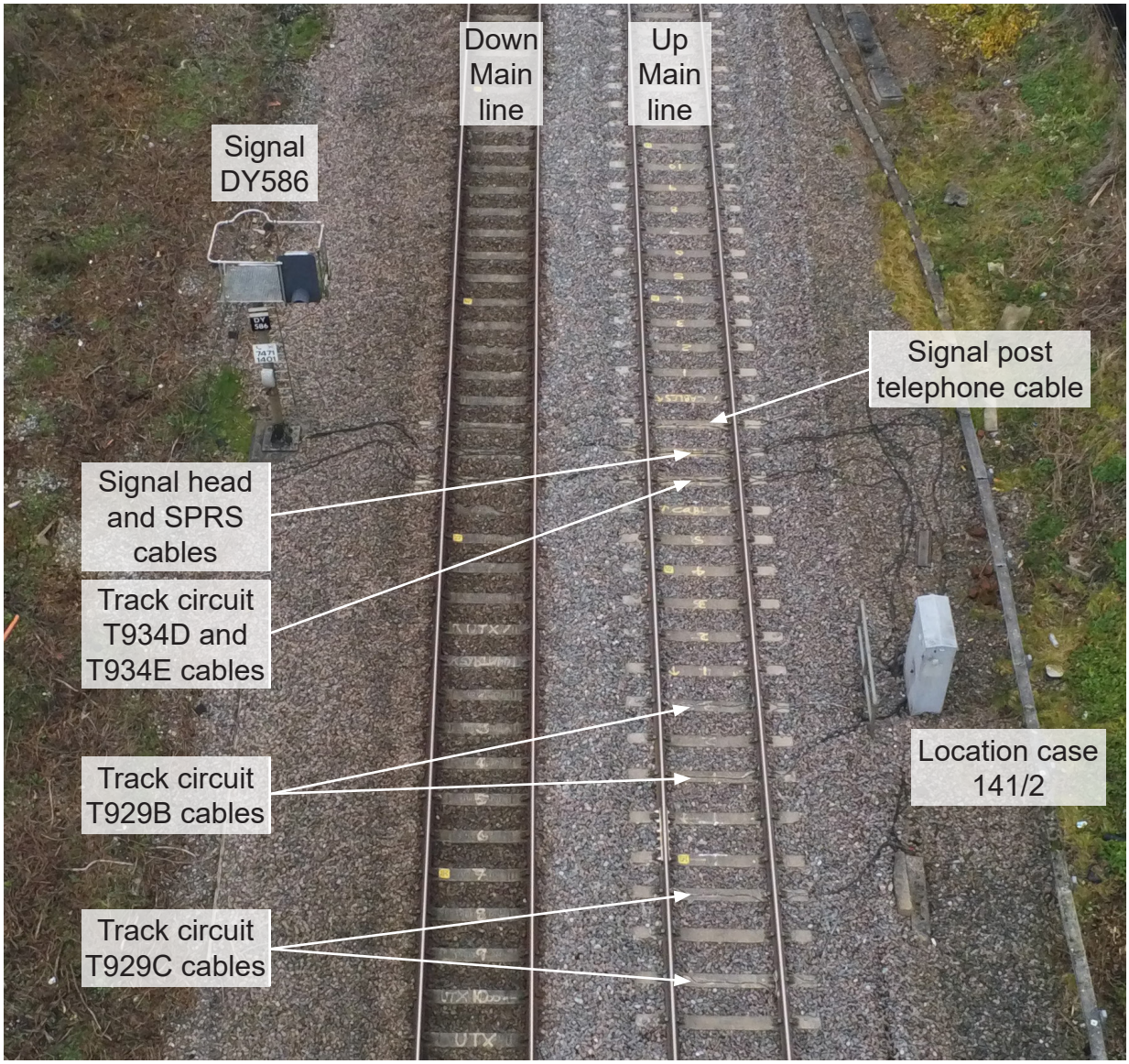

Figure 8: The cables disconnected by the signalling group.

47 At about 04:15 hrs, once the on-track machines were clear of the area in the vicinity of signal DY586, the signalling group started reconnecting the signalling cables. The on-track machines completed the second pass at 04:40 hrs and then headed north on the Up Main line, moving clear of where the signalling related work was taking place by 05:04 hrs.

48 Between 05:09 and 05:23 hrs, SMT3 tested the four track circuits that had been disconnected and reconnected. From 05:25 to 05:40 hrs, SMT1 and SMT3 made telephone calls to both the Derby and Chesterfield signallers, plus the signalling technician based at EMCC, about changing the aspect of signal DY586 to test it, but they were unable to command the signal to display a yellow aspect.

49 At 05:41 hrs, SMT1 called the Chesterfield signaller and asked them to change the aspects on the signals they controlled so that signal DY586 would display a green aspect. The signaller responded that they were busy arranging for the on-track machines to exit the north end of the possession and told SMT1 to call back in ten minutes.

50 At 05:51 hrs, SMT1 called the Chesterfield signaller back. The signaller changed the aspect on signal DC4833 (paragraph 20) from red to green, which in turn allowed signal DY586 to display a green aspect. At 05:54 hrs, SMT1 called the Chesterfield signaller to say that their testing was complete. Shortly afterwards, the signalling group left the railway to go back to their vehicles at the access point. At 05:56 hrs, SMT1 called the Derby signaller and handed all the signalling equipment back into service. At 05:57 hrs, the engineering supervisor gave up the work site. The possession was handed back at 06:05 hrs for trains to start running on both lines.

51 Between 06:40 and 07:00 hrs, three trains passed through the Wingfield area on the Down Main line without incident. These were a passenger train going from Kettering to Sheffield, a track recording train from Derby to Barnetby and a passenger train from Birmingham to Edinburgh. When all three trains passed signal DY586, it was correctly displaying a green aspect.

Events during the incident

52 At 07:01:50 hrs, train 5C23, the fourth train along the Down Main line that morning, passed the preceding signal on the approach to signal DY586, signal DY584, while it was displaying a green aspect. The train was travelling at 100 mph (161 km/h) and continued at this speed. At 07:02:29 hrs, as train 5C23 approached signal DY586, the driver began braking as they could tell in advance that signal DY586 was unexpectedly displaying a red aspect because the red light from the signal was reflecting off the inside of the rails on the right-hand curve. Signal DY586 then came into the driver's view; its aspect was red.

53 At 07:02:34 hrs, while still travelling at 100 mph (161 km/h), train 5C23 passed over the AWS magnet associated with signal DY586 (paragraph 18). This sounded a horn in the cab which the driver acknowledged by pressing a pushbutton. Five seconds later, the train passed the red signal while travelling at 89 mph (143 km/h). At 07:03:25 hrs, train 5C23 stopped, with its leading end about 760 metres beyond the signal. Ten seconds later, the driver of train 5C23 called the Chesterfield signaller to report that their train had passed signal DY586 displaying a red aspect.

54 At 07:05:56 hrs, the following train, 1F02, departed from Belper station. At 07:06:39 hrs, its driver responded to a request from the Derby signaller to call them. The signaller told the driver about an incident involving the train ahead in the Wingfield area, that it had passed a red signal and that it might have had a problem stopping. The signaller advised the driver to reduce their speed and expect signal DY584 to be at red. In response, the driver of train 1F02 maintained a speed of about 40 mph (64 km/h) and further reduced the train's speed to 20 mph (32 km/h) after passing signal DY584 displaying a yellow aspect.

55 At 07:17:56 hrs, train 1F02 passed over the AWS magnet for signal DY586 while travelling at 20 mph (32/km/h). The driver could see the signal was displaying a yellow aspect. At 07:18:27 hrs, train 1F02 passed signal DY586. Almost straight away, the driver of train 1F02 saw a red light ahead but was unsure what it was. In response they put the traction controller to the off position at 07:18:30 hrs. The train then continued travelling at 20 mph (32 km/h) until the driver realised there were in fact two red lights, and these were the taillights of a train stopped ahead. At 07:19:15 hrs, the driver of train 1F02 applied the brakes to make a controlled stop. Train 1F02 stopped at 07:19:27 hrs, with its leading end about 75 metres from the rear of train 5C23.

Events following the incident

56 At 07:20 hrs, the Chesterfield signaller called the driver of train 5C23. The signaller asked the driver if they had seen a yellow signal and the driver confirmed all the signals before signal DY586 had been displaying green aspects. While this conversation was taking place, at 07:21 hrs the Derby signaller called the driver of train 1F02 just as the driver was about to call the signaller to report what had happened. The signaller asked the driver to confirm the train's location. The driver replied that their train was now stopped but was in the same signal section as the train ahead, having passed signal DY586 displaying a yellow aspect. At 07:25 hrs, the Derby signaller called the driver again and instructed that train 1F02 not be moved.

57 At 07:27 hrs, the Chesterfield signaller called the driver of train 5C23 and instructed that their train be moved forward two signal sections to signal DC4837 (passing signals DC4833 and DC4835 in between). At 07:39 hrs, the driver called the signaller back to report the train was now at signal DC4837. The Chesterfield signaller asked the driver to call East Midlands Railway control. The driver spoke to a controller and agreed to take the train forward to Sheffield and then back to Derby. At 07:49 hrs, the driver then called the Chesterfield signaller and advised that they had spoken to their control and that they were going to take the train to Sheffield. At 07:51 hrs, the Chesterfield signaller gave the driver of train 5C23 permission to proceed. At 08:03 hrs, the Chesterfield signaller called the driver of train 1F02 and gave permission for the train to proceed to Chesterfield station where the service would terminate.

58 At about 10:00 hrs, having been requested by the signalling staff at EMCC, a signalling maintenance team (paragraph 6) arrived on site at Wingfield to carry out a signalling failure investigation for signal DY586. At 10:47 hrs, the team reported it had found a wiring anomaly in location case 141/2. The team recorded and then corrected the wiring anomaly. At 12:47 hrs, normal working resumed after the team had completed its testing of signal DY586 and confirmed that it was now operating as expected.

Analysis

Identification of the immediate cause

59 Signal DY586 displayed incorrect aspects to the drivers of trains 5C23 and 1F02 because the wiring for its red and yellow aspects was crossed within location case 141/2.

60 The local signalling maintenance team who attended afterwards (paragraph 6) found the internal wire for the signal's red aspect was connected to terminal C2, the yellow aspect output, whereas it should have been connected to terminal C3, which corresponds to the red aspect output (figure 9). Conversely, the team found the internal wire for the signal's yellow aspect was connected to terminal C3 instead of terminal C2. This wiring configuration meant the signal's red and yellow aspects were transposed.

61 When train 5C23 approached signal DY586, it was travelling at 100 mph (161 km/h) (paragraphs 52 and 53) as the previous signal had displayed a green aspect and the maximum permitted speed was 110 mph (177 km/h). However, signal DY586 was unexpectedly displaying a red aspect, meaning that train 5C23 was unable to stop before passing it. Signal DY586 should, however, have been displaying a yellow aspect (as train 5C23 was catching up with the train ahead).

62 When train 1F02 approached signal DY586 at a slow speed (paragraph 55), the signal was displaying a yellow aspect. In this case, the signal should have been displaying a red aspect due to train 5C23 being stopped in the signal section ahead. This allowed train 1F02 to enter the same signal section as train 5C23.

63 The aspect of signal DY586 is controlled by the state of two relays. These are the 586D1PR relay and the 586H1PR relay. If the 586D1PR and 586H1PR relays are both energised, the signal should display a green aspect. If only the 586H1PR relay is energised, the signal should display a yellow aspect. If neither relay is energised, the signal should display a red aspect. Figure 9 shows the signalling circuit diagram for the signal's aspects.

64 With the internal wiring to links C2 and C3 transposed, when the 586D1PR and 586H1PR relays were energised, the signal correctly displayed a green aspect (figure 10). With only the 586H1PR relay energised, the signal incorrectly displayed a red aspect instead of a yellow aspect. With neither relay energised, the signal incorrectly displayed a yellow aspect instead of a red aspect.

65 The forward-facing CCTV footage from the two trains supported the accounts given by both drivers as to what aspects the signal displayed when each train approached. A data logger in location case 141/2, which recorded the state of the two relays, evidenced what aspect the signal should have displayed to each train driver. The local signalling maintenance team who attended (paragraph 58) recorded a video of the signal incorrectly displaying its red and yellow aspects as a train was passing it (figure 11). The team also recorded the incorrect wiring when it diagnosed the problem with the signal.

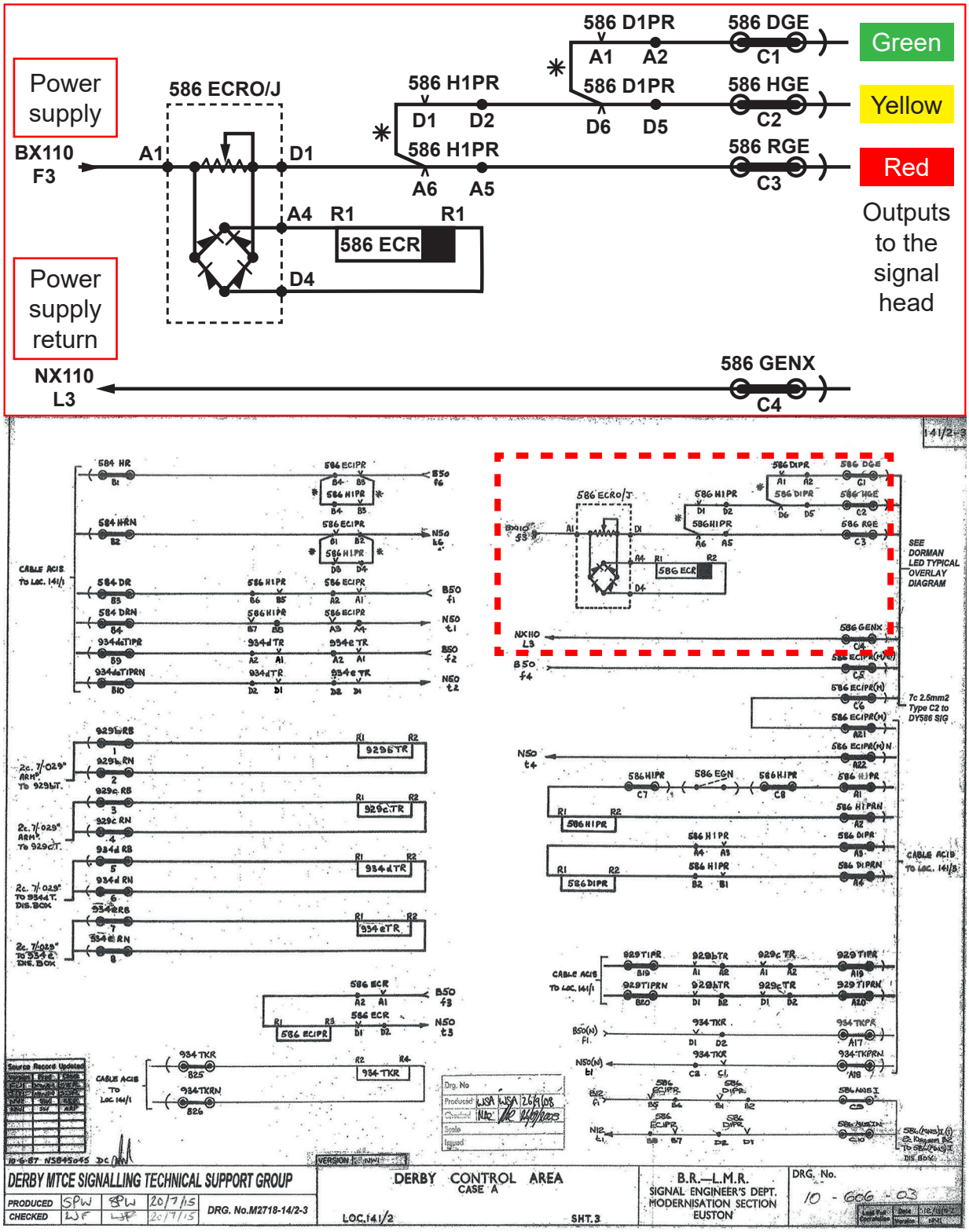

Figure 9: Signalling circuit diagram for the signal's aspects.

