RAIB
Rail Accident Investigation Branch

Rail Accident Report

Train struck and damaged by equipment cabinet door in Watford Tunnel
26 October 2014

Report 12/2015
August 2015

This investigation was carried out in accordance with:

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

Any enquiries about this publication should be sent to:

RAIB	Email: enquiries@raib.gov.uk
The Wharf	Telephone: 01332 253300
Stores Road	Fax: 01332 253301
Derby UK	Website: www.gov.uk/raib
DE21 4BA	

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

Preface

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

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

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

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

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

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

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

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

This page is intentionally left blank

Train struck and damaged by equipment cabinet door in Watford Tunnel, 26 October 2014

Contents

This page is intentionally left blank

Summary

At around 07:19 hrs on Sunday 26 October 2014, train 2K00, the 06:42 hrs Milton Keynes Central to Euston passenger service struck an open door of a lineside equipment cabinet while travelling through Watford Tunnel. The cabinet door detached from its hinges, hitting the side of the train and damaging a door on one of the carriages. The damage to the train door caused a safety circuit to detect that the door was no longer properly closed and the train's brakes were applied automatically. On examining his train, the driver found that a door on the fourth carriage had been severely damaged. Passengers in this carriage also reported they had been showered by flying glass from the damaged door, although none reported any injuries.

The RAIB's investigation found that the cabinet door had opened under aerodynamic forces as the train passed, probably because the door had been left closed, but unsecured, during work that had been taking place on equipment in the cabinet overnight. A number of reasons that may explain why the door had been left unsecured were identified, including poor task lighting, the methods that had been employed during the work overnight, no-one being allocated the responsibility for checking that cabinet doors were closed and secured and the possibility that the staff involved may have been suffering from fatigue, making it more likely that a mistake would be made. An associated underlying factor was that Siemens, the employer of the staff involved, had not fully implemented its policy on fatigue management.

The cabinet involved had been installed recently as part of a re-signalling project for the Watford area. It was equipped with two doors with side hinges and had been positioned such that an open door could be struck by a train. An underlying factor was that the risk of this happening had not been identified when this design of cabinet was selected for use in Watford Tunnel. Previous risk assessments undertaken during the period when the cabinet was originally subject to product acceptance were not available to the project team or Henry Williams Ltd, the manufacturer of the cabinet involved.

The RAIB has made six recommendations. Four recommendations have been made to Network Rail, covering processes for handing back sections of railway after engineering work, its policy on locating lineside equipment in areas of restricted clearance, the design of lineside equipment for areas of restricted clearance and improvements to its product acceptance processes so that previously undertaken risk assessments are available to future users of individual items of equipment. One recommendation has been made to Siemens UK Ltd in respect of the implementation of its policies on staff welfare (including fatigue management), and one recommendation has been made to Henry Williams Ltd in conjunction with Network Rail to make sure that it has full details of the certification of its products used on the railways.

The RAIB has also identified two learning points. The first relates to the adequacy of task lighting and the need for staff on site to reach a clear understanding about who will be responsible for closing cabinet doors. The second is a reminder of the need for staff involved in projects to implement existing processes for risk assessment and product acceptance.

Introduction

Key definitions

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

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

The accident

Summary of the accident

3 At around 07:19 hrs on Sunday 26 October 2014, train 2K00, the 06:42 hrs Milton Keynes Central to Euston passenger service (the first southbound train of the day using the up fast line), struck an open door of a *location cabinet* (referred to as 'the cabinet' in the remainder of this report) while travelling through Watford Tunnel at 88 mph (141 km/h). The cabinet door detached from its hinges, hitting the side of the train and damaging a door on one of the carriages. The damage to the train door caused a safety circuit to detect that the door was no longer properly closed and the train's brakes were applied automatically. The train stopped beyond the southern end of the tunnel, a short distance from Watford Junction station (figures 1 and 2).

4 The train driver reported to the signaller that a door on the fourth carriage had been severely damaged and was potentially out of *gauge*. Passengers in this carriage also reported they had been showered by flying glass from the damaged door, although none reported any injuries.

