



Report 15/2017
October 2017

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- the Railway Safety Directive 2004/49/EC;
- the Railways and Transport Safety Act 2003; and
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Preface

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

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

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

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

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

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

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

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

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Serious irregularity at Cardiff East Junction, 29 December 2016

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Summary

Over the Christmas and New Year period from 24 December 2016 to 3 January 2017, Network Rail carried out extensive resignalling and track remodelling work in and around Cardiff Central station. This was the final stage of the Cardiff area signalling renewal scheme, a project which has been in progress for several years. This stage involved the closure of the power signal box at Cardiff, with control of the signalling in the area moving to the Wales Railway Operating Centre (WROC), and changes to the track layout and signalling on the east side of Cardiff Central station.

Some of the new layout was brought into use on 29 December. At 08:37 hrs on that day, the driver of a train from Cardiff Central to Treherbert, which had just left platform 7, noticed that points in the route his train was about to take were not set in the correct position, and stopped the train just before reaching them.

The points at which the train stopped were redundant in the new layout, and should have been secured in readiness for their complete removal at a later date. The project works required eight sets of points in two separate locations to be secured. In the event only six of the eight points were secured, and the line was re-opened to traffic without the omission having been identified by the testing team through the normal checking processes which should take place as part of this type of work. The two sets of points which were missed were left in a condition in which they were unsecured and not detected by the signalling system, and the points at which the train stopped were set for the diverging route. If the driver had not noticed the position of these points and stopped, the train would have been diverted on to a line which was open to traffic, on which trains can run in either direction, and on which another train passed over about three minutes after the train involved in the incident came to a stop. The new signalling system uses axle counters for train detection, and in this situation the system would not have immediately identified that the train was in the wrong place.

The points had been left in this unsafe condition because they had not been identified as requiring securing by the team securing points during the works. Furthermore, no one had checked that all the points that needed to be secured during the works over the Christmas period had been. Route proving trains, a performance and reliability tool used to ensure the system was working correctly before running passenger services, had been cancelled.

The investigation also found that a work group culture had developed between long standing members of the project team that led to insular thinking about methods of work and operational risk. This meant that team members relied on verbal communications and assurances. An underlying factor was insufficiently thorough project governance and a possible underlying factor was ineffective fatigue management.

In this case, no-one was injured and no damage was caused by the event, and Network Rail acted quickly to secure both sets of points.

RAIB has identified four learning points and made three recommendations. The learning points relate to the need for testers in charge to be able to confirm that all redundant wiring and equipment has been checked; the need for each intermediate state in which the railway is to operate before completion of the scheme to have an up to date and correct signalling scheme plan reflecting the true state of the layout; the need to mitigate the effect of cancelling route proving trains at the end of commissioning works; and the need to carefully consider the value and purpose of team briefings relating to large scale works to avoid people being overloaded with superfluous information.

Three recommendations have been made, all directed to Network Rail. The first relates to the need for good project governance to ensure a project complies with guidance, procedures and processes to enable the railway to be handed back after works are completed in a safe state to resume operational service. The second is concerned with document management systems, and the third recommendation deals with fatigue management for people working on projects and commissioning, recognising that fatigue in the workplace needs to be managed and mitigated, not just the risk of workers suffering fatigue while travelling to and from their place of work.

Introduction

Key definitions

- 1 Metric units are used in this report, except when it is normal railway practice to give speeds and locations in imperial units. Where appropriate the equivalent metric value is also given.
- 2 The report contains abbreviations and technical terms (shown in *italics* the first time they appear in the report). These are explained in appendices A and B. Sources of evidence used in the investigation are listed in appendix C.

The incident

Summary of the incident

- 3 At 08:37 hrs on 29 December 2016, approximately one minute after leaving platform 7 of Cardiff Central station, the driver of the 08:36 hrs service from Cardiff Central to Treherbert (train reporting number¹ 2T08), stopped his train approximately three metres short of 817A points (figures 1 and 2). This was because he had noticed that the points were incorrectly set for the route the train was supposed to take.

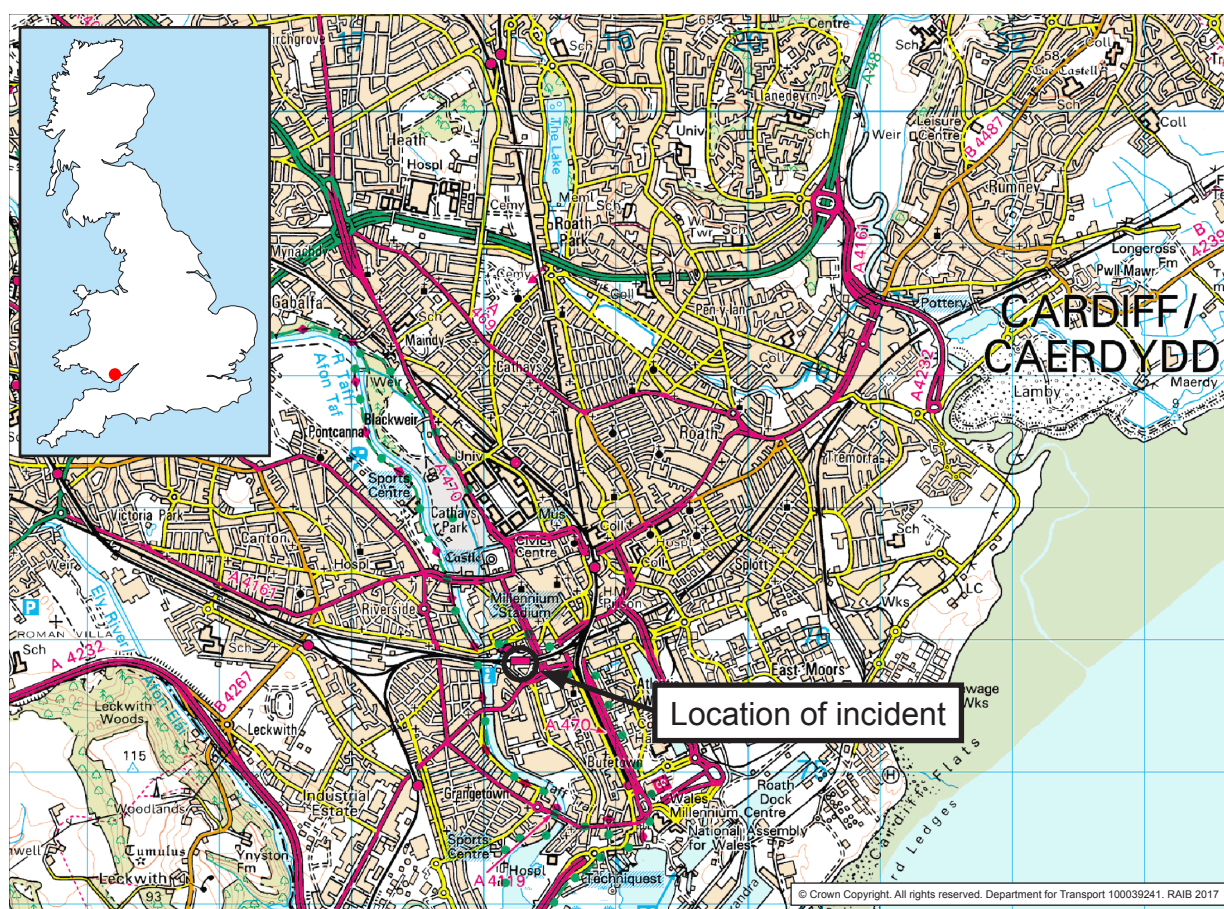


Figure 1: Extract from Ordnance Survey map showing Cardiff Central station and surrounding area

- 4 Train 2T08 was the first train on this route since the re-opening of the line after project works on the track and signalling over the Christmas period.
- 5 The driver contacted the Valleys workstation signaller at the Wales Railway Operating Centre (WROC), and alerted the signaller to the problem.
- 6 The signaller initially had difficulty identifying the location at which the train was located, as 817A points were not shown on his screen. Once the signaller had established where train 2T08 was standing, he made arrangements for the points to be correctly secured so that the train could continue on its journey.