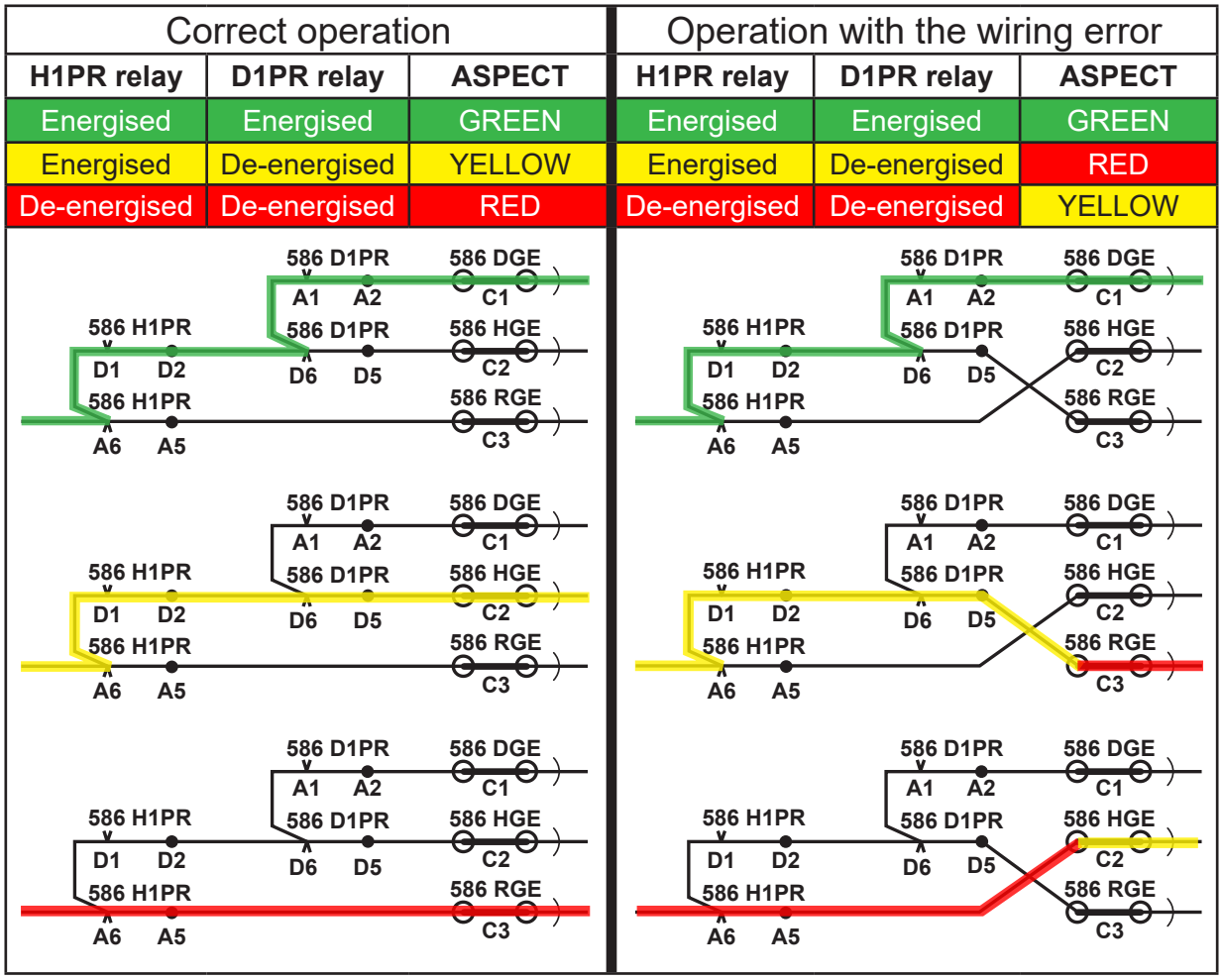

Figure 10: The operation of the relays and the aspect displayed by the signal.

Figure 11: Stills from the video footage recorded by the local signalling maintenance team showing signal DY586 displaying the incorrect aspect (courtesy of Network Rail).

Identification of causal factors

66 The incident occurred due to a combination of the following causal factors:

a. The overnight work by the HOTR project introduced a cross-over in the wiring in the location case (paragraph 67).

b. The signal maintenance testers who tested signal DY586, after the cable to the signal was reconnected, did not identify that this cross in the wiring had occurred (paragraph 79).

Each of these factors is now considered in turn.

Disconnection of signal DY586

67 The overnight work by the HOTR project introduced a cross-over in the wiring in the location case.

68 When the signalling group began disconnecting the signalling equipment, SMT2 was tasked by SMT1 with disconnecting the cable in location case 141/2 that ran from the cabinet to signal DY586. The wiring for this external cable goes to terminal bar C and is connected to the left-hand side of terminals C1 to C6 (figure 12). The corresponding wiring on the right-hand side of terminals C1 to C6 is internal wiring to equipment within the location case and did not need disconnecting.

69 The signalling circuit diagram (figure 9) depicts the internal wiring on the left and the external wiring for the signal cable on the right. This was drawn the opposite way to how the wiring was physically connected in the location case. As the signalling circuit diagram had been updated in 2015 when the signal head was changed (paragraph 32), the diagram could have been amended with 'L' and 'R' markings to show that the physical arrangement was the opposite way round to how it was drawn (figure 13). However, this amendment was not present on the diagram.

70 SMT2 was working under instruction when tasked with disconnecting the cable going to the signal. Witness evidence is not consistent as to who gave instructions to SMT2 while they were doing this. SMT1 and SMT3 were both on the other side of the location case and had the diagrams at this time. This meant that SMT2 was not able to refer to any of the diagrams when doing this work. Witness evidence also conflicts as to who advised SMT2 on which terminals the signal's external cable was connected to, although witness evidence is consistent that no one advised SMT2 as to which side of terminal bar C it was connected to.

71 Before SMT2 disconnected any wiring, they were required by SMTH test plan NR/SMTH/Part04/CA12,[15] 'Remove and Refit a Multi-core Cable', to carry out a pre-disconnection wire count. A wire count is a visual examination to check that the number of wires on each termination point corresponds to the applicable signalling circuit diagram. SMT2 did not have the drawings at the time but called out to SMT1 their observations that core one of the cable to the signal was connected to terminal C1, core two to terminal C2 and so on. SMT1 later recorded this information on a wire count sheet at the end of the night. To see which of the external cable's cores were which, SMT2 began disconnecting the wiring for the signal at the same time as they carried out the wire count.

[15] NR/SMTH/Part04/CA12, 'Remove and Refit a Multi-core Cable', issue 01, dated 4 June 2022.

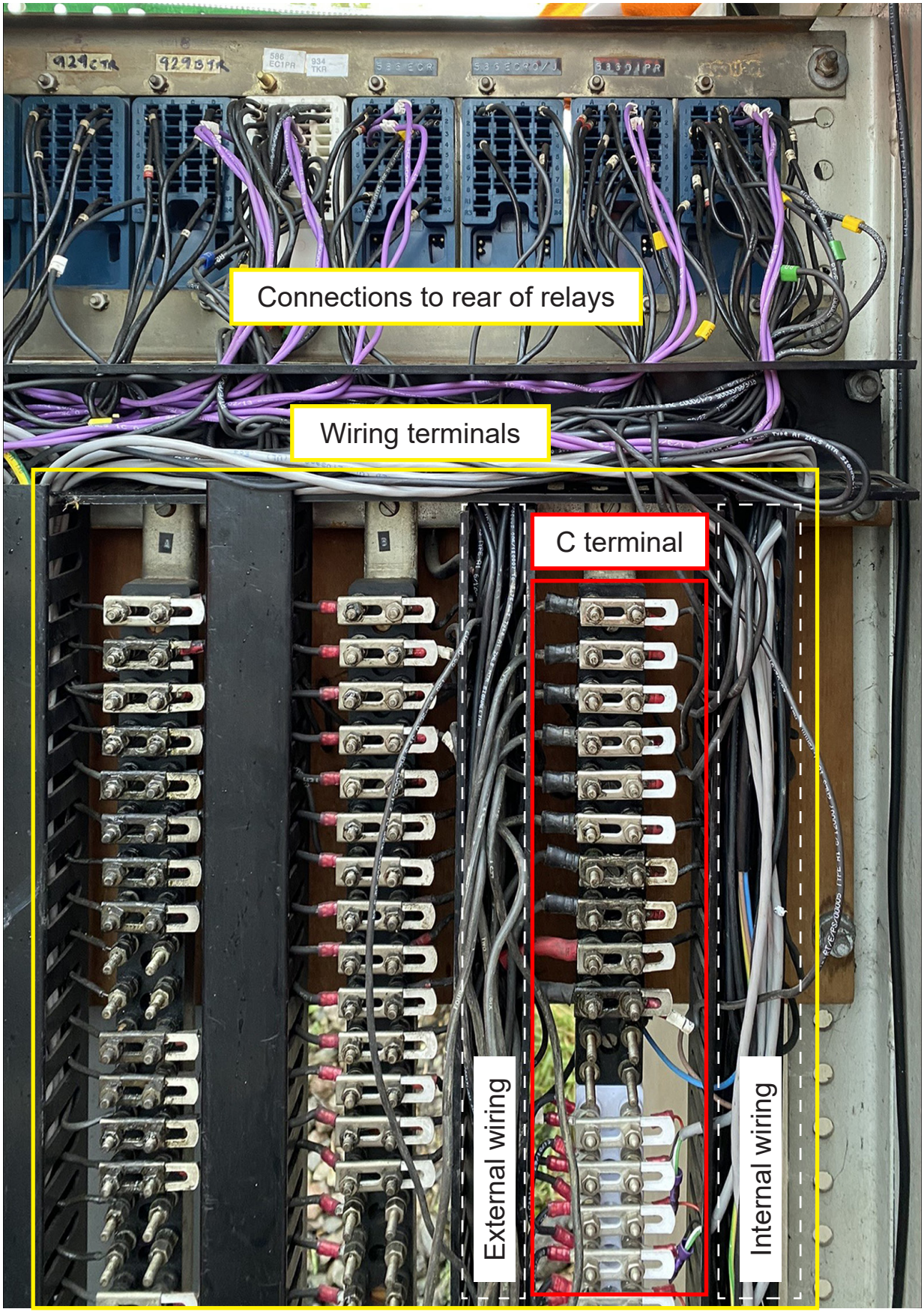

Figure 12: The wiring terminals within location case 141/2.

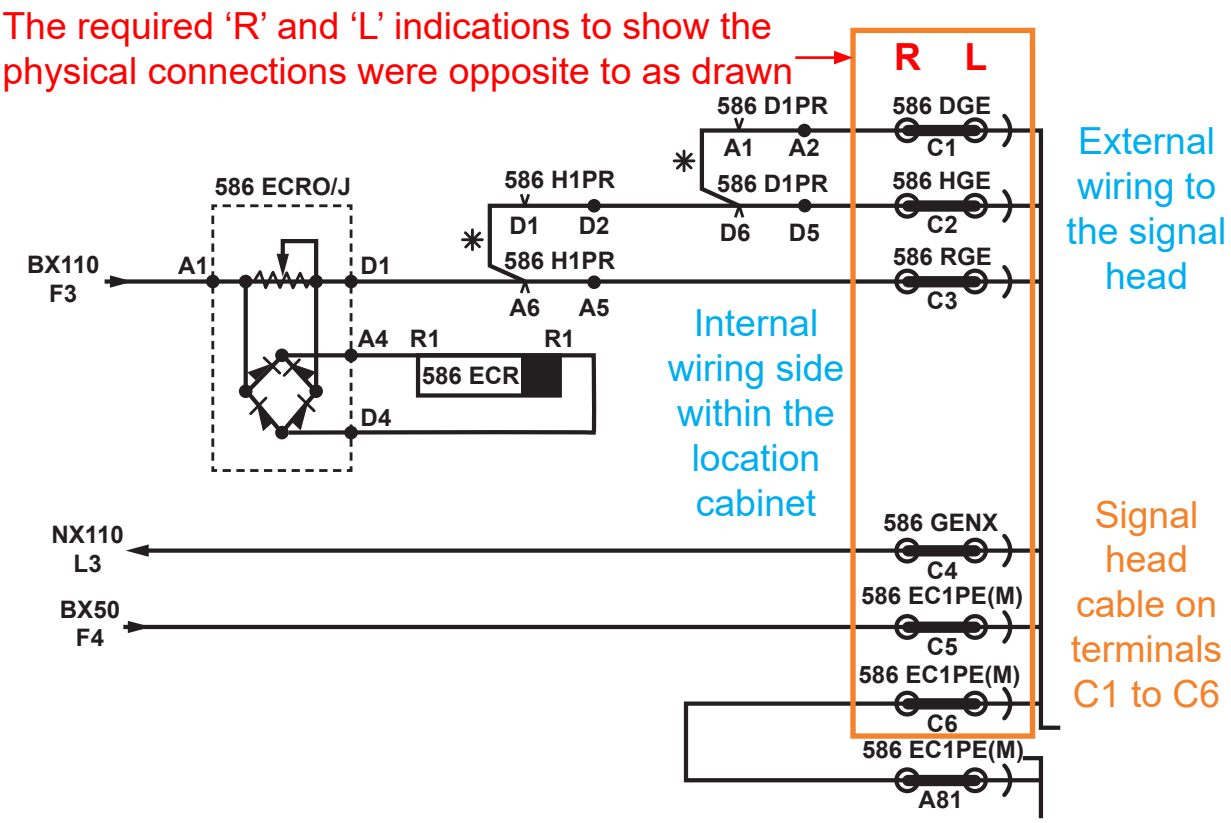

Figure 13: How the signalling circuit diagram could have been annotated.

72 Photographs and videos taken after the incident by the local signalling maintenance team, with the fault still present, showed the internal wiring on the right-hand side of terminals C2, C3, C4 and C5 had been removed from the wiring loom and cabling trunking at some point (figure 14). None of these wires ran through the slots in the side of the trunking and into the wiring loom, whereas the other internal wires on this terminal bar did. This suggests that the internal wires on the right-hand side of terminals C2, C3, C4 and C5 had been disturbed since they had been installed.

73 RAIB has concluded from witness evidence that it was probably SMT2 who mistakenly disconnected the wiring on the wrong side of the terminals. This included disconnecting the internal wiring on terminals C2 and C3 for the signal's red and yellow aspects.

74 SMT2 stated that they cannot remember disconnecting the internal wiring. No one monitored what SMT2 was doing when they disconnected the external cable because they were certified, and held an authority to work issued by their employer, which allowed them to undertake these installer activities unsupervised (see paragraphs 139 and 140). Consequently, there is no witness evidence from anyone else who was present to confirm whether it was SMT2 who had disconnected the internal wiring.