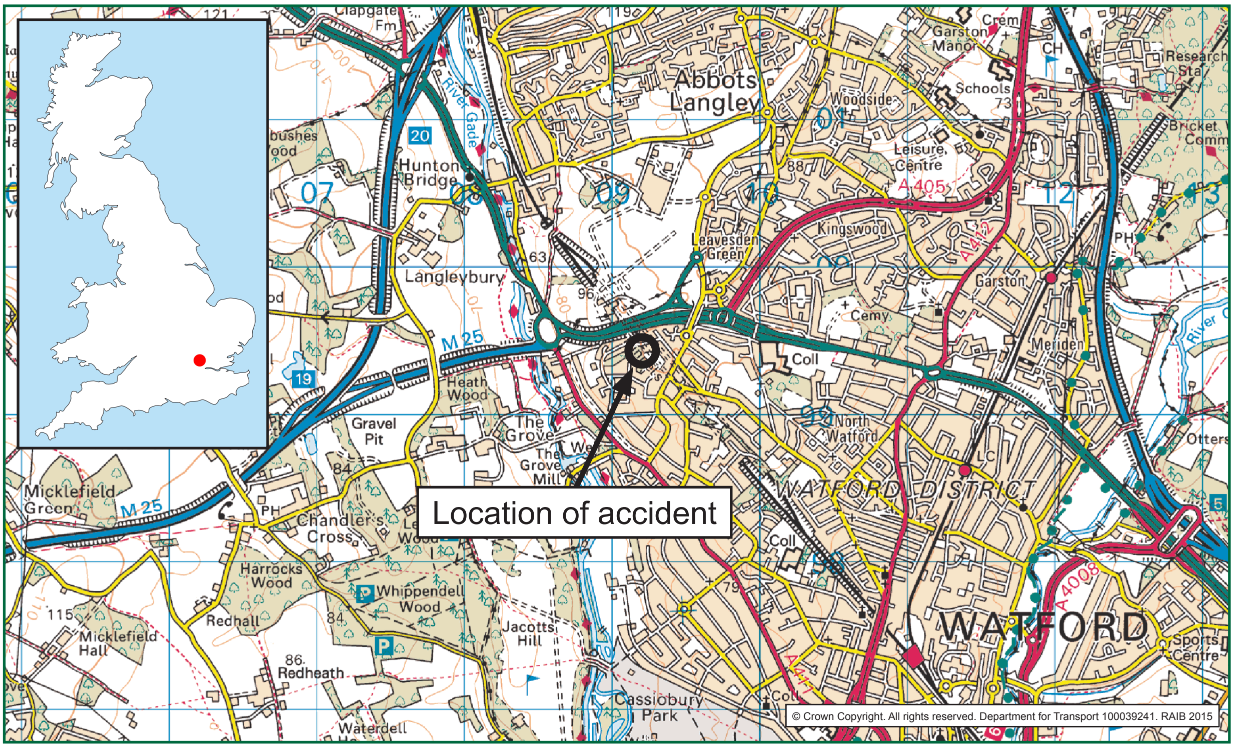


Figure 1: Extract from Ordnance Survey map showing location of accident

Context

Location

5 The Watford Tunnels are on the West Coast Main Line, and comprise separate bores for the fast and slow lines (two tracks in each bore). The fast line tunnel is just over a mile (1.6 km) in length, with the southern portal located at 18 miles 38 chains[1] from London Euston.

6 The lines through the tunnel are electrified using 25 kV overhead line equipment and equipped with four-aspect signals which, at the time of the accident, were controlled from Watford Power Signal Box[2]. The maximum permitted speed on the fast lines is 110 mph (177 km/h).