¹ An alphanumeric code, known as the 'train reporting number', is allocated to every train operating on Network Rail's infrastructure.

- 7 817A points had been left unsecured, *undetected* and in the wrong position at the end of the works, earlier on the same day. They were due to be removed as part of final project works taking place during the Easter period in 2017. In the position in which the points were lying, train 2T08 would have been routed onto the former down relief line, which became line E as part of the works, and will be referred to as line E throughout this report.
- 8 817B points at the other end of the same *crossover* (figure 3) had also been left unsecured and undetected in the layout. However, this end of the crossover had been left set in the correct position for trains to pass along line E. 817B points were to be removed as part of the works carried out by 3 January 2017.
- 9 Line E was signalled for train movements in both directions, and at the time of the incident it had a 15 mph (24 km/h) temporary speed restriction in place.



Figure 2: Overview of the lines out of Cardiff Central station showing the location of 817 points

- 10 There were no casualties, no damage and only a short delay caused as a result of the incident.

Context

Location

- 11 The train stopped approximately three metres west of 817A points on the *Up Llandaff line*, a location which is measured as 170 miles and 18 chains² from Paddington (via Gloucester).

Organisations involved

- 12 Network Rail is the owner, operator and maintainer of the infrastructure as well as the principal contractor for the re-signalling works in the Cardiff Area Signalling Renewals (CASR) project. It employed the signallers and other staff at the WROC, the senior project manager, the designated project engineer, the senior construction manager and other project staff.

² A chain is a unit of length, equal to 22 yards (about 20 metres).

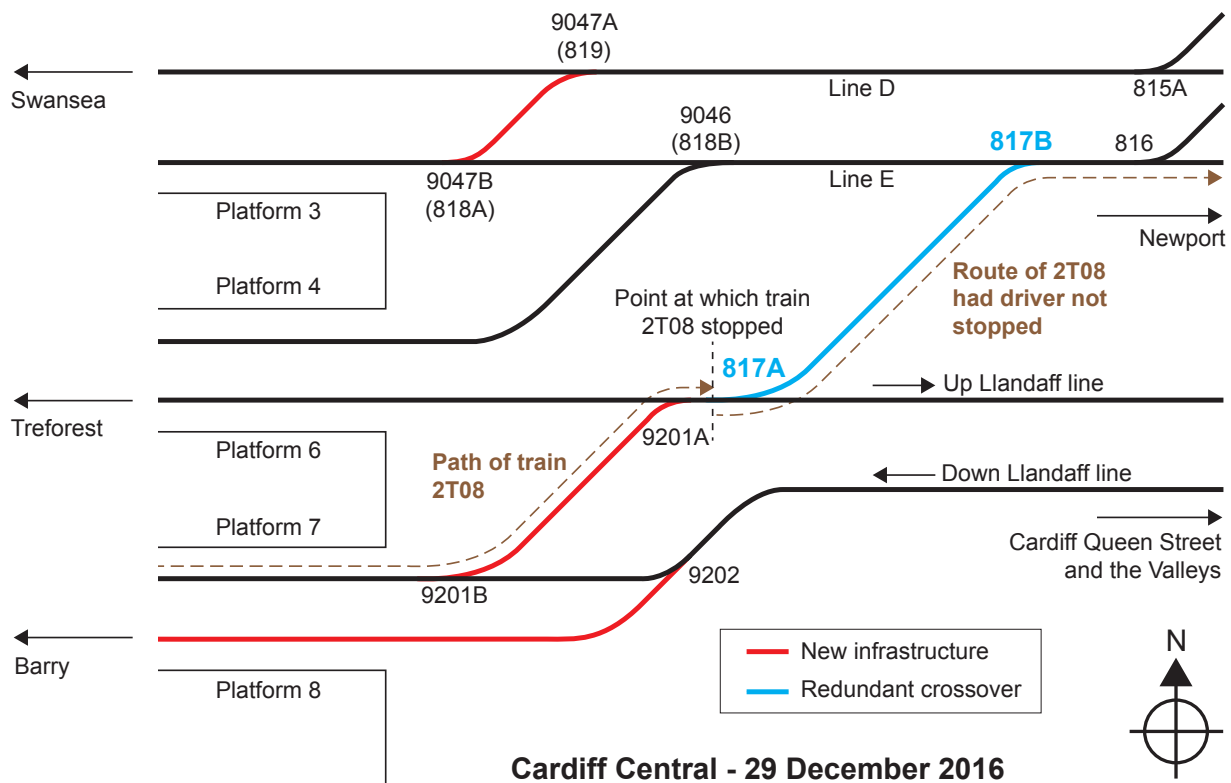


Figure 3: Simplified track layout showing the area and the location of 817 points

- 13 Atkins was responsible for the design, construction, testing and commissioning of signalling and power and distribution works for the CASR project, and employed the tester in charge.
- 14 Balfour Beatty was responsible for the design, construction, testing and commissioning of the permanent way works for the CASR project, and employed the contractors' responsible engineer.
- 15 Arriva Trains Wales was the operator of train 2T08, and employed the train crew.

Trains involved

- 16 In addition to train 2T08, two other trains ran over unsecured points. These were train 1V02, the 05:37 hrs Cross Country service from Birmingham New Street to Cardiff, which passed over line E and 817B points in the *down* direction at around 08:24 hrs, and train 1L34, the 07:37 hrs Great Western Railway service from Swansea to London Paddington, which departed from platform 4 a few minutes late at 08:40 hrs, and travelled over line E and 817B points in the *up* direction.
- 17 There is no evidence that the condition or operation of any of the trains contributed to this incident.

Rail equipment/systems involved

- 18 Network Rail's CASR project began in 2006. It followed on from previous work to resignal the Newport and Port Talbot areas, and involved the renewal of the signalling over a large area of South Wales, remodelling of the track layout and provision of additional capacity at Cardiff Central station, and the transfer of control of signalling on the routes concerned to the new WROC. The final stage of the project covered changes to the area around Cardiff Central station and the main line as far as Pontyclun, and the final closure of the Cardiff power signal box.
- 19 Following this work, all the signalling in the area was to be controlled from the WROC, where signallers use workstations with display screens, which show the relevant track layout, points, crossings and signals, to operate discrete geographic areas of the railway. At Cardiff Central station, the Cardiff Mainline workstation controls platforms 0 to 3 (including lines A to E), and the Valleys workstation controls platforms 4 to 8 (including the up and down Llandaff lines).
- 20 To facilitate the works various lines in the area were closed (known as a blockade), and it was during this period that the incident occurred. This was part of the fifth and final stage of the CASR project and took place between 24 December 2016 and 3 January 2017.
- 21 The work during the blockade was completed in sub-stages to enable some trains to run on some of the lines through Cardiff Central station, between 29 and 31 December 2016. Originally this was to enable a limited number of freight trains to run to provide fuel for a power station. However, the opportunity was taken by the train operating companies to run passenger services through the area during this time.
- 22 During this period, the trains used the former down relief line as a bidirectional single line. This line was re-laid on 2 January 2017 and was renamed line E.
- 23 817A and 817B points formed a crossover between Line E and the Up Llandaff line. They were power operated and had been controlled from Cardiff power signal box, which was decommissioned at the beginning of the Christmas blockade. These lines were due to close again on 31 December for further works to be completed, after which all the lines would be re-opened through the area and a number of temporary speed restrictions would be lifted.