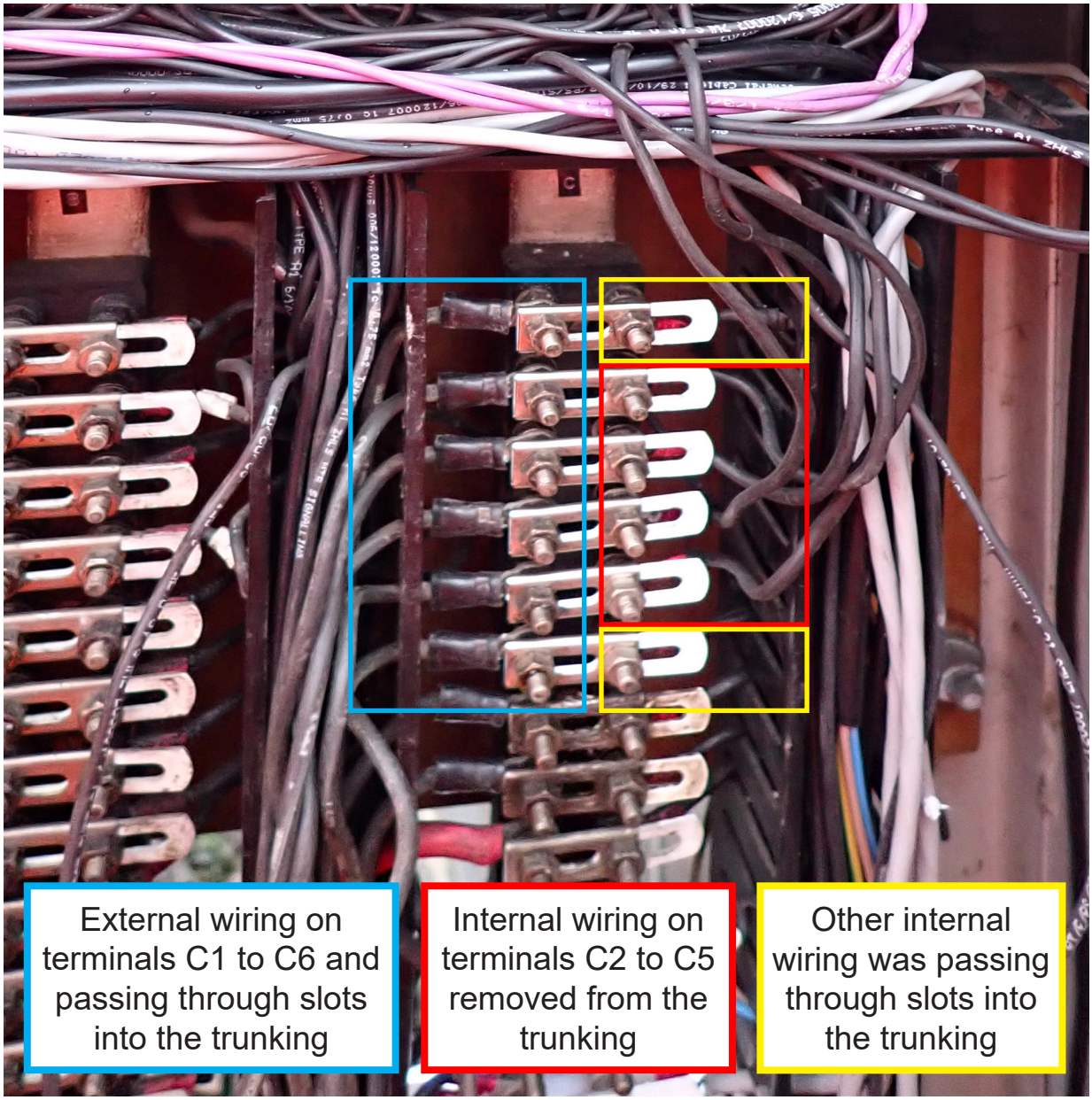

Figure 14: Close-up of the internal wiring on terminals C1 to C6.

75 Due to its age (paragraph 21), there was no requirement to fit labels to the wiring either side of terminals C1 to C6 when this wiring was first installed or retrospectively. That meant there were no labels fitted to this wiring to identify it as either internal or external wiring, although the external cable wiring could be identified from its thickness and the cores having their respective core number printed on them (figure 15). However, it was dark when SMT2 was identifying what wiring to disconnect, with the only source of light coming from their headtorch, so picking out these subtle differences in the wire types would have been challenging. The location case was not fitted with any internal lighting, none of the signalling group used portable lighting to illuminate where they were working, and there were no nearby external light sources (paragraph 30).

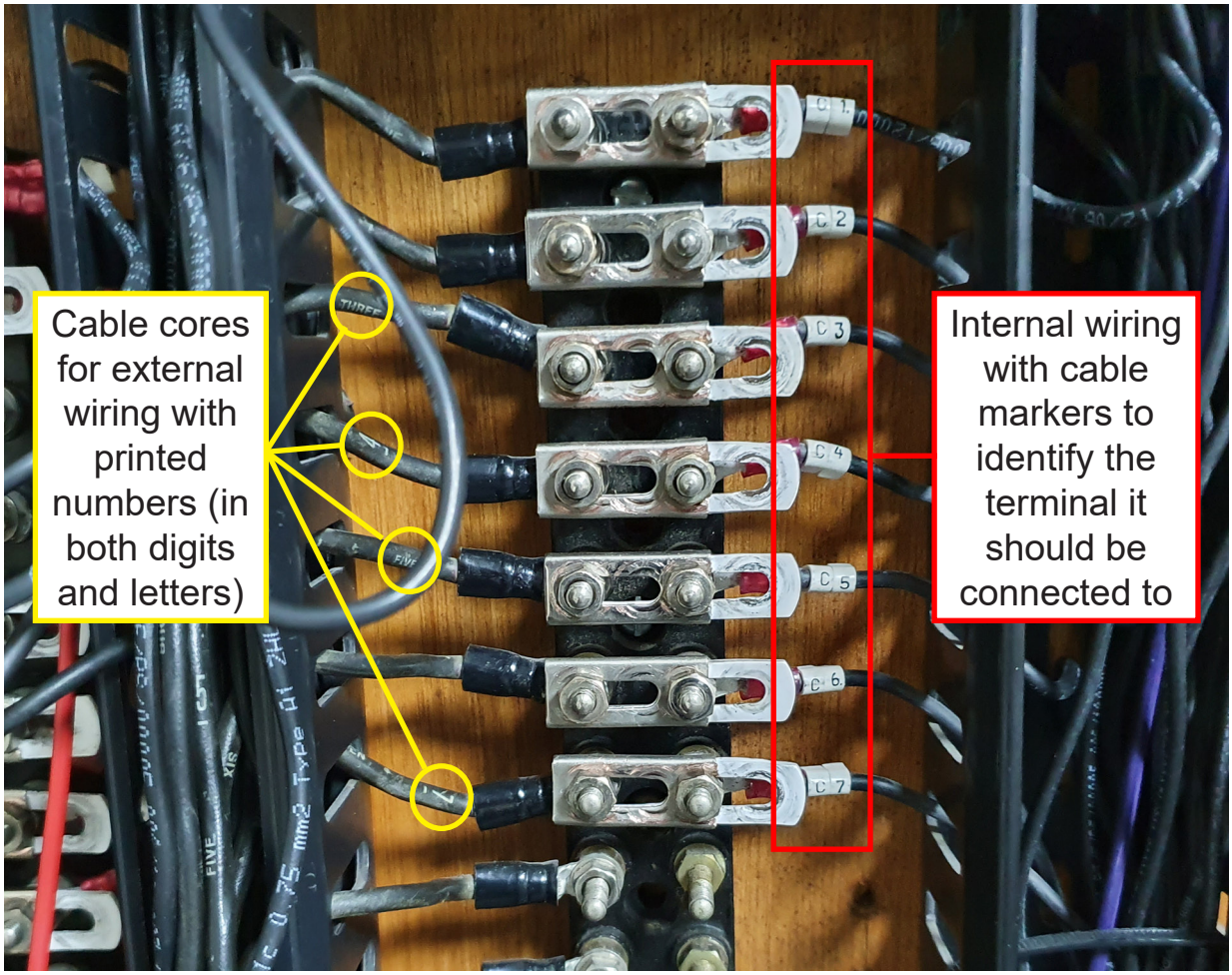

Figure 15: Example of how cables can be identified.

76 Although it was common for members of the signalling group to work only by the light from their headtorch, it is possible that this lack of lighting, a lack of cable markers, and SMT2 not directly referring to a correctly annotated drawing, led SMT2 into mistakenly disconnecting the wiring on the wrong side of the terminal bar. RAIB has also concluded that SMT2 probably reconnected the internal wiring onto the terminals after realising their error, but that they inadvertently crossed the two internal wires going to the C2 and C3 terminals as they did so.

77 RAIB considered other potential causes for the wiring cross, such as the wiring error being introduced when the signal head was replaced (paragraph 32), but none of these were supported by the evidence. Maintenance records showed the last visit by a local signalling maintenance team was in August 2022 (paragraph 34). This visit included testing the operation of the SPRS which would have revealed the wiring error if it had been present at that time. There were no records of any other work taking place on the signal in the intervening time before the incident. RAIB also has witness evidence that SMT2 tested the operation of the SPRS before the work to disconnect the cabling to the signal had started, with the signal correctly changing from displaying a green aspect to a red aspect. This leaves the scenario that SMT2 introduced the wiring error to be the most likely one.

78 The process for disconnecting and connecting cables is designed to avoid introducing wiring anomalies, but as with any human activity, errors can and do happen. However, in the case of signalling installation activities, such errors should be identified and corrected by the subsequent testing activities as required by the SMTH process.

Reconnection and testing of signal DY586

79 The signal maintenance testers who tested signal DY586, after the cable to the signal was reconnected, did not identify that this cross in the wiring had occurred.

80 At the start of the work that night, the three signal maintenance testers allocated the upcoming work among themselves. SMT3 chose to test the track circuits and SMT2 the signal post telephone, leaving SMT1 to test the signal.

81 The HOTR project had provided SMT1, as lead tester, with a work pack which included a maintenance test plan list. This list identified the SMTH test plans for each item of affected signalling equipment. It listed two SMTH test plans that SMT1 needed to carry out to test the aspects shown by signal DY586. These were:

- Test plan NR/SMTH/Part04/CA12, 'Remove and Refit a Multi-core Cable'.
- Test plan NR/SMTH/Part04/SG55,[16] 'Replace a Light Emitting Diode (LED) Signal Head'.

82 Test plan CA12 included steps to carry out wire counts before the cable was disconnected (paragraph 71) and after it was reconnected. It is unlikely that the wire count after the cable was reconnected would have identified the problem with the crossed internal wiring, as it was focused on the external wiring going between the location case and signal head.

83 Step 11 of test plan CA12 called on SMT1 to check the maintenance test plan list for any other test plans that were listed for the equipment fed by the affected cable, and then carry out any steps in those test plans that were marked with a red asterisk. As test plan SG55 was listed, SMT1 was only required to carry out the two test steps that were marked with a red asterisk in this test plan. These were:

- Step 18 – '*Test the supply to each SLM* [Signal Lamp Module] *and record the test measurements along with the other details required on the NR/SMS record card, together with the reason for the test*'.
- Step 20 – '*ASPECT TEST signal*'.

[16] NR/SMTH/Part04/SG55, 'Replace a Light Emitting Diode (LED) Signal Head', issue 01, dated 4 September 2021.

84 Test step 18 in test plan SG55 required SMT1 to measure and record the supply voltage to each aspect. On the night, it was SMT2 that measured these voltages on SMT1's behalf. The record card in location case 141/2 was marked 'Signal Lamp Voltage Test (Not LED Signals)' as it pre-dated the signal head change in 2015, and voltages for LED signals are not routinely recorded. However, SMT1 was required to record the measured values and needed somewhere to record them. The record card shows SMT1 recorded voltage values for the red and green aspects on 26 October 2022 but no value was recorded for the yellow aspect. It is possible that SMT1 overlooked recording this voltage as the testers were rushing to complete their work when the yellow aspect was tested (see paragraph 100). The actions required to measure these voltages would not in themselves have identified the wiring problem, but the difficulties the testers had in getting the signal to display a yellow aspect could have prompted one of them to realise there was a problem with the signal (see paragraphs 94 to 99).

85 Part 03 of SMTH documents the common tests and checks that are called up by many of the maintenance test plans. These are known as defined tests and checks. The aspect test called for by step 20 in test plan SG55 is a defined test, reference NR/SMTH/Part 03/Test B07.[17] The purpose of test B07 is to:

- check that the correct aspect (including any appropriate indication of route) is displayed
- check that no other aspects, lamps, or signal lamp modules are falsely illuminated during this test.

86 There were four opportunities for the wiring problem with the signal to have been identified by the test steps in test B07. The first opportunity was step a) which required a check that each aspect control relay corresponded to its associated aspect. This would require SMT1 to check the state of the two control relays when the signal displayed a green, a yellow and a red aspect. After the incident, SMT1 told their manager at Bridgeway that they would normally do this but had not done it on 26 October (see paragraph 104 for the factors that affected the testing activities). If SMT1 had checked the status of the 586H1PR and 586D1PR relays for signal DY586 (figure 10) in the location case against the red aspect the signal was displaying when it was first powered back up, they would have identified that it should have been displaying a yellow aspect. Similarly, when the signal was displaying a yellow aspect, this test step would have identified that it should have been displaying a red aspect.

87 The second opportunity within test B07 for the problem to be identified was when SMT1 needed to change the aspect shown by the signal. This was because steps a) to d) of test B07 must be repeated for each aspect that can be shown by the signal. For signal DY586, this meant carrying out each of these four test steps when it was displaying a red, a yellow and a green aspect.

88 Test B07 does not specify how a signal maintenance tester should change the signal aspect. For a controlled signal, testers are trained to normally ask the signaller to change the signal aspect for them. This also allows the signaller to report back to the tester what is shown on the signaller's display, so this can be corresponded by the tester against what aspect the signal is displaying, which is step b) in test B07.

[17] NR/SMTH/Part 03/Test B07, 'Defined Test: Aspect Test', issue 06, dated 3 March 2018.

89 However, signal DY586 is an automatic signal, with no replacement facility for the Derby signaller to change its aspect (paragraph 17). This signal is also the last signal on the Derby workstation, so the signaller has no control over what aspect it displays by being able to change the aspects of signals beyond it as these fall within the control area of the Chesterfield workstation signaller. Signal DY586 is also within a relay interlocking dating back to 1969, which does not provide any information about the signal's aspect back to the signaller's display. Consequently, while the location of the signal is shown on the Derby workstation signaller's display, its aspect is greyed out (figure 7). As the signaller had no visibility of what aspect signal DY586 was displaying, that meant step b) in test B07 could not be carried out.

90 For automatic signals, signal maintenance testers are trained to 'slip links' in the location case to change the signal's aspect when carrying out these steps in test B07. This is a reference to the links on each terminal bar connection that provide electrical continuity from one side to the other (figure 16). If the nuts securing the link are loosened, the link can be slid across ('slipped') moving the connection from a conductive to a non-conductive part of the link and so breaking the electrical connection.