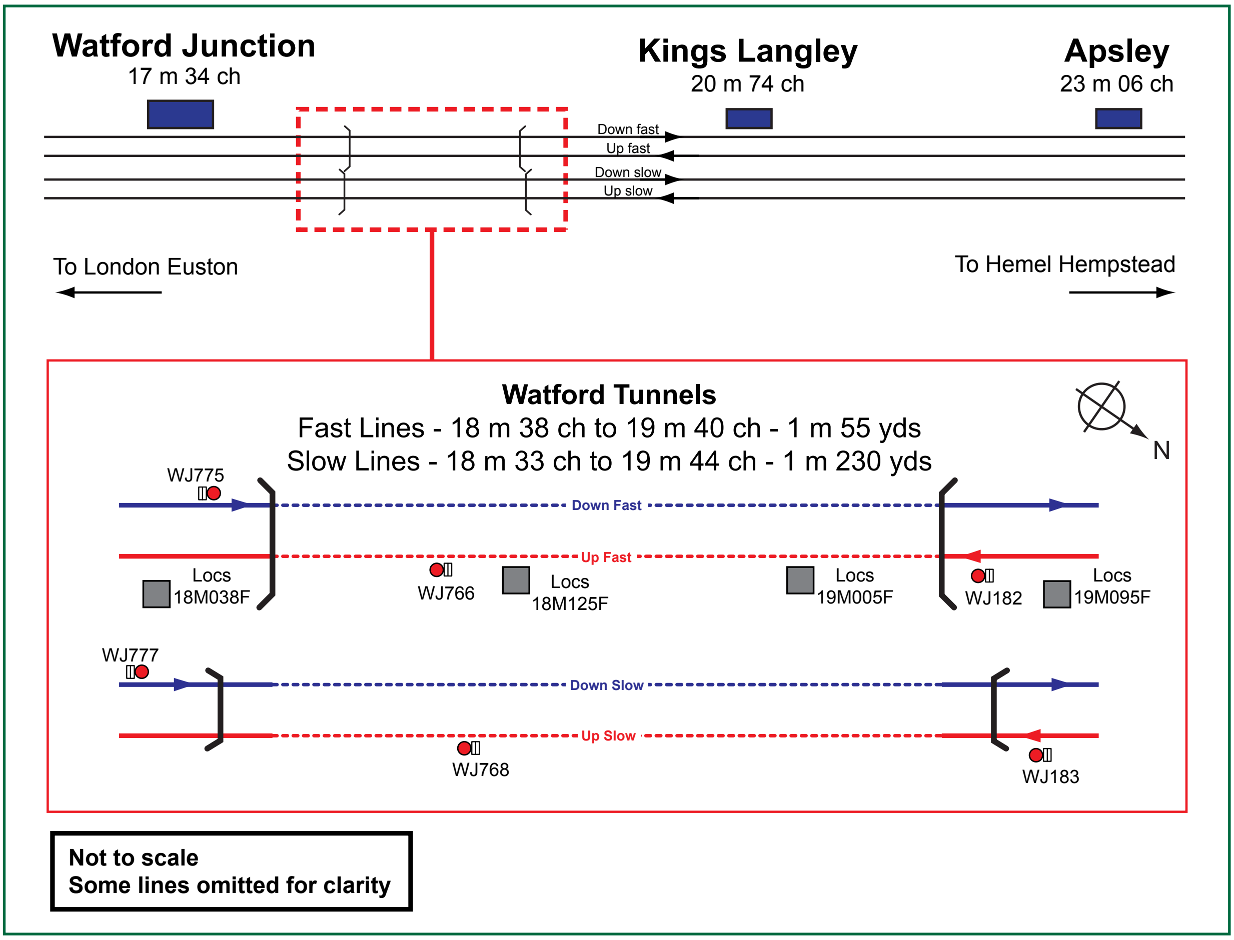


Figure 2: Track layout showing the location of the equipment and site of work

Organisations involved

7 Network Rail owns, operates and maintains the infrastructure, and was also managing a project to renew signalling in the Watford area, which included the installation of new signalling cabinets in Watford Tunnel.

8 London Midland was the operator of train 2K00 and employer of the train driver and conductor.

[1] There are 80 chains in a mile.

[2] Watford Power Signal Box closed on 25 December 2014 and the signalling in the area is now controlled from Wembley Main Line Signalling Control Centre.

9 Siemens Rail Automation Holdings Limited (referred to as Siemens in the remainder of this report) was the contractor responsible for the project management, design and installation of works and equipment associated with the re-signalling project in the Watford area (figures 2 and 3). It also employed the signalling installation and testing technicians who worked in Watford Tunnel in the hours leading up to the accident.

10 Henry Williams Limited was the manufacturer of the cabinet that was involved in the accident.

11 All the above organisations freely co-operated with the investigation.

Train involved

12 Train 2K00 was formed of a class 350/1 'Desiro' four-car electric multiple unit. The investigation has found that neither the condition of the train nor the actions of the train driver and conductor played any part in the accident.