Staff involved

- 24 The driver of train 2T08 joined Arriva Trains Wales in May 2013, and qualified as a driver in January 2014. The driver passed his route familiarisation training for the CASR stage 5 works in September 2016 and all his evidence of competency was up to date.
- 25 The signaller on the Valleys workstation at WROC had worked for 25 years as a signaller. He had worked in Cardiff power signal box from February 2004 until April 2013, when he transferred to the WROC. His evidence of competency was up to date and he was trained to work the control system that had been installed as part of the CASR project.
- 26 The Mainline workstation signaller at WROC had been a signaller for nine years. He had worked in the WROC since December 2012 and was trained on both the control systems in the WROC. His training and competencies were up to date.

- 27 The shift signalling manager had 18 years' service with Network Rail, and had been a signaller between May 1998 and September 2012, when he became shift signalling manager.
- 28 The CASR senior project manager in post at the time of the incident joined Network Rail in 2009 as a graduate trainee on a project management scheme. He had various placements and secondments and in 2014 he was promoted to Senior Project Manager for CASR, but retained his role of programme manager for the project.
- 29 The designated project engineer (DPE) joined British Rail (BR) as a graduate engineer in 1993. He worked in railway signal engineering throughout his career, and after some time working for another contractor, he joined Network Rail on the CASR project in 2014 as DPE after phase 2 commissioning. The DPE's relevant competencies were up to date and he had a valid authority to work.
- 30 The senior construction manager (SCM) had worked in the railway industry for 30 years. He started as an apprentice electrician, then went to work in various parts of the railway industry including overhead line, property, operations and signalling. He had been on the CASR team in the same role since the beginning of the project.
- 31 The tester in charge (TIC) had been in the railway industry for 24 years. He was a testing and commissioning engineer for Atkins and had been a TIC for 17 years. Over the last eight years, he had worked as TIC for CASR and previously on the Newport re-signalling. The TIC's competencies were up to date and he had a valid licence.

External circumstances

- 32 The sunrise on 29 December was at 08:18 hrs. At 08:20 hrs the temperature was 0°C, with a wind chill of -2.5°C. It was damp and misty.
- 33 At 08:37 hrs, the early morning daylight was sufficient to allow the driver to see that the points were set in the wrong direction and stop his train short of them.
- 34 Earlier, darkness may have been a factor in the events that led to the points not being secured during the works.

Background information

- 35 The CASR project was organised in the form of a 'hub and spoke' arrangement. Network Rail, as client, also acted as the principal contractor and engaged various contractors to undertake the packages of work required to complete the different aspects of the project. Network Rail engaged its own internal work provider to undertake some pieces of work that had been omitted from the packages covered by the contractors, and also used its construction team to undertake other miscellaneous items of work not covered by other areas.

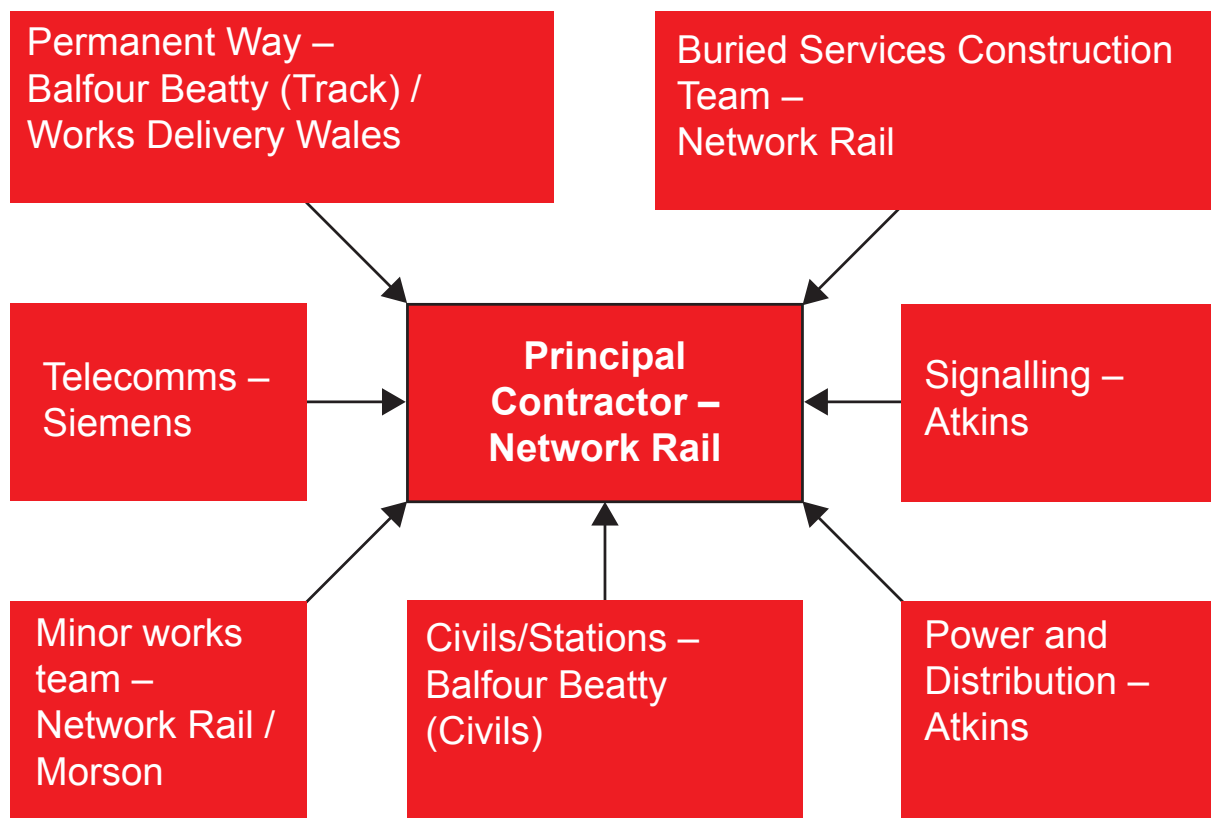


Figure 4: Diagram to illustrate the contracting arrangements for the CASR project

- 36 Network Rail was responsible for the integration, co-ordination, overall management and assurance of the project works. Network Rail set the standards to which the project was designed, installed and commissioned, and was responsible for ensuring compliance.

The sequence of events

Events preceding the incident

- 37 Before the main blockade, which started at 22:00 hrs on 24 December, key staff from the Network Rail, Atkins and Balfour Beatty project teams provided a briefing for the managers and team leaders on the project team who would be working during the blockade period. Due to the numbers of people involved and the fact that many of those working on the project worked shifts, the briefing was delivered in three sessions.
- 38 The briefing consisted of 123 slides, covering all aspects of the work, and health and safety information. It was presented by a number of different people.
- 39 One slide covered the need to secure and lock points and listed seven relevant *point ends* at Cardiff East Junction immediately to the east of Cardiff Central station, and at the Miskin loops, which are on the main lines about 16 km (10 miles) west of Cardiff (figure 5). The list had been copied from the project's Commissioning Management Plan, from which one of the eight required point ends (817B) was missing.
- 40 At 11:36 hrs on 28 December 2016 the SCM received an email from the contractor's responsible engineer (Balfour Beatty) who was checking that two redundant sets of points at Cardiff East Junction (816 and 815B) would be locked and secured out of use, as these points affected Balfour Beatty's scope of works. The SCM took the two point ends listed in this email to be all the point ends that required securing at Cardiff East Junction.
- 41 Later, the SCM briefed his works team that 816 and 815B were the points that needed securing as part of the night's works during the early hours of 29 December. This was the final shift before the temporary handback into operational service of the Vale of Glamorgan and Valley lines, as well as some of the lines through Cardiff Central station, including line E (see figure 5).
- 42 At around midnight on 28/29 December the SCM accompanied his team to secure the points at Cardiff East Junction. He took photographs of the points that had been secured (816 and 815B) and sent them to the TIC as evidence that the work had been completed. He then contacted the TIC by phone and confirmed that the points at Cardiff East Junction had been secured.
- 43 During the midnight project progress conference call, the signalling contractor declared that the blockade would overrun due to a damaged cable. The senior project manager, DPE, SCM and TIC all became involved in trying to develop a workable contingency plan to see if they could find a way of opening part of the railway on time.