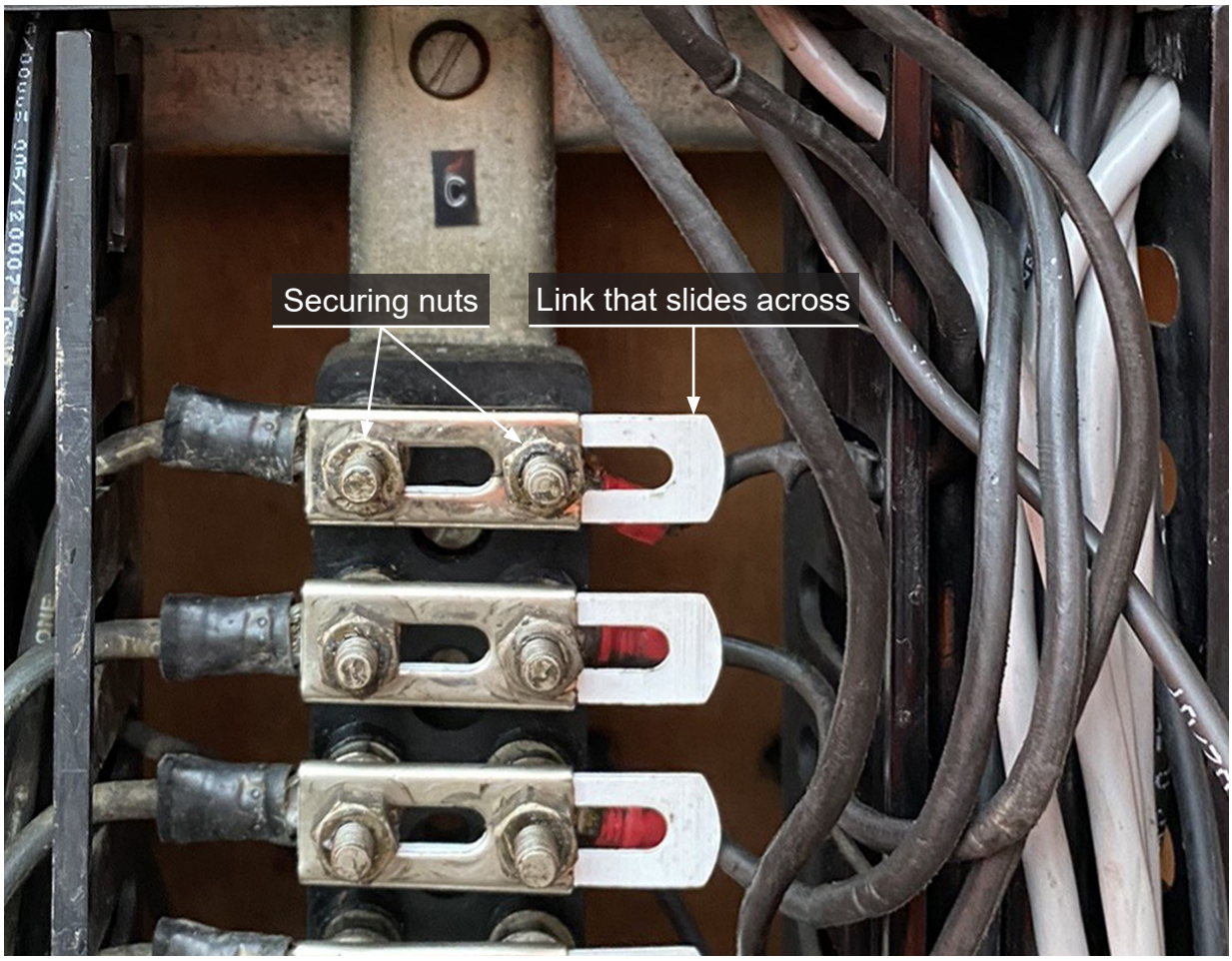

Figure 16: The links on the terminal bar.

91 To use this method, the signal maintenance tester must first get the signal under test to show a green aspect. This means the track sections beyond the signal need to be unoccupied and the signaller must remove any restrictions that would affect the signal's aspect. This could include removing restrictions on signals beyond the signal under test which affect the sequence of aspects.

92 When the signal aspect is green, the coils of the H1PR and D1PR relays that control the signal aspect are both energised (figure 10). The signal maintenance tester must use the circuit diagrams to identify a link in the circuit required to energise the coil of the D1PR relay and slip this link to remove the voltage energising the relay coil. Removing this voltage will cause the relay to de-energise and the signal to display a yellow aspect (figure 10). To complete step a) of test B07, the signal maintenance tester should ensure the states of the H1PR and D1PR relays match the yellow aspect being displayed. At this point, the signal maintenance tester can carry out any other test steps required for the yellow aspect, including measuring the supply voltage (paragraph 84).

93 After testing the yellow aspect, the signal maintenance tester must use the circuit diagrams to identify which link is in the circuit to energise the coil of the H1PR relay, and then slip this link to remove the voltage to the relay coil. This should cause the signal to display a red aspect (figure 10). The signal maintenance tester should check the red aspect being displayed corresponds with the state of the H1PR and D1PR relays. As with the yellow aspect, the signal maintenance tester can now carry out any other test steps required for the red aspect.

94 When SMT1 started to test signal DY586 it was displaying a red aspect. Instead of slipping links in the location case, SMT1 initially tried asking the signaller to change the signal's aspect. SMT3 called the Chesterfield signaller on behalf of SMT1 and asked the signaller to provide a green aspect on signal DY586. To do this, the Chesterfield signaller removed controls applied to two track sections beyond the first signal under their control, signal DC4833. This caused signal DC4833 to change from a red to a green aspect. This in turn caused signal DY586 to change from a red to a green aspect (figure 17). In their call to the signaller, SMT3 confirmed that signal DY586 was now displaying a green aspect.

95 About three minutes later, after the testers had completed their tests for the green aspect, SMT3 called the Chesterfield signaller again and asked if they could get signal DY586 to display a yellow aspect. The signaller reapplied controls to the two track sections which caused signal DC4833 to show a red aspect. As soon as this was done, SMT3 reported that signal DY586 had changed but was now also displaying a red aspect (figure 17). The signaller was confused as they expected with signal DC4833 at red, that signal DY586 would be showing a yellow aspect. The signaller then removed the controls from the track sections and instead operated an emergency replacement control for signal DC4833 which caused the signal to again display a red aspect. As soon as this was done, SMT3 reported to the signaller that signal DY586 was again displaying a red aspect. At this point, the signaller concluded that perhaps it was not possible to get signal DY586 to display a yellow aspect from that workstation and the call ended.

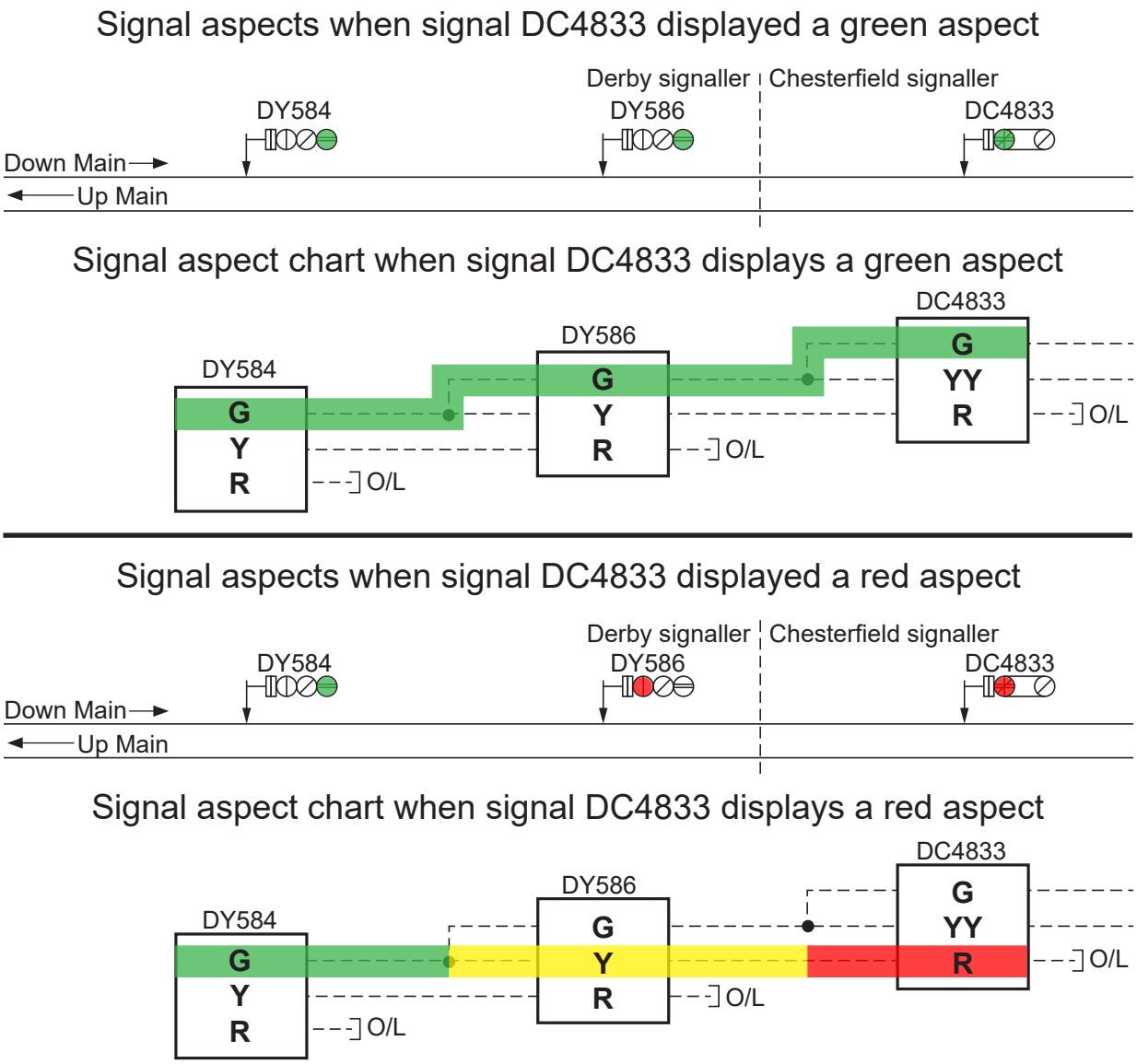

Figure 17: The aspects shown by signal DY586 through the actions taken by the Chesterfield signaller.

96 SMT1 then spoke to the signalling technician at EMCC to ask for their help to change the aspect on signal DY586 (paragraph 48). The signalling technician advised that they could not do this for signal DY586 due to it being in a relay interlocking. Earlier that month, SMT1 had been regularly working in areas with a different type of interlocking, where the signalling technician could assist when testing signal aspects by carrying out actions on a technician's terminal which resulted in changes to the aspect displayed by the signal. As soon as SMT1 made this call, they realised this request would not work due to the type of interlocking in the area they were working in.

97 SMT1 and SMT3 then decided that they needed to complete the aspect test by slipping links. SMT1 called the Chesterfield signaller to ask for signal DY586 to display a green aspect, but by this time the signaller was busy dealing with train movements (paragraph 49). SMT1 called the signaller back ten minutes later (paragraph 50) and the signaller removed controls which allowed signal DC4833 to display a green aspect, which in turn meant signal DY586 also displayed a green aspect. At this time, SMT1 and SMT3, along with the circuit diagrams, were on one side of the location case, while SMT2 was on the other side, next to the terminals. Witness accounts report that SMT2 slipped a link to de-energise the 586D1PR relay, which should have changed the signal aspect from green to yellow. However, this did not work as expected, as the signal changed to display a red aspect.

98 Witness evidence explains that SMT2 then slipped another link to change the signal aspect. Some witnesses described various letters and numbers being called out between the testers when deciding which link to slip. Eventually, the signal changed to display a yellow aspect. This could only have happened because SMT2 had slipped a link to de-energise the 586H1PR relay (figure 10). However, at this point, the signal should have been displaying a red aspect, not the yellow aspect that was actually being displayed.

99 Throughout their conversations with the Chesterfield signaller, and when they slipped links to change the signal aspect, none of the testers realised there was a problem with the signal which was preventing them from getting the yellow aspect as expected.

100 Once the signal was displaying a yellow aspect, the testers completed their testing. It took about three minutes from the Chesterfield signaller providing a green aspect on signal DY586 to the completion of the remaining test steps. While slipping the links, there was no check that the slipped links, or the aspect being displayed by the signal, matched the expected state of the 586H1PR and 586D1PR relays. If they had done so, then it would have revealed the problem caused by the crossed internal wiring.

101 A third opportunity to find the problem was test step c) in test B07, which was to check that the signal's lamp proving circuits were working for each aspect that the signal displayed. The lamp proving circuit checks whether current is flowing through the signal head, which is used to prove the integrity of the circuit illuminating the aspect and that the aspect is lit. If no current is flowing, the lamp proving relay, called the ECR relay, de-energises indicating a problem. For this test, the tester should slip a link for the aspect that is lit to remove the voltage supply going to it. This would be the C1 link for the green, C2 link for the yellow and C3 link for the red aspect. The tester should then check that the ECR relay coil is de-energised. All the testers were trained and assessed to check the state of the H1PR and D1PR relays while they checked the state of the ECR relay. Witness evidence indicates that this test step was not carried out, so none of the relays were checked.

102 The fourth opportunity in test B07 to find the problem with the signal was test step e) which required the testers to operate the SPRS (paragraph 17). This test calls on the tester to operate the SPRS when the signal is showing a proceed aspect to ensure it changes to display a red aspect. This test would have revealed the crossed wiring as the signal would have displayed a yellow aspect after operating the SPRS. Witness evidence confirms that none of the testers carried out this test step.

103 There were other steps in test B07 that would not have found the problem with the signal but that the testers were still required to carry out. Test step f) was to check that adequate sighting was achieved for all signal aspects, and test steps g) and h) were to check there was no ambiguity or conflict with any other signals or extraneous lighting. There is no evidence that these tests were done and it is very unlikely these test steps could have been carried out in the short time taken to finish testing after a yellow aspect was obtained. Overall, RAIB has concluded that test B07 was not carried out correctly or to the required standard.

104 The effectiveness of the testing activities was affected by a combination of the following:

a. The signalling group was under time pressure because the time available to complete the reconnection and testing work had been reduced (paragraph 105).

b. While SMT1 had overall responsibility for testing the signal, they were not focused on this activity because of the workload that was placed on them (paragraph 118).

c. The signal maintenance testers were unfamiliar with the configuration of the signalling equipment at this location. This was a possible factor (paragraph 127).

Each of these factors is now considered in turn.

Time pressure

105 The signalling group was under time pressure because the time available to complete the reconnection and testing work had been reduced.

106 The role of the HOTR project signalling team for Central depot was to scope what signalling related work needed to be carried out wherever its HOTR train was planned to work. For Wingfield, this involved team members attending the site walk out (paragraph 37) to identify what signalling assets would be affected by the work. The team then determined, using a time reckoner, how long it would take to disconnect, reconnect and test the identified signalling assets, based on the level of resource to be provided. The process used to determine how much time was needed had been developed over many previous years of experience. In this case, the team decided that three signal maintenance testers and three technicians would be needed to carry out the work within a timeframe that fitted in with the other activities.

107 The HOTR project signalling team then provided its planned times for the signalling related work into the overall planning of the work. The team was next involved in various review stages as the plan for the work was further developed. The times proposed for each signalling related activity by the HOTR project signalling team were adopted and included in the plan issued by the HOTR project without changes. The plan was issued in both a chart and a list format. A copy was given to the works manager and the plan was available to everyone at the sign-in point.