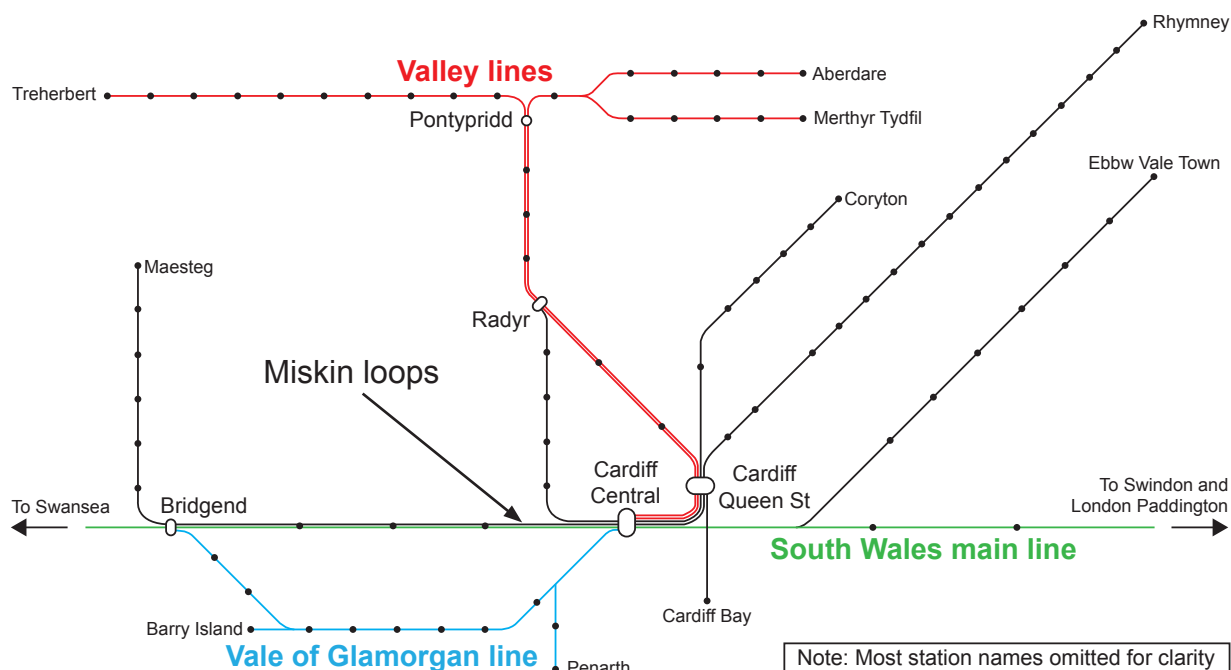


Figure 5: Map showing the Valley, Vale of Glamorgan and main lines out of Cardiff

- 44 At 03:00 hrs the senior project manager decided that it was not practicable to implement any of the contingency plans, and the pressure on the team was creating too much stress. Rather than continuing to struggle to open the railway at the time originally planned, with agreement from Network Rail's operational management, they decided to declare that the project works would overrun by four hours. He then checked whether the redundant points had been secured. The SCM confirmed that the points at Cardiff East Junction had been secured, but not those at Miskin loops. The senior project manager asked the SCM to go to the Miskin loops and secure four point ends there.
- 45 The SCM and his team secured the four point ends at Miskin loops, took photographs, sent them to the TIC and verbally confirmed to the TIC that the four ends had been secured.
- 46 The senior project manager asked the TIC whether he was content that the redundant point ends at Cardiff East Junction had been secured. The TIC replied that although he had not checked the evidence, he was happy that he had received confirmation that they had been secured.
- 47 The senior project manager then asked the TIC if he was happy that the redundant point ends at the Miskin loops had been secured. Again the TIC explained that he had not had time to go through the evidence, but that he had confirmation that they had been secured. The senior project manager and the TIC listed the four ends that they believed had needed to be secured.
- 48 At around 04:00 hrs the senior project manager then contacted the SCM to check that all the points at Cardiff East Junction and the four ends at the Miskin loops had been secured. The SCM confirmed that all the point ends had been secured.

Events during the incident

- 49 The Valley lines and lines through Cardiff Central were handed over by the CASR project and opened for traffic at 07:50 hrs. The first train over line E was 1V02, the 05:37 hrs service from Birmingham to Cardiff Central, which ran over 817B points and into platform 3 at around 08:24 hrs. At 08:36 hrs, train 2T08 departed from platform 7, and approached 817A points. The driver noticed that, although the signal at the end of platform 7 had shown an indication routing the train towards the Up Llandaff line, these points were set to divert his train towards line E. He knew, even taking into account the recent changes to the track layout, that this was not a possible route for the train to take to reach Treherbert, so he stopped his train short of the points and contacted the signaller at the Valleys workstation in WROC.
- 50 The driver advised the signaller that his train was stationary and that the points ahead were wrongly set. The signaller was initially unable to identify what points the driver was referring to, because the redundant crossover formed by 817A and 817B points was not shown on the workstation screen that he was using. However, as he had previously worked at the former Cardiff signal box (paragraph 25), he remembered the previous track layout and was able to deduce that the train must be at the redundant 817A points. He told the driver to remain where he was, and consulted the shift signalling manager at WROC at 08:38 hrs.
- 51 The shift signalling manager told the signaller to stop all trains in the area covered by the Valleys workstation. However, there were no other trains in that area at the time. A short time later, at about 08:40 hrs, train 1L34 departed from platform 3 and passed over 817B points in the trailing direction. These points were on the section of line now controlled by the Mainline workstation.

Events following the incident

- 52 Once the driver of train 2T08 had alerted the Valleys workstation signaller to the problem with the points, the signaller contacted the project team and asked them to come to site to establish how 817A points were set and to rectify the situation.
- 53 The SCM and his team arrived at the points by 08:45 hrs. They set 817A points to the correct position and *clipped and padlocked* them. They also noticed that 817B points were unsecured, and took action to secure them.
- 54 At 08:56 the SCM confirmed to the signaller that the points were in the correct position and secured, and that his team was clear of the track and the railway was safe for trains to run. Train services resumed on the Valley lines at 09:05 hrs.

Key facts and analysis

Identification of the immediate cause

55 The CASR Project team handed back 817A and 817B points in an unsafe condition.

56 The project team handed the railway back into operational service without points 817A and 817B being secured in the correct position. Both sets of points were unsecured, and undetected by the signalling system. Points 817B were lying in the correct position for trains on line E to travel over, but points 817A were lying in the position which would divert trains over the redundant crossover. Consequently, the signalling system would not prevent a train routed over 817A points coming into conflict with trains on other signalled routes.

Identification of causal factors

- 57 The incident occurred due to a combination of the following causal factors:
- a. the SCM did not identify all the points requiring to be secured to the team securing them (paragraph 58); and
 - b. among the members of the project team, the responsibility for checking the securing of redundant points was not clearly allocated or understood, and they did not make arrangements for these checks to be made (paragraph 63).

Each of these factors is now considered in turn.

Identification of points for securing

58 The SCM did not identify all the points requiring to be secured to the team securing them.

- 59 The SCM read the email he received regarding the redundant points that Balfour Beatty required securing, and took this to be the full list of all the points that needed securing at Cardiff East Junction. He did not check this against any other information, though it is not clear what, if any, documents he could have used (see paragraph 61). The RAIB considers that it is likely that he did this because of a combination of the lack of a single source of information, and fatigue (see paragraph 62).
- 60 There was no single project document with a complete list of all the points that required securing. They were not listed in the minutes of the review meetings, nor in any method statement, works package plan or action from any other meeting. In contravention of Network Rail company standard NR/L2/SIG/11201 Issue 10 'Signalling Design Handbook', section 15.3, individual *signalling scheme plans* had not been produced for the sub-stages of the stage 5 works. If such plans had been available, it would have been clear which points required securing from the scheme plan, from appendix J of the testing and commissioning plan, and from the *test copies*.

- 61 The only document that correctly listed the point ends to be secured was one created by the DPE for his own purposes and to guide the duty managers, which listed all the things that needed to be done before the 'entry into service' paperwork could be signed off. As an aid to others the DPE put his list up on the walls at the site and project offices, as other people found it useful to work to and used it as a tick list (which was not his intention). The SCM did not consult this list. He should have been able to derive the information from either the scheme plan or the testing and commissioning plan, but as neither of these contained the correct work for this sub-stage, what needed doing was not obvious.
- 62 It is also possible that the SCM's decision to take the email as the full list was influenced by fatigue. He was on his first night shift (23:00 hrs - 11:00 hrs), having just completed seven day shifts since his previous rest day, the last two of which were also 12 hour shifts. First night shifts are known³ to produce a high risk of fatigue, and RSSB has published guidance⁴ on how best to manage this risk (the management of fatigue risk in this project is discussed further in paragraphs 81 to 92).

Checking the points were secured correctly

63 Among the members of the project team, the responsibility for checking the securing of redundant points was not clearly allocated or understood, and they did not make arrangements for these checks to be made.

- 64 Network Rail company standard NR/L2/SIG/30014/A110 Issue 4, 'Signal works testing', clause 4.6.5 states that all redundant wiring and equipment⁵ that cannot be removed shall be clearly detailed in the test copies provided to the TIC by the responsible design office, as set out in NR/L2/SIG/11201 Issue 10 'Signalling Design Handbook' mod A8 section 3.2. The TIC is responsible for ensuring that all changes detailed in the design are complete, and signs off the test copies as a record that he has satisfied himself of this fact. The implication of this requirement is that he must take steps to satisfy himself that all equipment shown on the signalling scheme plan as remaining in-situ, but to be removed at a later date (this includes clipped and padlocked points) is left in a safe condition.
- 65 The TIC produced a testing and commissioning plan for the works to be carried out over the Christmas period, appendix J of which detailed equipment affected by the works, using the signalling scheme plan to derive a full list of all the things he needed to check, be assured of, or ask his team of testers to check on his behalf. In turn, this enabled him to populate the TC1 form, which TICs use to be able to confirm that signal testing is complete and the railway can be handed back (from a signalling perspective) to operational use. Appendix J did not include 815B, 816, 817A or 817B points and this was not noticed in the independent checks of the document, which was signed off by Network Rail for use.

³ [RAIB report 15/2011](#) 'Uncontrolled freight train run-back between Shap and Tebay', 17 August 2010, paragraphs 34 to 38.

⁴ RSSB – Guidance on fatigue control options for first night shifts (T1084 Good practice guide), ORR – [Managing Staff Fatigue Guidance](#), ORR – [Fatigue Factors information sheet](#).

⁵ Points and their associated mechanisms, and circuitry are included under the term equipment.

- 66 The TC1 form included a statement for the TIC to confirm that he had received confirmation that all out of use points were safely secured and padlocked. The points were not listed individually, and the TIC signed the form on the basis that the SCM had confirmed that the points had been secured. This was non-compliant with the standards governing the commissioning of signalling equipment⁶, as the SCM was involved in carrying out the work. It is an important part of the signalling testing and commissioning process, that work is independently checked before being put into service.
- 67 The signalling scheme plan used for the stage five commissioning showed the final track and signalling layout at Cardiff as it would be after Easter 2017. However, the railway was re-opened to traffic on two occasions: the first time on 29 December 2016 for three days, and the second time on 3 January 2017 for over three months. On each occasion the TIC used a signalling scheme plan that was not a reflection of the work that was to be completed during that stage. It is possible that the reason that the TIC did not believe he needed to make any further check of the state of the redundant points 817A and 817B was that the scheme plan he was using showed that they had been removed, as they would have been for the final commissioning. However, witness evidence and the DPE's checklist clearly showed that the project team knew that the points would remain in situ until further works had been undertaken.
- 68 The project team did not prepare signalling plans which covered the layout as installed on the ground for the periods when the railway was operational, both from 29 to 31 December 2016, and from 3 January 2017 to the end of the Easter 2017 works (paragraph 95). Network Rail company standard NR/L2/SIG/11201 Issue 10 'Signalling Design Handbook' section 15.3 requires that accurate signalling plans and stage scheme plans reflecting the state of the equipment on the ground are required for every occasion on which the railway is returned to operational service. The more complex a signalling commissioning, the more critical it is that there is a complete design for each commissioning to direct the installation and testing work.
- 69 If the TIC had reviewed the photographs that the SCM sent him, he would probably have become aware that they did not include 817A and 817B points. However, for the reasons discussed in paragraph 67, he might not have realised that these points should have been included. Witness evidence indicates that the DPE had removed the responsibility for checking the securing of points from the TIC, as he believed the TIC had too much else to do, but he did not allocate the responsibility to anyone else. The TIC was not aware this responsibility had been removed, but he believed in any case it was not his responsibility to check them, though it is not clear why he believed this.
- 70 It is possible that the project overrun and the extra work entailed in trying to pull back as much time as possible, coupled with fatigue from the number of long shifts the TIC had worked up to and including the date of the incident (paragraph 84), led to him deciding he did not have the time or the need to check the photographs of the secured redundant points.

⁶ Network Rail standard NR/L2/SIG/30014/A110 'Signalling Works Testing' section 4.5.1.3.

- 71 As part of the assurance process to the operators, the project had agreed that before handing the railway back for operational service, two route proving trains would be run to ensure the signalling system would operate correctly and to minimise the risk of any problems caused to the operating service after commissioning.
- 72 Due to the problems with the damaged cable during the commissioning (paragraph 43), and the overrun that resulted, Network Rail's operational management, with the agreement of the train operator, decided to cancel the route proving trains. This was not prohibited by Network Rail standard NR/L2/SIG/30014/A110 'Signalling Works Testing' section 4.5.8, which states that running a test train after commissioning works is not normally required. Time was saved by not running them.
- 73 The SCM and a colleague (the engineering supervisor who was responsible for ensuring the line was clear of staff and equipment prior to the line being re-opened) walked the track. They were primarily focused on looking for tools or equipment that had been left on the track, and were not looking at the arrangement of the track layout or the position and securing of points.

Identification of underlying factors

Work group culture

74 The project team had developed a work group culture that led to insular thinking about methods of work and operational risk.