108 At the beginning of the night, the work to disconnect the signalling equipment started fifteen minutes early and was completed four minutes later than planned (paragraph 43). The next planned activity for the signalling group was to start reconnecting the signalling equipment at 03:30 hrs and finish this at 04:05 hrs, followed by testing which was planned to start at 04:15 hrs and finish at 04:55 hrs. On the night, the signalling group began reconnecting the signalling equipment 45 minutes later than planned, because the work done by the on-track machines was running late (paragraphs 46 and 47).

109 The on-track machines started the first pass 26 minutes later than planned. This was due to additional activities being required of them which had not been accounted for in the plan, and a delay when the HOTR train was being prepared to move clear of the site (paragraph 46). This first pass finished 50 minutes later than planned at 04:00 hrs, because a component on the first on-track machine broke and needed to be replaced. The second pass by the on-track machines subsequently started 47 minutes later than planned. The on-track machines worked southwards along the Up Main line and had passed the area of the signal and location case by about 04:15 hrs. The signalling group was then able to start working on the reconnections, but the time they started (04:15 hrs) was much later than that originally planned (03:30 hrs).

110 After the on-track machines completed their work, they moved back northwards, passing through the area where the signalling group was working on the reconnections. The machines were clear of where the work was taking place 49 minutes later than planned (paragraph 47). They needed to be clear of this area so that the affected track circuits on the Up Main line could be tested after they were reconnected. The signalling logs show that, five minutes after the on-track machines were clear of the area, SMT3 began testing the four track circuits that had been disconnected and reconnected during the work (paragraph 48).

111 The work site was due to be handed back at 05:20 hrs, but with the testing still taking place, the delay had come to the attention of the works manager, works supervisor and engineering supervisor. There was 25 minutes of contingency built into the plan, but the delay had now consumed this. The works manager, who was on site, was now under pressure due to the work overrunning. While the testers were testing signal DY586, the works manager began to press the testers about how long they were going to be. The works manager made comments about how much an overrun would cost and repeated these comments several times, which unsettled SMT1 and SMT2. SMT1 stated they felt under further stress, because as lead tester they were already conscious that their part of the work was running late due to starting later than planned.

112 The works manager later explained they had made these comments to reinforce how serious an overrun would be as they felt under pressure to avoid delays. They had also expected SMT1, as lead tester, to have advised them earlier if the signalling work was going to run late. However, the works manager should already have been aware of the potential for an overrun much earlier in the night, as the on-track machine activities had started and finished much later than planned, and the works manager had already reported these times to Network Rail.

113 Witness evidence explains that the pressure on SMT1, due to the work overrunning, was affecting their thinking. This is cited as the reason why SMT1 called the signalling technician at EMCC to ask for their help to change the aspect on signal DY586 even though they then realised almost straight away that this was pointless in the circumstances (paragraph 96).

114 Signal maintenance testers often need to work under pressure due to the nature of their work, which involves carrying out the last activities that need to be completed before a site can be handed back. Testers are told during their training that they need to prioritise the completion of their testing work to the required standards over any competing needs (such as minimising train delays). However, it is difficult to recreate this pressure in a training environment so that testers can receive practical training on how to react and give an appropriate response.

115 SMT1 felt they could not tell the works manager to go away and leave them to complete their testing. This was because SMT1 was unfamiliar with this works manager and they felt concerned about their future working relationship with the works manager if they said anything. However, the importance of following the SMTH process should have guided SMT1 in terms of how they interacted with the works manager and how they completed their work when under time pressure (see paragraphs 154 and 155).

116 Faced with mounting time pressure, SMT1 had several options:

- They could have handed the signalling equipment back untested and therefore out of use. They had done this on a few occasions in the past, so knew what to do, and generally had had no concerns doing it.
- They could have called upon the on-call signalling support provided through the HOTR project. The signalling work pack given to SMT1 provided them with the contact details of a manager from the HOTR project that they could speak to for help with any problems related to the signalling work.
- They, and the other testers, could also have invoked a worksafe[18] procedure provided by either Network Rail or by their employer.

117 Due to the time pressure placed on them, none of the testers considered doing any of these things and instead just focused on completing the testing as quickly as they could. They rushed the testing of the yellow aspect in less than three minutes (paragraph 50), so that they could get off the track as soon as possible, to allow the work site and possession to be given up.

[18] Any employee of a company working on Network Rail managed infrastructure may invoke a worksafe procedure if they feel an action may compromise their safety or the safety of others. The person in charge of the work will then assess the situation and try to agree a way ahead in discussion with the employee. If no agreement can be reached, the work will not be restarted and the person in charge would consult their manager to agree when and how the work can be made safe.

Workload

118 While SMT1 had overall responsibility for testing the signal, they were not focused on this activity because of the workload that was placed on them.

119 As well as testing signal DY586, SMT1 was the nominated lead tester for all the signal maintenance testing. The HOTR project had allocated SMT1 to do this role in the work pack, although SMT1 had not requested this role or been asked if they would accept it. SMT1 had not objected to being given the lead tester role so the HOTR project had made SMT1 its default choice for this role for about the previous six months.

120 Module 03 in part 01 of the SMTH standards explains that the lead tester shall be in overall charge of the testing. This meant that SMT1 was required to carry out many additional activities. These included briefing the signalling group on the work to be done at the start of the night, and managing the signalling related work as it progressed, which included organising what the other testers and technicians did. It also required SMT1 to communicate with the signallers to sign the signalling equipment in and out of service, and throughout the night update the works manager and works supervisor about the progress of the signalling work. At the end of the night, it required SMT1 to check that all the test log sheets, forms and other paperwork in the signalling work pack were completed.

121 The HOTR project planning activities included identifying what signalling equipment was affected, listing the test plans that were needed to test the affected signalling equipment, deciding what level of resource was needed for the volume of work to be done, and allocating how much time was needed. However, no information or guidance was given to SMT1, as lead tester, about how the work to disconnect, reconnect and test the signalling equipment should be organised and implemented on the night.

122 When they were deciding who would do what, SMT1 as lead tester could have told the other testers what to test. Instead, the testers decided among themselves, so SMT3 volunteered to test the track circuits and SMT2 the signal post telephone. This left SMT1 with the responsibility to test the signal. If SMT1 had been more assertive and allocated the available tester resources to the testing activities in a different way, their workload could have been significantly less, leaving them to support the testing and carry out all the non-testing duties placed on them.

123 In addition to being lead tester, SMT1 was also the COSS responsible for everyone in the signalling group (paragraph 42). Normally the staff in the signalling group worked in pairs, with one tester working alongside one technician. One of the pair would sign in to the work site with the engineering supervisor as a COSS for the pair. The pair would then stay together while working in the work site.

124 However, on the night, SMT1 was the only member of the signalling group who had received a briefing from the engineering supervisor (paragraph 42). Consequently, SMT1 was the only one in the signalling group who could sign into the work site as a COSS. When SMT1 was called into the briefing at 20:45 hrs, ahead of a 21:00 hrs start for the signalling group, the engineering supervisor had advised SMT1 that their start time was 20:30 hrs. The engineering supervisor wanted to complete their briefing so that they could head out to be in position to place the protection for the work site out on the track.

125 As the other COSS-qualified staff in the signalling group arrived at the planned start time of 21:00 hrs for their shift that night, they missed the engineering supervisor's briefing. SMT3 and one of the technicians contacted the engineering supervisor but were told they were too late to be briefed. This decision by the engineering supervisor was not in line with normal practice for the signalling group and meant that everyone needed to sign in to the work site with SMT1 as their COSS. SMT1 subsequently gave a COSS briefing to the whole signalling group and everyone signed SMT1's COSS paperwork to record they had been briefed.

126 Because they were required to be COSS for everyone in the signalling group, SMT1 had safety responsibilities to continuously monitor what everyone else was doing and keep everyone in sight. While both lines at Wingfield were under possession, SMT1 still needed to be aware of where everyone was, particularly when the HOTR train and on-track machines were moving about within the work site. It was also difficult for SMT1 to keep track of everyone in the dark. This added to the workload on SMT1 and witness evidence confirms it was a distraction from their testing duties.

Familiarity

127 The signal maintenance testers were unfamiliar with the configuration of the signalling equipment at this location. This was a possible factor.

128 The nature of the work carried out by the HOTR project means that the HOTR train can be programmed to work anywhere on Network Rail's infrastructure. As both the Network Rail staff and contractors who regularly work with the HOTR train tend to follow it around the country, they often go to places where they have never worked before.

129 The testers were unfamiliar with working in the Wingfield area so they did not know specific details about the type and configuration of the signalling equipment they would be testing. The HOTR project provided information in the work pack to help the testers in this regard. This included some diagrams, such as a hand drawn sketch of the affected equipment and cabling layout, line diagram extracts showing the layout of the signals, and drawings showing the layout of the location cases along the railway. This information did not include a signalling plan or aspect chart as these can be difficult to find in the records held by the National Records Group (NRG).[19] However, from the information that was provided, the testers could have worked out the aspect sequence needed for signal DY586 to show a yellow aspect.

130 The work pack also gave SMT1 information about the numbers of each type of signalling asset to be tested, as these were shown on the maintenance test plan list. However, for some of the listed assets, SMT1 needed to work out for themselves exactly what type it was once at the site. Similarly, SMT1 also needed to determine what type of interlocking the trackside signalling equipment was connected to.

[19] The organisation that maintains and manages the signalling design records (source records) for Network Rail's infrastructure.

131 Their unfamiliarity with the area also meant that the testers were unaware of other details which were relevant to the signalling arrangements at this location. Initially they did not realise that the signal was the last signal before the boundary between the Derby and Chesterfield signallers' control areas. The testers also did not know that the signallers they had spoken to could not see what aspect signal DY586 was displaying, as it was greyed out on the workstation displays (figure 7).

132 SMT1, as lead tester, had limited opportunities to familiarise themselves with the location and the type of signalling equipment in advance. They were, for example, not involved in any of the planning activities beforehand. Lead testers do not participate in any of the walk outs or surveys when work is planned. This is because the lead tester will often be a contractor, and when these planning activities take place, the Network Rail staff working for the HOTR project will not know that far in advance who the lead tester will be.

133 The draft signalling work pack, which included information about the signalling equipment, was emailed to Bridgeway on 18 October and Bridgeway passed it on to SMT1. The HOTR project signalling team expected SMT1, as the nominated lead tester, to provide comments back if there were any problems with the work pack. Often the lead tester, being a contractor, is not given any time to look at the work pack and this means that the HOTR project signalling team rarely gets any comments back. If the lead tester manages to look at a work pack in advance, it is usually only to get an idea as to how much work there will be each night.

134 In addition, SMT1 did not usually attend possession planning meetings to discuss the upcoming work, which are normally held on the Thursday the week before, in daytime. Witness evidence explains this is because SMT1 was often working night shifts on that current week's site. As the lead tester is invited to attend the meeting online, a recording of the meeting is available should they wish to view what was said. Again, no time is given to the lead tester to view the recording, so this often does not happen.

135 SMT1's unfamiliarity with the location also meant that they needed to do a lot of thinking on the night about how the work would be carried out by the signalling group. The lead tester needed to work out how to do the disconnections, by determining which end it would be best to disconnect each of the cables from. They then needed to determine exactly how to carry out the testing required by the maintenance test plans.

136 However, there had been an opportunity the night before for SMT1 to familiarise themselves with the signalling at Wingfield and plan how the work would be done the following night. The signalling group was at Wingfield on the first night, but there were no signalling equipment disconnections and reconnections to do. This meant that they had a lot of free time during that shift, so could have used this opportunity to look at and plan what they would be doing the following night, but they did not do this. Instead, they remained in their vehicles at the nearby access point.

Identification of underlying factors

Assurance of signal maintenance testers

137 Activities undertaken by Network Rail with the aim to improve the robustness of work carried out on its infrastructure under the SMTH process, which incorporated the training and assessment of the attitudes and behaviours of its signal maintenance testers, had not yet included signal maintenance testers employed by contractors. This is a probable factor.

138 The SMTH standard states its purpose as providing a maintenance testing regime for the replacement or installation of signalling equipment that does not affect the logic of the system or the controls of the system that have previously been tested to signal works testing.[20] The signalling related work at Wingfield that night fell within this scope.

139 The SMTH standard defines a signal maintenance tester as an individual with the competencies and authority to work appropriate for the work to be done, who can carry out the tests necessary to ensure that the physical implementation of the signalling equipment is correct, and that it meets all the specified test and acceptance criteria. Each tester at Wingfield held the required SMTH competency and their certification was in date. Their competency was assessed every two years by a training provider. That assessment was focused on the core technical competencies that a signal maintenance tester needs to have, as the number of SMTH test plans meant that it was not possible to assess testers against every one of them. Test B07, the aspect test (paragraph 86), was one of the core competencies that the training provider had included in the assessment.

140 Alongside their SMTH certification, all the testers also held an authority to work that was issued by their employer. The authority to work showed what types of signalling equipment each tester could work on, and to what level of competence. The competence levels ranged from being an assistant through to installer, maintainer or tester, and identified if the person was under mentorship for any of the listed competencies. SMT1 and SMT3 held an authority to work that allowed them to test signals. The authority to work for SMT2 showed they were under mentorship for testing signals.

141 The SMTH standard does not include any references to the signal maintenance testers being required to hold an appropriate Institution of Railway Signal Engineers[21] (IRSE) licence (see paragraph 177). SMT3 held the required IRSE licence. SMT1 held an IRSE licence, but it was not the required category needed to test the signal, and SMT2 did not hold any IRSE licences.

[20] Signal works testing is a process that covers the construction and installation of new or modified signalling equipment and/or its application logic where the work changes, or potentially changes, the configuration or functionality of the signalling system. This definition includes the installation of totally new systems, the alteration of existing systems, and the abolition (also known as 'recovery') of existing signalling systems.

[21] The Institution of Railway Signal Engineers states it is a professional institution for people engaged in, or associated with, railway signalling and telecommunications, train control, traffic management and allied professions. It states that it aims to advance train control and communications engineering within the industry, and to maintain high standards of knowledge and competence within the profession. Its overriding purpose in doing this is for the public benefit, to help ensure the safe and efficient movement of people and freight by rail.

142 Module 01 in part 01 of the SMTH standard covers the principles of SMTH testing. It describes the objectives of maintenance testing and explains that the testing must prove that the signalling equipment can be safely returned to service. It details how the test plans contain all the vital steps, in a logical order, to confirm the safe working of equipment, and that no necessary steps in a test plan must be overlooked during the testing. Module 05 in part 01 of the SMTH standard is about test plans. It explains how the test plans are the primary test documents, how each test plan consists of numbered steps in a logical sequence, that these steps are the minimum safety tests to check the safe operation of the affected signalling equipment, and that the tester must confirm that all the steps have been completed. It also states that testing activities must not be carried out without reference to these documents. It is clear from these modules that the SMTH process is reliant on testers following every step in the test plans.

143 In 2019, Network Rail began an investigation into the SMTH process after it perceived that there was an increase in the number of close calls, incidents and wrong side failures that were happening due to SMTH testing irregularities. Network Rail reported that, at the time, it was recording about eight SMTH related incidents per four-week period involving its staff. The purpose of the investigation was to understand if the SMTH testing process was fit for purpose and to discuss problems that staff were faced with when undertaking SMTH testing.