- 75 The majority of the project team members had worked together on the project over a number of years and, understandably, a great deal of trust had developed between them. These longstanding relationships also resulted in the development of fixed mind-sets about methods of work, a lack of recognition of alternative procedures available for undertaking tasks and an incomplete understanding of the risks to which the project might be exposing the operational railway.
- 76 The project team was relying on processes for securing redundant points that had worked without incident for previous stages of the project. However, in previous stages, with smaller workloads overall, the securing of points had been considered to be the major item of risk during the works carried out during the stage. In stage five, the project felt that the work of highest risk being done during the stage was the significant change to the track layout and extensive signalling commissioning using new technology, and therefore the team's attention was not sufficiently focused on ensuring and checking that the redundant points had been secured correctly.
- 77 The team did not recognise that the securing of eight point ends, in addition to a large workload arising from the commissioning stage, resulted in an increased risk to the railway if something was missed or went wrong. Despite the large number of ends that required securing, witness evidence suggests this work was regarded as a minor part of the total works to be completed, relative to the large list of tasks for the stage five works, and of little overall risk to the railway.

- 78 No review was conducted to determine whether the processes for securing and checking redundant points that had been used for previous stages would be appropriate for the increased scale of works being completed over the Christmas blockade.
- 79 A significant amount of the communication and transfer of knowledge regarding tasks which needed to be completed was done verbally, and the team assumed that people would retain, remember and complete the actions assigned to them.
- 80 Team members were content to rely on the word of other team members to confirm that the points had been correctly identified and secured in position (rather than checking photographs (paragraph 69)). Accountability for checking that the work was correct was not clearly defined within the team, and the project team did not appreciate the need or the importance of carrying out an independent check against the design, for assurance purposes.

Management of fatigue

81 The project team (excluding Atkins) had signed up to a fatigue management agreement, but it was not effectively implemented. This is a possible underlying factor.

- 82 The SCM was rostered to work ten consecutive 12 hour day shifts over the commissioning period. However, at the time of the incident he had instead worked day shifts up to 27 December and then switched to the night shift on 28/29 December. He had another four long shifts to work before the end of the period, which were a mixture of day and night working.
- 83 It is possible that fatigue, arising from the number of shifts, and the fact he was working a first night shift, led the SCM to decide to take the email from the Balfour Beatty contractor's responsible engineer as referring to all the points that required securing at Cardiff East Junction, rather than cross checking this with other information (paragraph 62).
- 84 It is also possible that the TIC's actions with regard to feeling he did not have time to check the photographs of the secured points sent by the SCM were affected by fatigue (paragraph 70). The TIC was on his fifth of ten consecutive 12 hour night shifts at the time of the incident. Although he stated that he felt fine at the time of the incident, he also stated that it took him over a week to recover from these shifts.
- 85 At an earlier stage of the CASR project, in May 2012, the project team had developed an agreement to keep well within the Network Rail management of fatigue standard NR/L2/ERG/003 issue 5 'Control of working hours for staff undertaking safety critical work' (see figure 6), though this agreement did not meet current good practice as defined in footnote 4. The project developed a spreadsheet on which it was intended to record names of those people who had exceeded 11 hour shifts, so their working times could be monitored.
- 86 Network Rail provided the RAIB with data indicating the times that staff signed in and out of the site of work at Cardiff over the ten day period of the blockade. The RAIB's analysis of this data showed that 250 shifts of 12 hours or longer were worked, including 34 over 13 hours. However, because of problems with the implementation and monitoring of the electronic signing-in system, only one person was recorded on the spreadsheet (paragraph 84) as having worked in excess of 11 hours.

- 87 The data above is not a complete record of the actual hours worked, as evidence shows that there are significant gaps in it. There are some cases where staff are not recorded as having been working on particular shifts, yet there is clear evidence from other sources to show that at that time they were trackside or at the project offices. In two cases, the data only records half of the number of shifts actually worked.
- 88 Atkins did not sign up to the CASR project's fatigue management scheme (figure 6), and instead put in place its own rostering guidelines and fatigue management arrangements. A result of this was that 26 of Atkins' staff and at least two Network Rail staff due to work over the Christmas blockade were rostered to exceed the *Hidden limits*⁷. The company believed it had mitigated the risk from these working hours in advance, by ensuring that staff were accommodated in hotels close to the project work sites, provided with packed lunches and evening meals, and were able to stay in the hotel for an additional shift before and/or after the blockade.
- 89 Witness evidence indicates that these measures were intended to minimise the risk of staff having to drive to and from work while tired. Whilst this is undoubtedly a good thing, such measures are unlikely to be effective in minimising the risk of fatigue leading to errors at work.
- 90 Network Rail's project team did not calculate fatigue risk index scores (which give an indication of the likely level of fatigue for a pattern of shift work), on the basis that they were working to the guide laid out in figure 6, and therefore considered the fatigue risk to already have been effectively managed. Atkins did produce fatigue risk index scores for its staff.
- 91 The fatigue and risk index (FRI) tool is designed to provide a guide as to how likely a worker is to feel sleepy during a shift (fatigue index), and the likely risk of the worker having an incident or making a work related error during their shift (risk index)⁸. Because these scores can only give a guide, other tools and procedures are intended to be used in conjunction with the FRI to establish and minimise staff fatigue risk.
- 92 Although the FRI is not designed to be used to support threshold decisions about fatigue risk, Atkins used a widely adopted threshold score to determine whether its rosters were acceptable. Out of the 51 Atkins staff who were to work over the period, the FRI tool used by Atkins showed that 26 had scores which exceeded their recommended limit at least once. Some staff had been rostered to work in the commissioning period even though their FRI scores showed they exceeded the limits at the start of the commissioning period.

⁷ The Hidden limits are the limits on working hours for safety critical staff that were recommended by Anthony Hidden QC in his report on the Clapham Rail Accident on 12 December 1988. The investigation found one that of the causes of the accident was that workers' performance had probably been affected by fatigue. These limits were intended to bring the working hours of safety critical staff down to more acceptable levels. However, they have subsequently been superseded by a risk-based approach to determine working hours and for avoiding fatigue, described in the ORR guidance and RSSB research linked to in footnote 4.

⁸ Further information from www.hse.gov.uk/research/rrhtm/rr446.htm, RSSB's [guidance on bio-mathematical fatigue tool](#), ORR's [Information Sheet summarising key points for FRI users from T1084](#).

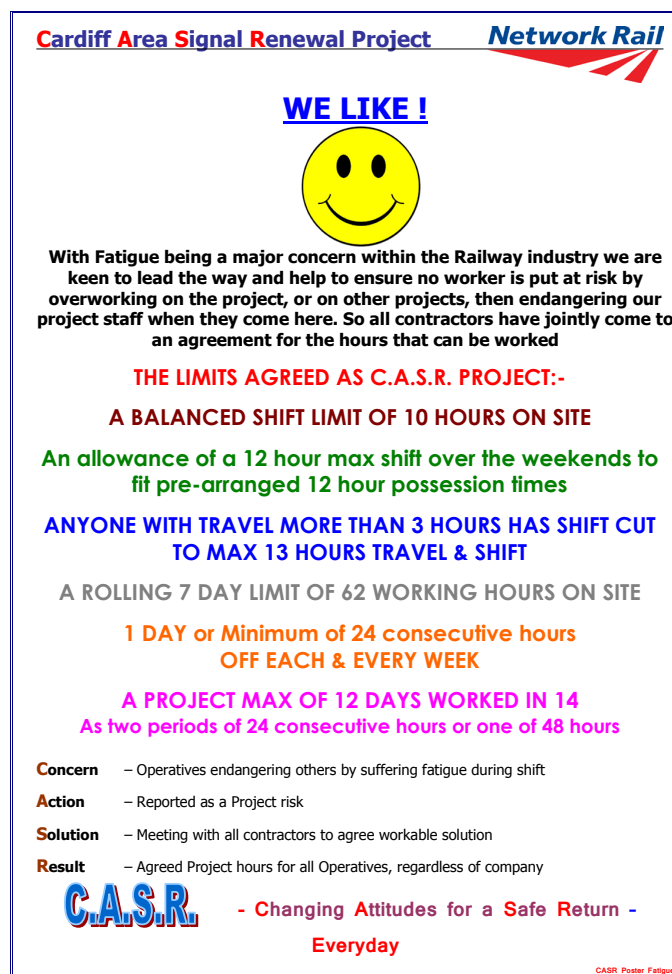


Figure 6: Poster showing the fatigue management agreement developed by the CASR project

Project Governance

93 Network Rail's project governance was not sufficiently thorough.

- 94 The Network Rail project team was responsible for pulling together all the different parts of the project, integrating them and ensuring that no element of the works required was overlooked. The team also needed to ensure that regulations, standards, processes and procedures were correctly followed, that all the documentation submitted by the various contractors covered all aspects of the work, and that the work plans interfaced properly with the other parties' works on the project.
- 95 While the project team completed the required documentation for the project, not all areas were covered in sufficient detail, there were insufficient versions of the signalling scheme plan (paragraph 68), and the documentation was not thoroughly completed or checked. Mistakes such as the omission of one of the redundant point ends were not picked up or corrected in document checks.
- 96 The project did not adequately plan the decommissioning activity required, as there is very little documentation to cover this aspect of the works. For instance, the redundant 817A and 817B points were not listed as assets affected by the works in the appendix of the project test plan documentation listing affected equipment.

- 97 The project team were very focused on the new systems and equipment that were being brought in and the risks these would introduce to the railway. There is no recorded appreciation of the risks of leaving redundant, unsecured, and undetected assets in the layout.
- 98 The project team had created a Commissioning Management Plan that was intended to pull together all the workstreams and work package plans from Balfour Beatty, Atkins and Network Rail. In such a large project, with multiple contractors carrying out different areas of work, it is necessary, so that workstreams or items are not overlooked or conflict with work being carried out by other parties, to have an overall document that pulls together all the works package plans for all the aspects of the works. However, this document was not complete, and works package plans relating to the testing work over the Christmas 2016 blockade were not included in it.
- 99 The document management system used by the project was not user friendly. This became particularly apparent during this investigation when Network Rail had difficulty providing documentation for the investigation in a timely manner. Witnesses from the project team explained that it was an onerous and time consuming task to access files. This may explain why people in the project team had grown to rely primarily on verbal communications, discussions in meetings and email to agree and confirm tasks, rather than using the formal channels.
- 100 There was very little recorded accountability within the team, with most actions being allocated to company or department titles rather than to named individuals, until a very late stage. This is contrary to good project management practice. By allocating actions to companies or teams, there is no named responsible person to complete tasks. That means that actions that need doing have a greater chance of not getting done, being delayed or not being completed as intended.
- 101 After the incident, key members of the project team were of the view that after decommissioning, 817A and 817B points no longer existed and therefore required no further consideration or action to be taken to verify they had been secured correctly. This is in part because the points were shown as removed on the signalling stage plan, despite the fact that 817A points remained in the layout until the works due to be undertaken at Easter 2017 (paragraph 67).
- 102 Network Rail's project management arrangements for the CASR scheme included safety assessments producing a declaration of control of risk (under article 16 of the Common Safety Method for risk evaluation and assessment 402/2013⁹), an element of assurance external to the project team, which was carried out by the Network Certification Body. However, the RAIB's investigation has found no evidence that the assurer considered either the staffing levels allocated to the commissioning stages, or the adequacy of the arrangements for decommissioning of redundant equipment.

⁹ The Common Safety Method for risk evaluation and assessment is a risk control process used, in the case of CASR, alongside Network Rail's Health and Safety Management system to assess and confirm that any safety risks, either current or imported as part of the works, are managed satisfactorily and controlled so the work can proceed, and that all identified hazards and associated risks arising from them are controlled as far as reasonably practicable.

- 103 During the night shift on 28/29 December, running up to the handback of the railway to the operator, a single individual acted as programme manager, senior manager on duty and project manager on site. This meant that the escalation process, used when things go wrong on site and contingency plans need to be brought into use, or other arrangements need to be developed and agreed at very short notice to bring the work back on schedule, could not be implemented effectively because all the managerial roles were being covered by the same person. It is not clear whether this was due to lack of resources or a poor project decision during planning. Although other Network Rail staff were on-call and available by phone, there is no evidence that any of them were consulted at the time.

Factors affecting the severity of consequences

- 104 The driver of train 2T08 was alert, and stopped his train short of 817A points, which were incorrectly set for his route.**

- 105 It is not the responsibility of a driver to check that any points in the route are correctly set once they have checked that the signal for the route is clear for the train to proceed. This is because the interlocking that allows the signal to clear should ensure that any points are correctly set for the route the train needs to take before the signal can be cleared, and it is not possible for a driver to observe points at high speed or in darkness.
- 106 Given the above, it is commendable that the driver noticed that the points in his route were incorrectly set and brought his train to a stand before travelling over them (paragraph 49). Had the driver not noticed, his train would have passed undetected on to line E and could have travelled a further 115 metres beyond 817B points before the signalling system, which uses axle counters for train detection, would have detected that the train was in the wrong position. Had train 2T08 had been slightly later, it could have come into collision with train 1L34. The signallers were not aware until after the incident that the problem with unsecured points affected the main lines as well as the Valley lines.
- 107 At the time of the incident, a temporary speed restriction of 15 mph (24 km/h) was in place on the lines through Cardiff Central station due to the ongoing work.

Observations

Team briefing

- 108 The all-team briefing contained a considerable amount of information, much of which was superfluous to many of the attendees.**

- 109 The all-team briefing (paragraph 37) had 123 powerpoint slides, presented by a number of people, which covered health and safety, logistics, how the work should be carried out and the phasing of works on site. Some of the information was important, some less so, some inaccurate and some very poorly presented on the slides. People who attended the briefing said that they had difficulty filtering out the information that was relevant to them as there was so much detail, even where they were familiar with the whole scope of works.

Provision of information to signallers

110 The signaller had no information about the presence of the redundant points in the layout that he was controlling.

- 111 The workstation screens used by the signaller displayed the track and signalling layout as it would be after the completion of the works planned in Easter 2017, and showed a set of points due to be operational after Easter tagged as out of use on the screen to remind the signaller that they were not yet in use. This was done because of the significant costs involved in altering the workstation display to reflect changes in the layout.
- 112 The signallers had been trained on the new layout and the works being carried out by the project team. They had not been informed of, or provided with drawings to show, any redundant, undetected equipment that would be left in the layout. The project team did not feel this was necessary information for the signallers to have.
- 113 The signaller on the Valleys workstation had previously worked in the Cardiff power signal box, and was therefore able to establish where the train had come to a stand, although he had no accurate layout drawings which would have enabled him to confirm the location of the train.

Previous occurrences of a similar character

- 114 On 12 December 1988 a crowded commuter train ran into the rear of a second stationary commuter train in a cutting just south of Clapham Junction station, and a train of empty coaches travelling in the opposite direction ran into the wreckage, resulting in 35 deaths and 484 injuries. Several of the causal factors in the Clapham Junction accident are common to the incident at Cardiff East Junction:
- informal working practices had evolved among project staff;
 - key staff were carrying out more than one activity;
 - some personnel had been working excessive hours; and
 - the testing was signed off without the required checks.
- 115 One of the key outcomes of the investigation into the Clapham Junction accident was a recommendation for limits on working hours for safety critical staff, to minimise the risk of errors arising from fatigue (paragraph 88). Also relevant to this investigation were recommendations regarding the need for good controls on the design (to ensure it is a complete and accurate representation of the work), and the need for full and proper testing documentation.