144 The Network Rail investigation reviewed previous SMTH related incidents, looking for common factors and considering their underlying causes. The investigation also held two workshops with Network Rail staff, one with staff who managed SMTH activities and another with staff who carried out the SMTH testing. The investigation concluded that the fundamental SMTH process can provide an effective control when it is followed properly, but there were improvements which could be made. The main areas for improvement were the competency and assurance of the staff who carry out the SMTH testing, and simplification of the testing process itself.

145 The investigation noted that the SMTH process is focused on Network Rail maintenance staff, so it did not take into account different roles or organisations within Network Rail, such as the HOTR project.

146 The investigation also noted some important themes and issues that were raised by the workshops, many of which were present at Wingfield on the night of 25 to 26 October. For instance, it noted that:

- It was not always clear when independence was necessary due to conflicts of interest within signalling teams, with the tester often wanting to help with the installation work rather than doing nothing while waiting to do the testing.
- Most of the irregularities were related to work involving cables.
- Testers had got used to skipping steps on a regular basis.
- Test log sheets to record the testing activities were not completed on site as it was not practical to fill them in while doing the testing.
- Test log sheets were used to inform auditors that work was completed but did not provide an indication of how well the work was carried out.
- No one was assuring the tester’s work and surveillance was not being undertaken correctly.

147 The workshops also highlighted specific issues related to pressure, workload and resources such as:

- Lead testers often had to deal with people from many disciplines such as supervisors, on-call managers, signallers, and control room staff.
- The lead tester had to take on several other roles such as COSS, team leader, and person in charge.
- Overrunning work by other disciplines meant testing time was cut short.
- The testing work tended to be done towards the end of the shift when pressure to hand back the possession was at its greatest, which led to testers taking shortcuts and omitting test steps.

148 The investigation recognised that pressure and workload were important concerns, as the SMTH process relies on the attitude and aptitude of the SMTH testers to make safe decisions and ensure that processes are followed. It stated that this reliance on following the SMTH process should be tied into formal training and knowledge sharing exercises, so made a recommendation to review initial SMTH training and assessment to ensure that the training did this. The recommendation also called for the training to explain what the consequences can be, such as unsafe events occurring, if the SMTH process is not followed. The intent of the recommendation was that testers displayed the correct attitude and aptitude for SMTH testing.

149 Due to its continuing concerns about the number of SMTH testing irregularities that involved its own staff, Network Rail implemented the recommendation by changing how it trained and assessed its staff who held the SMTH competency. Online assessment (known as assessment in the line) was withdrawn. This was because Network Rail identified that many of its staff held the SMTH competency through online assessment but were not practising it. Online assessment also had not allowed Network Rail to identify those staff who were struggling to carry out maintenance testing activities correctly.

150 Online assessment was replaced by practical face-to-face assessments carried out by external training providers. This initially involved about 1,800 SMTH competency holders employed by Network Rail being assessed, with priority given to assessing the signalling team leaders and technicians in the signalling maintenance teams. Initially only 50 to 60% of staff taking the practical assessment passed it. This rose to about 80% when staff were given refresher training before taking the assessment. Anyone who did not pass the assessment was retrained by sitting the initial SMTH training course. By December 2022, Network Rail reported there had been five consecutive periods with no SMTH testing irregularities attributed to the actions of its staff.

151 In addition to the practical face-to-face assessments, Network Rail provided its SMTH competency holders with non-technical skills training. Non-technical skills are the social, cognitive and personal skills that can influence the way that individuals undertake technical tasks. Network Rail had recognised that staff competence, which comprises knowledge, skills and attitudes, should encompass both the technical and non-technical skills needed to undertake a job role. When undertaking complex safety-critical tasks, such as testing under the SMTH process, it is vital that signal maintenance testers not only have a good understanding of the equipment they are working with and the principles that underpin the mandated SMTH procedures, but it is also essential for them to properly appreciate the consequences of the actions they take.

152 The non-technical skills training given to the Network Rail SMTH competency holders comprised seven modules in an e-learning[22] format, with an assessment and certification provided at the end of the training. Network Rail had created this training in response to recommendation 1 from RAIB's Waterloo investigation report (see paragraph 198). One element of the training covered handling situations when placed under pressure, with an overall aim of improving the decision-making by both signal works and signal maintenance testers. It was recognised that signal maintenance testers often work in small teams with limited support available, so would benefit from these skills when deciding what to do.

153 The non-technical skills training was also aimed at addressing concerns over staff not understanding the risks associated with the work they do. The training reinforces messages about the importance of following the required testing processes, with references to previous accidents and incidents such as Waterloo (see paragraph 198), Clapham Junction (see paragraph 199) and Greenhill Upper Junction (see paragraph 202). None of the testers involved had received this training as it was not freely available to their employers at the time. Since this incident, Network Rail has made this training available to other organisations within the rail industry, although it is not mandatory for signal maintenance testers employed by contractors.

154 Knowing the importance of rigorously following the SMTH process should have guided the attitude of the signal maintenance testers at Wingfield, in terms of how they worked when placed under time pressure, and how they interacted with the works manager. All the testers, particularly SMT1 as lead tester, needed to have a mindset to prioritise their testing of the signalling equipment over any competing needs and to complete all steps needed for the testing regardless of how long it took, to be sure that it was safe for the signalling equipment to go back into service. The non-technical skills needed to manage time pressure and interactions with others were not trained or assessed when these testers gained their SMTH competencies.

[22] The delivery of training to gain competencies, knowledge, and skills through electronic media displayed on electronic devices, such as computers or tablets, that are connected to the Internet or a company Intranet.

155 The selection of staff to become a signal maintenance tester is usually based on their technical signalling experience, combined with a desire to move up to the tester role. Signal maintenance testers are not selected to have the type of personal characteristics that might allow them to manage interactions with others when testing, especially when interacting with staff in more senior roles. Some testers can manage these interactions, while others might be less likely to. Testers employed by contractors can also be reluctant to speak up, in case there are consequences such as complaints to their employer or a loss of future work opportunities, especially when it involves speaking to Network Rail staff in supervisory roles.

156 Network Rail, supported by its data showing a fall in the number of incidents due to SMTH testing irregularities by its staff (paragraph 150), believes that these changes to the training and assessment process to improve attitudes and behaviours, along with other planned changes to the training and competency management regime for signal maintenance testers (see paragraphs 225 to 227), will provide a better level of assurance for the work that both its staff and, critically in relation to this incident, contract staff undertake. As such, the fact that the training and assessment of the attitudes and behaviours of signal maintenance testers were not being applied to contract signal maintenance testers at the time of the incident is a probable underlying factor.

Assurance of HOTR project signalling activities

157 Network Rail was not carrying out any activities to assure itself that the work undertaken by the HOTR project to disconnect, reconnect and test signalling assets was being completed correctly. This is a probable factor.

158 The SMTH process relies on signal maintenance testers following its test plans and completing every step correctly for it to be successful (paragraph 142). Network Rail has a process documented in its company standard NR/L2/SIG/10027,[23] 'Surveillance of Signal Maintenance Activities', which aims to provide additional assurance of staff competency, by confirming that work on signalling assets is being completed correctly. This process was only being applied to Network Rail staff working within its maintenance delivery units. This meant that the HOTR project was not carrying out any specific assurance activities for the work carried out by signal maintenance testers on its behalf on Network Rail infrastructure.

[23] NR/L2/SIG/10027, 'Surveillance of Signal Maintenance Activities', issue 5, dated 3 September 2022.

159 Bridgeway was required under its labour supply contract with Network Rail to carry out assurance activities on its signal maintenance testers. It has an annual audit and inspection programme which covers all its staff, not just the staff who work on signalling assets. The site safety checks that Bridgeway carries out follow a checklist approach that covers things like making sure staff hold the correct documentation, have the required competencies for the work they are doing, and that their personal protective equipment is in good condition. Technical checks on the quality of work by its staff can be carried out too, but these checks are less frequent. The frequency of safety checks and the decision about who is checked is risk based. Before the incident at Wingfield happened, there was no history of incidents involving Bridgeway's signalling staff, so checks were infrequent, and happened about every twelve weeks on those staff selected. RAIB found no evidence of any technical checks on the quality of work carried out by any of the Bridgeway staff involved.

160 Examples of poor practices, indicating a lack of discipline by the signal maintenance testers to follow the SMTH process correctly, were identified for the work carried out at Wingfield. These included missing out steps in test B07 (paragraphs 86 and 101 to 103), relying on memory and past experience instead of referring to the test plans while testing, and completing test logs sheets and wire count sheets at the end of the shift (once off the track) rather than as the testing work progressed. There were also errors in the completed test log sheets, with test steps marked as completed when they were not applicable.

161 Further poor practice related to SMT2 being allowed to carry out important activities to test the signal. SMT2 carried out testing activities without adequate supervision, such as when they disconnected wiring while carrying out the initial wire count (paragraph 71), measured the supply voltages to the signal head (paragraph 84) and slipped the links to change the signal aspect during test B07 (paragraphs 97 and 98), when their authority to work required them to be supervised for work related to testing signals (paragraph 140). Also, as SMT2 had reconnected the cable, then their role in the testing, as the installer, should have been very limited. They were, however, allowed to perform a significant role in it.

162 The only requirement related to assurance in the SMTH standard was in module 09 in part 01. This required the tester, upon completion of their work and before leaving site, to email a copy of the completed test log sheets to a designated email address. SMT1 had complied with this requirement, as they had photographed and emailed pictures of the completed sheets at the end of their shift, even though SMT1 did not fill in these records until they got back to their vehicle after all the work was complete.

163 The assurance activities by the HOTR project for the signalling related work consisted mainly of checking the completion and submission of the test log sheets and wire count sheets. The HOTR project did also check that the required sheets in the work pack were all completed and signed off by the lead tester, to show that the testing had been carried out, when the work pack was handed back at the end of the work at a site. However, all these test records only act as evidence of the signal maintenance tester declaring that they have done the required testing and do not evidence how well the testing was carried out. This meant that any non-compliant practices that had developed over time by the signal maintenance testers working on the HOTR project could not be identified. Unchecked non-compliant practices, such as missing out steps in test plans, can result in signalling equipment being handed back in an unsafe state.

Factors affecting the severity of consequences

164 **While it was initially unclear why train 5C23 had passed signal DY586 displaying a red aspect, the potential for a collision between the two trains in the same signal section was reduced by the actions taken by the Burton and Derby signallers and the driver of train 1F02.**

165 After train 5C23 passed signal DY586 displaying a red aspect, its driver called the Chesterfield signaller, who began dealing with the incident (paragraph 53). The driver reported that they had passed the signal at danger (red) and were now at a stand. As required by the Rule Book, the driver reported the incident as a 'signal passed at danger' as this is the phraseology that drivers are required to use, regardless of the reason for passing a signal displaying a red aspect. This could include an error by a driver, a signalling irregularity, a signalling failure or a rolling stock brake problem. However, the driver's use of the term signal passed at danger set the mindset of the Chesterfield signaller into thinking the cause was driver error based on the information available to them at the time.

166 As the signaller workstations on the operating floor at EMCC are located close to each other, other signallers were soon aware that a train had passed signal DY586 displaying a red aspect. The signaller on the Burton workstation advised the signaller on the Derby workstation that the Wingfield area was known for poor adhesion, particularly during the autumn. They suggested that the Derby signaller contact the following train to advise its driver that there was a problem with the train ahead, and possibly poor adhesion conditions.

167 As suggested, the Derby signaller spoke to the driver of train 1F02 (paragraph 54). The signallers had assumed that train 5C23 had been catching up with the train ahead of it at the time, as this would explain why signal DY586, being an automatic signal, had been displaying a red aspect when it was approached and passed by train 5C23. The Derby signaller advised the driver of train 1F02 to expect a red aspect to be displayed by signal DY584, the one before signal DY586. As explained in paragraph 89, the signaller displays do not provide any information about what aspects the signals in this area are displaying (figure 7).

168 At about the same time, the Chesterfield signaller spoke again to the driver of train 5C23 and began filling in the required form for a signal passed at danger. During this conversation, the signaller asked the driver if the train's brakes had been automatically applied by one of the train's safety systems. The driver replied this had not happened, and then explained that they were running on signals with green aspects, until they noticed the next signal was at red and they then applied the brakes. The signaller did not question this, as they were focused on completing the rest of the form for the driver passing a signal at danger.

169 In response to what the Derby signaller had said, the driver of train 1F02 reduced the train's speed to 40 mph (64 km/h) and maintained that speed until they approached signal DY584. This signal was displaying a yellow aspect (paragraph 54) which the driver interpreted as meaning that the train ahead had started moving. After passing signal DY584 displaying a cautionary aspect, the driver decided to reduce the train's speed to 20 mph (32 km/h) and then maintained that speed.

170 The Chesterfield signaller and driver of train 5C23 then held a further conversation. The signaller asked the driver to explain again what had happened and the driver reiterated that they were encountering signals with green aspects and then encountered a signal displaying a red aspect (without seeing a yellow aspect at the previous signal). The driver confirmed to the signaller that signal DY586 did not show a proceed aspect at any point. It was only at about this time that the signalling staff began to realise that there was an issue with the signalling system that had caused train 5C23 to approach and pass signal DY586 while it was displaying a red aspect.

171 When the driver of train 1F02 approached signal DY586 and saw it was displaying a yellow aspect (paragraph 55), they thought the train ahead must still be moving, albeit slowly. Although the aspect displayed by signal DY586 meant the driver could go at least as far as the next signal, DC4833, the driver decided to carry on at about 20 mph (32 km/h). It was only after passing signal DY586 that the driver noticed a red light ahead. At first, they could not understand what this red light was, as they knew from their knowledge of this route that the next signal was much further away around a curve. As the driver got closer, they began to make out that it was the two red taillights of a train ahead. Once the driver realised this, they brought train 1F02 to a controlled stop.

172 The actions of the Derby signaller, prompted by the Burton signaller, had alerted the driver of train 1F02 that there was a possible problem ahead. There was no requirement in the Rule Book[24] or instruction in place at EMCC that required the signaller to do this. Once the driver was aware of a potential problem ahead, they had proceeded at a much slower speed than they might have otherwise, which greatly reduced the potential for a collision. Other drivers have remarked that it is common to pass a single yellow aspect at signal DY586 at a much greater speed, due to it being about 1.6 miles (2.5 km) until the next signal.

[24] Railway Group Standard GERT8000 which describes the duties and responsibilities of staff, and the regulations in force, to ensure the safe operation of the railway.

Observations

Test records

173 The SMTH standard does not require the defined test B07 (aspect test) to be recorded by signal maintenance testers.

174 Many of the defined tests in the SMTH standard have a dedicated form which signal maintenance testers use to record their testing activity. These forms help the tester keep track of what test steps have been completed. They also assist the tester with remembering which permutations have been carried out if a test needs to be repeated for different conditions or configurations. A common example is the form used for the out of correspondence test for a set of points to make sure all possible permutations are tested.

175 While signal DY586 is a relatively simple three aspect signal, other signals can be four aspect and have additional indications to show which route is set from the signal. Test B07 requires all these indications to be tested, meaning a tester might need to test many permutations.

176 The only record that test B07 has been carried out is one tick by the signal maintenance tester for a test step on the log sheet for the test plan that has called for this defined test to be done. Having its own form to record this test could help testers remember to carry out all the steps in test B07, as well as reminding them to test all the possible signal aspect and route indication permutations.

IRSE licences

177 Only one of the three signal maintenance testers held the required IRSE licence for testing the signalling equipment at Wingfield.

178 Network Rail company standard NR/L2/SIG/10160,[25] 'Specification for Application of the IRSE Licensing Scheme', sets out the requirement for the application of the IRSE licensing scheme by Network Rail. NR/L2/SIG/10160 describes IRSE licensing as an independent competency management scheme for individuals engaged in activities on signalling. It states that IRSE licensing provides a level of competency assurance in addition to the competency management systems used by employers. An individual can gain a licence for a particular activity by logging evidence of their work experience, training, mentoring and qualifications. This is then assessed by an IRSE approved assessor to confirm that the individual has met the criteria for that licence.

179 Compliance with NR/L2/SIG/10160 is mandatory, and has been for both Network Rail staff and its contractors since March 2004. It applies to anyone responsible for the design, installation, testing, maintenance, fault finding, or engineering management of signalling infrastructure managed by Network Rail. This means signal maintenance testers are required to hold the signalling maintenance tester IRSE licence to test signalling equipment.

[25] NR/L2/SIG/10160, 'Specification for Application of the IRSE Licensing Scheme', issue 3, dated 5 December 2020.

180 All three signal maintenance testers had been assessed and were certified to carry out testing under the SMTH process (paragraph 139) so knew what to do, and each held an authority to work from their employer (paragraph 140) which defined what they could test. However, only one of the three testers held the required signal maintenance tester IRSE licence. While the HOTR project checked that each signal maintenance tester proposed for this work held a valid SMTH competency and authority to work, no one questioned why two of the testers did not hold the required IRSE licence.

181 Network Rail does allow signal maintenance testers to work on its infrastructure if they are working towards getting their IRSE licence. At the time of the incident, many signal maintenance testers employed by contractors were doing this, and some had been doing so for a long time. NR/L2/SIG/10160 requires anyone working towards getting their licence to be mentored. The mentor must hold an appropriate IRSE licence relevant to the work undertaken by the unlicensed person, the mentee. NR/L2/SIG/10160 explains that mentoring, in the context of IRSE licensing, is advising and supervising the mentee. This is to check that the mentee understands the processes to be followed and the technical requirements necessary to complete work to an acceptable standard, which can involve the mentor directing the mentee. Until the mentee gains an appropriate IRSE licence, the mentor is responsible for their work and must confirm that the work has been performed correctly.

182 NR/L2/SIG/10160 explains that managing the transition towards competence requires judgement by the mentor. As a mentee gains skills through work experience and training, the need for direct and immediate observation reduces. Once the mentee can work correctly and safely, close supervision can be reduced to more difficult and unfamiliar activities. In some cases, checks can be made by reviewing results and documentation for the work, or by hearing an account from the mentee about how they carried out the work. There is no prescriptive formula for mentoring, so approaches vary across the industry, especially for contract staff. Mentoring for contract staff can also be more challenging as their work can take them from place to place and they may not regularly work with the same people. They may also see less variety in the work they are assigned. Mentoring can also be complicated by some signal maintenance testers working towards their licences already being very experienced in this type of work, so the role of the mentor becomes less clear. However, the two signal maintenance testers who did not hold the required IRSE license were not being mentored to gain their IRSE licence when they were working at Wingfield.

Drawing deficiencies

183 The drawings in location case 141/2 for signal DY586 did not match the drawings held by NRG and contained deficiencies.

184 The copies of the signalling drawings in location case 141/2 had some changes made to them by the local signalling maintenance team following the work to upgrade the signal head in 2015 (paragraph 32). This included providing a circuit diagram drawing to show the wiring arrangement for the new signal head but this was deficient as it was an unmodified typical circuit for an LED signal head. Typical circuits are provided as templates from which a site-specific version should be created. However, no site-specific drawing, showing the wiring arrangement for signal DY586, had been provided.

185 The circuit diagram drawing for the signal's control circuits was also not updated to the current standards following the signal head replacement. For example, it did not show the cable core numbers on it and the required 'L' and 'R' indications were not shown (paragraph 69).

186 Network Rail also reported that no one had recorded that the local copies of the drawings for location case 141/2 were now different to the copies held by NRG. When the local maintenance team carried out the work to upgrade the signal head (as part of a renewal campaign to replace all of the signal heads within the Ambergate interlocking area) it made change to its copies of the drawings for the new signal head, but it did not update the copies held by NRG. If the local maintenance team was not updating the NRG copies, it should have recorded the differences between the two sets of copies on a drawing deficiency form. It should have then submitted the form to the route engineer (signalling) for East Midlands route. Network Rail found that no drawing deficiency forms had been submitted to the route engineer (signalling) for signal DY586, nor for any of the other signals in the Ambergate interlocking, when the work to upgrade the signal heads took place.

Track circuit testing

187 **The functionality of a track circuit on the Up Main line was not tested after ballast cleaning work had taken place on the first night of work at Wingfield.**

188 On the first night of work at Wingfield, the HOTR train cleaned and replaced ballast over a distance of 144 yards (132 metres) on the Up Main line (paragraph 41). Network Rail company standard NR/L3/SIG/19810,[26] 'Signal Engineering Involvement in Track and Civil Engineering Work', applied to this work. The purpose of this standard is to reduce the risk of serious wrong side failures of signalling equipment following track engineering work. It also aims to confirm that signal engineering resources are co-ordinated in support of work on the track, so that signalling equipment is left operationally safe when work on the track is completed.

189 Appendix A of NR/L3/SIG/19810 lists examples of track engineering work that require signal engineering support. One entry states that track circuits must be tested when ballast cleaning work takes place, whether or not the SMTH process is required. The rationale given is that, by changing the ballast, the operation of the track circuit can be affected.

190 To comply with NR/L3/SIG/19810, track circuit T929B on the Up Main line needed to be tested at the end of the first night. There is no record that this test took place and there was no instruction to do this test in the work pack given to the signal maintenance testers. This track circuit was tested the next night by SMT3 after it had been disconnected and reconnected during that night's work.

[26] NR/L3/SIG/19810, 'Signal Engineering Involvement in Track and Civil Engineering Work', issue 3, dated 3 September 2022.

Driver welfare

191 While initial welfare checks were carried out for both drivers, no follow-up face-to-face welfare checks were carried out for the driver of train 5C23.

192 Although shaken by the incident, the driver of train 5C23 agreed with the signaller to move the train a short distance and then call East Midlands Railway control (paragraph 57). At this point, the driver still did not know what had caused signal DY586 to be at red when they approached it at high speed. When the driver spoke to their control staff, the driver was told it was the result of a signalling irregularity. It was only at this point that the driver knew for certain that the incident had not happened as a result of their own actions.

193 Staff in control carried out an initial verbal welfare check on the driver, which included asking the driver if they were fit to continue driving the train. The driver decided that they were fit to continue and advised control that they would continue driving the train to Sheffield, and then take it back to Derby, where they would then finish their driving duty for that day, which was earlier than planned. The driver expected to be met at Sheffield or Chesterfield by a member of the driver manager team to check on their welfare, but this was not arranged as the driver had advised control that they were willing to take the train back to Derby.

194 When the train arrived at Derby, no one was there to meet the driver. The driver then went back to the train crew depot in Derby and sat in the rest room while they completed some forms related to the incident. A driver manager happened to see the driver and it was only then that the Derby driver manager team found out about the incident. Due to the incident being classified as a signalling irregularity which had involved train 1F02, no one in East Midlands Railway control had informed the driver manager team in Derby about the involvement of the driver of train 5C23 in the incident, so no follow-up face-to-face welfare checks had been arranged. Control had informed the Nottingham driver manager team about the incident so face-to-face welfare checks were arranged for the driver of train 1F02 when they arrived back in Nottingham.

Previous occurrences of a similar character

195 Network Rail provided data for previous incidents related to signal maintenance testing, from a system it uses to record signalling related incidents. The data covered the period from the start of 2007 to the end of 2022, around the time the HOTR train has been in operation.

196 There were 379 events reported during this time that were related to testing under the SMTH process. A review found 81 events that related to wiring or cabling issues, of which 5 events directly mentioned HOTR work. These incidents had led to signalling failures involving track circuits and other signalling equipment, but none had involved irregular signal aspects. Another 24 events happened after signalling equipment was disconnected and reconnected for work to take place on the track infrastructure. Some common themes could be seen throughout the 81 events, such as test plans not being followed by the testers, staff being placed under time pressure to complete the testing work and a lack of independence after testers had become involved in the installation work.

197 A further wrong side failure of signalling equipment, related to work for the HOTR project, happened after the Wingfield incident near to Tyne Yard, Newcastle, on 3 December 2022. Staff carried out unplanned work overnight to install new cable disconnection boxes, then connected cables to them, but in doing so crossed the wiring for two track circuits. The lead tester ran out of time to test the work, so handed back one of the two track circuits out of use. As required by the Rule Book, the signaller then monitored the first train to pass over the track circuits and noticed that one of the track circuits did not show the train passing over it. The incident was investigated by Network Rail and it identified issues which included staff competence, a lack of independence between installation and testing work, and poor control of testing activities. After this incident all work on the HOTR project was stopped (see paragraph 221).

198 RAIB's report into a collision at London Waterloo station (RAIB report 19/2018) explains how a set of points, which was not in the correct position, directed a passenger train away from its intended route and into the side of a freight train (figure 18). The train driver and signaller had received indications that the points were correctly set. However, the signalling system did not detect that the points were in the wrong position because staff had made an uncontrolled modification to the signalling system during testing and commissioning activities. The investigation found the actions of the staff involved in this testing work indicated that appropriate non-technical skills were not applied.

Figure 18: The accident at Waterloo.

199 The investigation into the accident at Waterloo, supported by RAIB's investigation of a serious irregularity at Cardiff East Junction (RAIB report 15/2017), suggested that some in the railway industry might be forgetting the lessons learnt from the Clapham Junction accident[27] in which 35 people died (figure 19). This accident, which happened on 12 December 1988, involved three trains colliding just south of Clapham Junction, in London. A train driver received a proceed aspect at a signal which should have been displaying a red aspect, and collided with the train in front which should have been protected by the signal. A third train then collided with the wreckage. The incorrect proceed aspect was shown because inadequate working practices during a re-signalling project had resulted in a loose, uninsulated, redundant wire remaining close to, and eventually coming into contact with, other circuitry.

Figure 19: The accident at Clapham Junction (Christopher Pillitz / Alamy Stock Photo).

200 The Clapham Junction accident is of particular relevance to the incident at Wingfield. Both involved a train driver receiving a proceed aspect at a signal which should have been displaying a red aspect, as there was a train in front which should have been protected by the signal, due to a problem with the signal's wiring after work had taken place on it.

[27] A public inquiry for the fatal accident at Clapham Junction was chaired by Anthony Hidden QC. The report of the investigation, also known as the Hidden report, is available at: http://www.railwaysarchive.co.uk/documents/DoT_Hidden001.pdf

201 The Clapham accident resulted in major changes to how signalling was designed, installed and tested. These changes not only included new processes for work on new or altered signalling, but also included new processes for the maintenance testing of signalling. This is what led to the creation and application of the SMTH process, which remains in place today. RAIB explained in its Waterloo report that it was concerned that the need for rigorous application of these processes was being forgotten as people with personal knowledge of this tragedy retired or moved away from frontline jobs. This deep-seated, tacit knowledge was part of the corporate memory vital to achieve safety. Loss of this type of knowledge was a risk which needed to be addressed by organisations committed to achieving high levels of safety.

202 RAIB has previously carried out two investigations involving testing activities under the SMTH process, both of which involved a set of points. These were at Greenhill Upper Junction (RAIB report 04/2010) and more recently at Dalwhinnie (RAIB report 10/2022). In both cases, signal maintenance testers did not identify wiring errors when the testing was carried out. This was primarily because test plans were not followed, with test steps missed out or not carried out correctly.

Summary of conclusions

Immediate cause

203 Signal DY586 displayed incorrect aspects to the drivers of trains 5C23 and 1F02 because the wiring for its red and yellow aspects was crossed within location case 141/2 (paragraph 59).

Causal factors

204 The causal factors were:

a. The overnight work by the HOTR project introduced a cross-over in the wiring in the location case (paragraph 67, no recommendation).

b. The signal maintenance testers who tested signal DY586, after the cable to the signal was reconnected, did not identify that this cross in the wiring had occurred (paragraph 79, **Recommendations 1 and 2**, **Learning point 1**). This causal factor arose due to a combination of the following:

i. The signalling group was under time pressure because the time available to complete the reconnection and testing work had been reduced (paragraph 105, **Recommendations 1 and 2**, **Learning point 2**).

ii. While SMT1 had overall responsibility for testing the signal, they were not focused on this activity because of the workload that was placed on them (paragraph 118, **Recommendation 3**).

iii. The signal maintenance testers were unfamiliar with the configuration of the signalling equipment at this location. This was a possible factor (paragraph 127, **Recommendation 3**).

Underlying factors

205 The probable underlying factors were:

a. Activities undertaken by Network Rail with the aim to improve the robustness of work carried out on its infrastructure under the SMTH process, which incorporated the training and assessment of the attitudes and behaviours of its signal maintenance testers, had not yet included signal maintenance testers employed by contractors (paragraph 137, **Recommendations 1, 2 and 4**).

b. Network Rail was not carrying out any activities to assure itself that the work undertaken by the HOTR project to disconnect, reconnect and test signalling assets was being completed correctly (paragraph 157, **Recommendation 4**).

Factors affecting the severity of consequences

206 While it was initially unclear why train 5C23 had passed signal DY586 displaying a red aspect, the potential for a collision between the two trains in the same signal section was reduced by the actions taken by the Burton and Derby signallers and the driver of train 1F02 (paragraph 164, **Learning points 3 and 4**).

Additional observations

207 Although not directly linked to the incident on 26 October 2022, RAIB observes that:

a. The SMTH standard does not require the defined test B07 (aspect test) to be recorded by signal maintenance testers (paragraph 173, **Recommendation 5**).

b. Only one of the three signal maintenance testers held the required IRSE licence for testing the signalling equipment at Wingfield (paragraph 177, action already taken (see paragraph 219)).

c. The drawings in location case 141/2 for signal DY586 did not match the drawings held by NRG and contained deficiencies (paragraph 183, action already taken (see paragraph 220)).

d. The functionality of a track circuit on the Up Main line was not tested after ballast cleaning work had taken place on the first night of work at Wingfield (paragraph 187, **Learning point 5**).

e. While initial welfare checks were carried out for both drivers, no follow-up face-to-face welfare checks were carried out for the driver of train 5C23 (paragraph 191, **Learning point 6**).

Previous RAIB recommendations relevant to this investigation

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

Collision at London Waterloo, 15 August 2017, RAIB report 19/2018, Recommendation 1

209 This recommendation reads as follows:

> *Recommendation 1*
>
> *The intent of this recommendation is to ensure that the competence of signalling staff includes the attitudes and depth of understanding that is needed to properly appreciate the importance of applying all the relevant design, installation and testing processes. It is expected that effective implementation by Network Rail will necessitate input from the Institution of Railway Signal Engineers, signalling contractors and other infrastructure managers.*
>
> *Network Rail should take steps to reinforce the attitudes and depth of understanding needed for signal designers, installers and testers to safely apply their technical skills and knowledge. These steps should include:*
>
> - *the education of existing staff and their managers, and future recruits, to promote a better understanding of industry processes, and an improved understanding of how the lessons learnt from previous accidents have shaped today's good practice;*
> - *the enhancement of processes for the assessment, development and ongoing monitoring of the non-technical skills of signal designers, installers and testers; and*
> - *measures to monitor and encourage compliance with process, and safe behaviours on projects.*

210 While this recommendation related to an investigation that was focused on signal works testing handbook activities, the Wingfield investigation has shown how the changes that were called for by this recommendation equally applied to those staff involved in signal maintenance testing.