Summary of conclusions

Immediate cause

116 The CASR project team handed back 817A and 817B points in an unsafe condition (paragraph 55).

Causal factors

117 The causal factors were:

- a. The SCM did not identify all the points required to the team securing them (paragraph 58, **Recommendation 1**).
- b. Among the members of the project team, the responsibility for checking the securing of redundant points was not clearly allocated or understood, and they did not make arrangements for these checks to be made (paragraph 63, **Recommendation 1**).

Underlying factors

118 The underlying factors were:

- a. The project team had developed a work group culture that led to insular thinking about methods of work and operational risk (paragraph 74, **Recommendation 1**).
- b. The project team (excluding Atkins) had signed up to a fatigue management agreement but it was not effectively implemented. This is a possible underlying factor (paragraph 81, **Recommendation 3**).
- c. Network Rail's project governance was not sufficiently thorough (paragraph 93, **Recommendations 1, 2 and 3**).

Factors affecting the severity of consequences

119 Factors that mitigated the consequences of the event were as follows:

- The driver of 2T08 was alert, and stopped his train short of 817A points which were incorrectly set for his route (paragraph 104).
- A temporary speed restriction of 15 mph (24 km/h) was in place due to the ongoing works (paragraph 107).

Additional observations

120 Although not linked to the incident on 29 December 2016, the RAIB observes that:

- a. The all-team briefing contained a considerable amount of information, much of which was superfluous to many of the attendees (paragraph 108).
- b. The signaller had no information about the presence of the redundant points in the layout that he was controlling (paragraph 110).

Previous RAIB recommendations relevant to this investigation

- 121 The RAIB has investigated many incidents where fatigue has been a factor. However, most of these are related to operational staff rather than project staff. In [RAIB report 12/2015](#) 'Train struck and damaged by equipment cabinet door in Watford Tunnel' the following recommendation was made:

Recommendation 3

Siemens UK should commission an independent review of the implementation of those aspects of its safety management system relating to the welfare of safety critical staff working on infrastructure projects, including its arrangements for managing fatigue, and take action as appropriate to rectify any deficiencies found.

In response to this recommendation, the Office of Rail and Road (ORR) has reported to RAIB that Siemens commissioned a consultant to carry out a review of its health, safety and fatigue management, and has provided ORR with relevant sections of the report. The review uncovered a number of weaknesses in how Siemens was managing the risks to safety critical staff working on infrastructure projects. Siemens is taking action to address these matters.

Recommendations and learning points

Recommendations

122 The following recommendations are made¹⁰:

- 1 *The intent of this recommendation is to ensure that projects, particularly those with a long duration, are appropriately held to account by the assurance process external to the project, and continue to follow good practice throughout so reducing the risk of safety critical errors and omissions, ensuring that a safe railway is handed back for operational service.*

Network Rail should review its project assurance process as applied to the CASR scheme, and identify the deficiencies which resulted in the management shortcomings described in this report. Network Rail should then use the findings of this review to establish suitable and sufficient management processes to assure itself that major projects deliver a safe railway on each occasion that it is handed over for service. These should cover as a minimum, all aspects of project governance, including quality assurance throughout all stages of the project lifecycle, organisational structure, record keeping and administrative systems (paragraphs 117a, 117b, 118a and 118c).

- 2 *The intent of this recommendation is to improve the quality and functionality of Network Rail document management systems so that documents are easily identified, retrieved, traced and updated as necessary.*

Network Rail should review the document management system used for the CASR project and ensure that any identified areas for improvement are incorporated into systems currently and planned to be in use by other projects (paragraph 118c).

¹⁰ 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.

- 3 *The intent of this recommendation is to establish effective implementation of fatigue risk management in the project environment, particularly in relation to major projects.*

Network Rail, in conjunction with its contractors, should review how it implements its standards and processes relating to the management of fatigue risk during major projects. The results of this review should be used to identify measures to provide assurance that all project staff, whether direct employees or contractors, work within appropriate standards and good practice guidelines, and to minimise the risk that staff fatigue may contribute to an error or omission during the commissioning of safety critical equipment and systems (paragraphs 118b and 118c).

Learning points

123 The RAIB has identified the following key learning points¹¹:

- 1 The importance of clear arrangements in every case to make sure that the tester in charge can check and confirm that all redundant wiring and equipment that cannot be removed is clearly detailed in the test copies, as required in NR/L2/SIG/300014/A110 Issue 4, 'Signal works testing', clause 4.6.5.
- 2 The need for each stage of works in which changes to the infrastructure have been made, and after which the railway is returned to operational service, to have a signalling plan that accurately reflects the infrastructure and assets on the ground, regardless of the functionality of those assets.
- 3 The value and purpose of team briefings prior to large commissionings should be carefully considered in terms of the quantity and relevance of information being delivered. The number of slides and the length of presentations should be optimised to the audience, with the aim that people are given information that is appropriate and necessary for the work that they have to do.
- 4 When considering whether it is necessary to run a route proving train as part of the commissioning process, it is important to identify the types of fault which the train is intended to detect, and assess whether any other measures may be appropriate to detect and/or deal with those faults if the train does not run.

¹¹ 'Learning points' are intended to disseminate safety learning that is not covered by a recommendation. They are included in a report when the RAIB wishes to reinforce the importance of compliance with existing safety arrangements (where the RAIB has not identified management issues that justify a recommendation) and the consequences of failing to do so. They also record good practice and actions already taken by industry bodies that may have a wider application.

Appendices

Appendix A - Glossary of abbreviations and acronyms

CASR	Cardiff Area Signalling Renewals
DPE	Designated Project Engineer
FRI	Fatigue and risk index
RAIB	Rail Accident Investigation Branch
RSSB	The not-for-profit company registered as 'Rail Safety and Standards Board'
SCM	Senior Construction Manager
TIC	Tester in Charge
WROC	Wales Railway Operating Centre

Appendix B - Glossary of terms

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

Clipped and padlocked	A term found on signalling plans, describing a set of points secured out of use by means of a switch clamp padlocked in place.*
Crossover	Two sets of points connected to permit movements between parallel tracks.*
Down	In the direction towards Swansea (on the main lines) or towards the coast (Valley lines)
Hidden Limits	The limits on working hours introduced by British Rail to restrict the hours worked by safety critical staff in response to recommendations made by Sir Antony Hidden in his public inquiry into the Clapham Rail Accident on 12 December 1988, one of the causes of which was that workers' performance was affected by fatigue.
Points	An assembly of switches and crossings designed to divert trains from one line to another.*
Point ends	A term describing a pair of switch half sets assembled to make a set of points.*
RSSB	A not-for-profit company owned and funded by major stakeholders in the rail industry, and which provides support and facilitation for a wide range of cross-industry initiatives. The company is registered as 'Rail Safety and Standards Board' but trades as 'RSSB'.
Signalling Scheme Plan	Diagrams which show the layout of signalling and points in an area, including both new and redundant equipment.
Test Copies	Documents created by the signalling designer and signed by off by the Tester in Charge, which ensure that all testing and commissioning works have been carried out to the signalling scheme plan which gives an accurate picture of the exact state and condition of all signalling equipment available to anyone that may need to work or operate the equipment at the end of works.
Undetected	In the context of points: the position of the points is not linked to the signalling system or interlocking. So there is the potential for conflicting routes to be set across the points unless appropriate mitigation measures, such as securing the points in a known and agreed position, are taken.
Up	In the direction towards London (main lines) or away from the coast (Valley lines)

Appendix C - Investigation details

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

- information provided by witnesses;
- forward facing closed circuit television (CCTV) recordings taken from train 2T08;
- site photographs and measurements;
- voice recordings;
- weather reports and observations at the site;
- project documentation;
- Network Rail standards; and
- ORR and RSSB guidance and good practice.

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