211 In March 2022, ORR reported in its role as the safety authority that this recommendation had been implemented following work by Network Rail, which it noted to be a diverse programme of work aimed at ensuring the competence of signalling staff. Actions reported by Network Rail had included publishing modified standards, a module covering staff competence, and its e-learning modules for non-technical skills (paragraph 152). Another action by Network Rail was to engage with senior management at its signalling related suppliers, to establish points of contact and share its experiences. Network Rail had also gained the support of the IRSE, with the IRSE publishing articles supporting non-technical skills, deciding that its focus for the year 2022 to 2023 would be on competence and behaviours, and revising behavioural assessments for IRSE licences.

212 The actions taken by Network Rail were aimed at making sure its staff had the attitudes and depth of understanding needed to properly appreciate the importance of applying all the relevant design, installation and testing processes. Network Rail also wanted to prompt a culture change where people reflected on their actions and the limits of their competence and capability when working on signalling systems. Network Rail had reported to ORR that there had been a positive engagement with the programme by its staff, and that it had seen a reduction in incidents attributed to behaviour such as ignoring processes or standards.

213 The implementation of this recommendation was focused on staff carrying out activities under the signal works testing process, but Network Rail recognised that staff carrying out activities under the SMTH process also need the same attitudes and depth of understanding to properly appreciate the importance of applying all the relevant installation and testing processes. Consequently, Network Rail developed its non-technical skills training course so that it applied to all testing activities on its signalling. It had then given this training to all its staff who held the SMTH competency (paragraphs 151 and 152), but SMTH competency holders working for contractors, like those working at Wingfield, had not received this training.

Collision at London Waterloo, 15 August 2017, RAIB report 19/2018, Recommendation 2

214 This recommendation reads as follows:

> *Recommendation 2*
>
> *The intent of this recommendation is for OSL to implement actions already started (paragraphs 197 and 198) in respect of non-technical skills relevant to its staff in advance of any relevant actions triggered by implementation of Recommendation 1.*
>
> *OSL Rail Ltd should enhance its existing processes for the assessment, development and ongoing monitoring of those staff who undertake signalling works so as to ensure that they have the depth of understanding, attitudes and non-technical skills that are needed to deliver work safely. Areas of enhancement should include the skills needed for effective communication and safe decision making in complex project environments.*
>
> *This recommendation may apply to other signalling design, installation and testing organisations.*

215 In March 2022 ORR reported that OSL had undertaken a programme of work aimed at improving the non-technical skills of its staff through training, briefing and assessment. It also noted that OSL was engaging with the wider signalling industry through chairing an industry forum for signalling and telecommunications engineers. After reviewing the information provided to it, ORR concluded that OSL had taken the recommendation into consideration and taken action to implement it.

216 The implementation of this recommendation was focused on staff working for a contractor who were carrying out activities under the signal works testing process when the accident happened. While RAIB did note that this recommendation may apply to other signalling design, installation and testing organisations, it could equally apply to organisations who provided Network Rail with resources to carry out activities under the SMTH process.

Recommendations that are currently being implemented

Wrong side signalling failure and derailment at Dalwhinnie, Badenoch and Strathspey, 10 April 2021, RAIB report 10/2022, Recommendation 5

217 This recommendation partly addresses one of the factors identified in this investigation, which is the signal maintenance testers who tested signal DY586 did not identify the internal wiring cross. This was because the testing of the signal was incomplete, with test steps missed, and none of the group had recorded the progress of this testing. To avoid duplication, it is not remade in this report. For completeness, this recommendation reads as follows:

Recommendation 5

The intent of this recommendation is to reduce the likelihood of essential signal maintenance testing tasks being overlooked and not completed.

Network Rail should review its arrangements for recording progress when carrying out testing defined in its signal maintenance testing handbook. This should take into account environmental and other challenges relevant to the workplace and make enhancements that ensure practical contemporaneous recording of:

- *the completion of each test step*
- *relevant test results, measurements, and findings.*

218 This investigation report was published on 26 September 2022. At the time of writing this report, RAIB has not yet received a response from ORR explaining what Network Rail is planning to do in response to this recommendation.

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

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

IRSE licences

219 Network Rail has taken action to enforce the requirement in NR/L2/SIG/10160 that all signal maintenance testers and installers working on its infrastructure must hold the required IRSE licence (paragraph 177). When the HOTR project's Central depot recommenced work after the post Tyne Yard incident hiatus (paragraph 197 and see paragraph 221), it could not find sufficient resources that met this criterion to carry out its signalling related work using the SMTH process. Consequently, the Central depot signalling team implemented a process based on signal works testing processes, with a tester in charge[28] on site who manages all the signalling related activities. Other HOTR project depots continue to work using the SMTH process, resourcing their signalling related work using a mix of Network Rail staff and contractors who hold the required IRSE licences.

Drawing deficiencies

220 The route engineer (signalling) asked the local maintenance team to create and submit drawing deficiency forms for all the signals in the Ambergate interlocking that were fitted with LED signal heads in 2015 (paragraph 32). This has been done, so these forms record the differences between the local and NRG copies of the drawings. The local maintenance team has requested that the drawings are updated and is planning to submit revised copies to NRG.

Other reported actions

221 After the incident near Tyne Yard (paragraph 197), the HOTR project stopped all work and carried out a safety review. It suspended its work for 17 weeks while the HOTR project decided what safety assurance activities it needed to implement. It recommenced work in April 2023, but only after getting permission from the route engineer (signalling) on the route where the work was to take place. This involved the HOTR project explaining to the route engineer (signalling) what actions it had taken and gaining their sign off to start work again. One of the requirements for sign off by the route engineer (signalling) was that all staff working on signalling related activities on HOTR project sites held the required IRSE licences.

222 Another action the HOTR project took while in hiatus was to introduce an engineering verification process which covers all its engineering disciplines, although it currently has a focus on signalling related activities. Staff in supervisory roles are required to plan and carry out at least one assurance check each period. These include a mix of office-based and on-site checks which follow a checklist approach. In the three periods (about 12 weeks) since work restarted, it has carried out 84 checks, with 25 of these focused on signalling related work.

[28] The signalling engineer with overall responsibility for the correct testing and commissioning of a new or altered signalling system.

223 The HOTR project has produced a signal testing form for its testers to use to record test B07, the aspect test (paragraph 86). This gives testers working on the HOTR project a way of tracking and recording what steps in test B07 they have completed. The completed form also provides the HOTR project with a detailed record for any signals that were tested during its work.

224 Bridgeway reported that since the incident:

- All its staff working in signalling related roles have received the same non-technical skills training as Network Rail SMTH competency holders (paragraphs 152 and 153).
- It has updated its worksafe procedure (paragraph 116), safety behaviours charter and staff induction, to encourage its staff to invoke the worksafe procedure should they feel pressured to take shortcuts to complete work due to time constraints.

225 In 2023 Network Rail began consulting other organisations in the rail industry about its plans to add the SMTH competency to the competencies which are recorded on Sentinel, which is its system for managing the competence of staff, including contractors, working in certain safety-critical roles. This will provide a standard format for SMTH competency certification. At present, each training provider issues its own certificates, which vary in format and level of detail.

226 Network Rail is also planning to standardise the training course for signal maintenance testers. Under the present arrangements, each training provider decides on the length of their training courses and exactly what is covered by it. Network Rail plans to provide a standard syllabus for this training, so all training providers cover the same subject areas. The syllabus will also include an element of non-technical skills training. Network Rail is then intending to provide standardised training and assessment materials for the training providers to deliver, along with a common assurance framework which is being developed in collaboration with other industry parties. Network Rail also has plans to standardise the format and information on the authority to work that is held by each signal maintenance tester (paragraph 140). At present, the current authority to work documents produced by employers vary significantly in terms of their format and the level of detail shown.

Recommendations and learning points

Recommendations

227 The following recommendations are made:[29]

1 *The intent of this recommendation is to ensure that the competence of all signal maintenance testing staff at Bridgeway Consulting Limited includes the attitudes and depth of understanding needed to effectively apply signal maintenance testing processes.*

Bridgeway Consulting Limited should take steps to enhance its existing processes for the assessment, development and ongoing monitoring of those staff who undertake signal maintenance testing on Network Rail infrastructure. These steps should:

a. give signal maintenance testers the depth of understanding, attitudes and non-technical skills that are needed to deliver their work safely

b. provide testers with the specific skills they need for effective communication, safe decision-making, and safe behaviours such as maintaining compliance with processes, particularly when placed under time or other pressures

c. implement measures to monitor and promote compliance with relevant processes, procedures and rules (paragraphs 204b, 204b.i and 205a).

2 *The intent of this recommendation is to ensure that the competence of all signal maintenance testing staff at Randstad Solutions Limited includes the attitudes and depth of understanding needed to effectively apply signal maintenance testing processes.*

Randstad Solutions Limited should take steps to enhance its existing processes for the assessment, development and ongoing monitoring of those staff who undertake signal maintenance testing on Network Rail infrastructure. These steps should:

a. give signal maintenance testers the depth of understanding, attitudes and non-technical skills that are needed to deliver their work safely

[29] 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.gov.uk/raib.

b. provide testers with the specific skills they need for effective communication, safe decision-making, and safe behaviours such as maintaining compliance with processes, particularly when placed under time or other pressures

c. implement measures to monitor and promote compliance with relevant processes, procedures and rules (paragraphs 204b, 204b.i and 205a).

Recommendations 1 and 2 may apply to other organisations with staff who carry out signal maintenance testing.

3 *The intent of this recommendation is to reduce the risk of pre-planned maintenance testing activities not being executed correctly due to the workload of staff who have the overall responsibility for the testing.*

Network Rail should review the workload placed on signal maintenance testers who are given the lead tester role for pre-planned work under the signal maintenance testing handbook process. The review should consider suitable criteria to determine when a lead tester should focus solely on leading the testing, and not undertake other roles, by considering thresholds for workload factors such as:

- how many testing teams the lead tester will be managing
- how the tester and installer resources will be allocated to the work
- how familiar the lead tester is with the signalling equipment and location where the work is taking place
- how much time the lead tester will be given in advance to plan how the installation and testing work will be executed
- the number of people or organisations the lead tester will need to communicate with while the work is taking place
- what other non-testing duties the lead tester will be required to carry out, such as safety responsibilities for the team.

The findings of this review should be used as required to produce appropriately updated rules, guidance and training for staff undertaking the lead tester role for pre-planned work under the signal maintenance testing handbook process (paragraphs 204b.ii and 204b.iii).

4 *The intent of this recommendation is to reduce the risk of signalling assets being placed into service in an unsafe condition after high output track renewals work.*

Network Rail should implement measures to assure itself that signal maintenance testing carried out on its signalling assets, by the testers it contracts to do this work on its high output track renewals project, is being completed in accordance with the requirements of its signal maintenance testing handbook. These measures should encompass checks on the technical skills of the testers and the quality of their testing work, as well as criteria which will allow it to be established if testers are displaying the required attitudes and non-technical skills needed to deliver their work safely and effectively (paragraphs 205a and 205b).

This recommendation may apply to other parts of Network Rail's organisation that carry out project-based renewals or maintenance activities which use the signal maintenance testing process to test any affected signalling assets as part of their work.

5 *The intent of this recommendation is to reduce risk of a signal being placed into service when all steps in the defined maintenance test plan for testing signal aspects have not been carried out.*

Network Rail should provide signal maintenance testers with a means of recording progress when carrying out NR/SMTH/Part 03/Test B07 'Defined Test: Aspect Test' so that they can record that all aspect permutations have been tested and that all test steps have been completed (paragraph 207a).

Learning points

228 RAIB has identified the following important learning points:[30]

1 Signal maintenance testers are reminded that signal maintenance testing processes exist to maintain the safety integrity of the signalling system. The importance of these established processes, and the potential for unsafe events to occur when they are not followed correctly, is demonstrated by the events at Wingfield. It is important that maintenance test plans are referred to during the testing, and that all the required test steps are completed correctly (paragraph 204b).

[30] '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.

2 Staff working in management or supervisory roles are reminded of the importance of not placing signal maintenance testers under undue time pressure to complete their testing, especially when the allocated time for the testing has been reduced by other work overrunning. Staff in these roles are reminded that although they might themselves be under considerable pressure due to the work overrunning, testers must be allowed to follow the signal maintenance testing handbook processes to maintain the safety integrity of the signalling system (paragraph 204b.i).

3 Events at Wingfield highlight the importance of communication between signallers and train drivers when an incident occurs. Prompt action by a signaller to inform a train driver approaching an area where an incident has happened can allow trains to be slowed down, and for driving styles to be adjusted accordingly (paragraph 206).

4 Events at Wingfield highlight the importance of signallers and the drivers of trains that have passed a signal displaying a red aspect without authority coming to a clear understanding about what has happened. Drivers unexpectedly passing a signal displaying a red aspect are very likely to refer to this as a SPAD, a commonly used term for a signal passed at danger, regardless of the reason. As signallers often associate the term SPAD with driver error, they might not then consider any other possible reasons for the signal being passed at danger (paragraph 206).

5 Staff responsible for the maintenance testing of signalling equipment, who are rostered to be on site when track engineering activities are taking place, are reminded that the operation of track circuits can be indirectly affected by this type of work even if the track circuits are not disconnected and reconnected. Network Rail standard NR/L3/SIG/19810, 'Signal Engineering Involvement in Track and Civil Engineering Work', explains the scenarios when this can happen, such as when the work on the track changes the condition of the ballast. It also explains the requirement to then test the affected track circuits to confirm they are left operationally safe when the work is completed, which reduces the risk of a wrong side failure (paragraph 207d).

6 Staff working in control rooms for train operating companies are reminded of the importance of considering the post-incident welfare of all drivers who have been involved in a signalling irregularity, not just in terms of checking their fitness to continue driving duties, but also to alert the relevant driver manager team so that follow-up face-to-face welfare checks can be arranged and carried out (paragraph 207e).

Appendices

Appendix A - Glossary of abbreviations and acronyms

AWS	Automatic warning system
CCTV	Closed-circuit television
EMCC	East Midlands Control Centre
HOTR	High output track renewals
IRSE	Institution of Railway Signal Engineers
LED	Light emitting diode
NRG	National Records Group
ORR	Office of Rail and Road
RAIB	Rail Accident Investigation Branch
SMTH	Signal maintenance testing handbook
SPAD	Signal passed at danger
SPRS	Signal post replacement switch
TPWS	Train protection and warning system

Appendix B - Investigation details

RAIB used the following sources of evidence in this investigation:

- information provided by witnesses
- site photographs
- voice communication recordings
- CCTV recordings taken from both trains
- information taken from the trains' on-train data recorders
- data recorded by loggers within the signalling system
- documentation for the layout and configuration of the signalling system
- testing and maintenance records for signal DY586
- Network Rail company standards related to signal maintenance testing
- training and assessment material for the signal maintenance testing competency
- competency management and training records for the staff involved
- documentation for the planning and delivery of the HOTR work at Wingfield
- weather reports and observations at the site
- a review of data for previous incidents involving the signal maintenance testing process
- a review of previous RAIB investigations that had relevance to this incident.

This page is intentionally left blank

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

Any enquiries about this publication should be sent to:

RAIB
The Wharf
Stores Road
Derby UK
DE21 4BA

Email: enquiries@raib.gov.uk
Telephone: 01332 253300
Website: www.raib.gov.uk