Rail equipment/systems involved

13 The cabinet involved in the accident was one of a number of such cabinets installed in Watford Tunnel on 4 October 2014 (figures 3 and 4). It contained equipment associated with the operation of signalling equipment in the tunnel. The installation of the cabinets was part of a project that started in 2009 to update the existing signals and associated equipment in the Watford area and to transfer control of the signalling equipment from Watford Power Signal Box to Wembley Main Line Signalling Control Centre.

Figure 3: The cabinet in its original condition in Watford Tunnel

Figure 4: The cabinet as found after the accident with the right door missing

Staff involved

Network Rail staff

14 The Project Manager with overall responsibility for the Watford re-signalling project was allocated to the Infrastructure Projects Signalling department and had 32 years' railway experience. He was appointed to the post in November 2013.

15 The Designated Project Engineer (DPE) (who also took the role of Programme Engineering Manager, but is referred to as the DPE for the remainder of this report) had 26 years' railway experience. He was appointed to the Watford re-signalling project in October 2010 and was responsible for the co-ordination and integration of the technical and engineering aspects of all activities within the project.

Siemens' staff

16 Siemens Contractor's Engineering Manager (CEM) (who was also the Contractor's Responsible Engineer (CRE), but is referred to as the CEM for the remainder of this report) was initially appointed in 2012 to work with Network Rail on the development phase of the Watford re-signalling project and was subsequently appointed as CEM in May 2013. The CEM had over 30 years' railway/project management experience and was responsible for day-to-day engineering activities during the design and construction phase of the contract.

17 The Contractor's Design Manager (CDM) had 26 years' railway/project management and design experience. He reported to the CEM. The CDM was appointed to the Watford re-signalling project in March 2012, with responsibility for scheme design. During 2013 and 2014, one of his tasks was to oversee the installation of signalling cabinets.

18 Four technicians (referred to as 'installers' in the remainder of this report) were tasked with installing equipment in the cabinets during the night of 25/26 October 2014. The four installers were all qualified and experienced.

19 A different group of four technicians (referred to as 'testers' in the remainder of this report) undertook functional testing of the equipment installed in the cabinets during the night of 25/26 October 2014. The testers' experience ranged from trainee level to 15 years. On the night of the accident, they were split into two groups of two. One group consisted of a *controller of site safety* (COSS) and the trainee tester. The other group consisted of a COSS and the lead tester. Both individuals performing the COSS role also undertook testing. Although each group worked separately, they were carrying out functional testing under the lead tester.

Henry Williams Limited staff

20 The Sales Engineer joined the company in 1987 as an apprentice electrician, becoming the Sales Engineer in 1999. He arranged and facilitated the initial order for the cabinets from Siemens' CDM. He left the company in June 2014.

External circumstances

21 There was no lighting installed in the tunnel. Before the testers started work, each COSS had given a task briefing which required staff to use hand held lamps or head torches. The possible role in the accident played by the limited lighting available is referred to in paragraph 39.

The sequence of events

Events preceding the accident

22 Overnight on 25/26 October 2014 a planned *engineering possession* took place of both the fast and the slow lines between South Kenton (9 miles 45 chains) and Bourne End (24 miles 53 chains), which encompassed Watford Tunnels. The possession of the fast lines was planned to start at 00:55 hrs on the morning of 26 October and finish at 06:45 hrs. Although there were multiple sites of work, there was only a single *worksite* for the fast lines with one *Engineering Supervisor* (ES) responsible for the worksite and all activities taking place within it. Siemens' staff were undertaking signalling installation and testing work in the tunnels and civil engineering work outside the tunnels in conjunction with other contractors.

23 The signalling installers were the first to arrive at the work location, and started installing equipment in the cabinets, with the two groups of testers following on behind to undertake functional testing of the equipment. The two teams of testers proceeded from cabinet to cabinet, overtaking each other as they moved through the tunnel and following the installers who were working ahead of them. The installers, who were working independently of the testers, finished their work and left the testers to complete the functional testing.

24 Cabinets WT18M125F 'A', 'B' and 'C' (referred to as cabinets A, B and C in the remainder of this report) were the three cabinets located on the tunnel wall adjacent to the up fast line. They housed the last items of equipment that were functionally tested before both groups of testers left the tunnel having completed their work. Cabinet A, the door of which was later struck by the train, was the most northerly of the three cabinets in the group (figure 5).

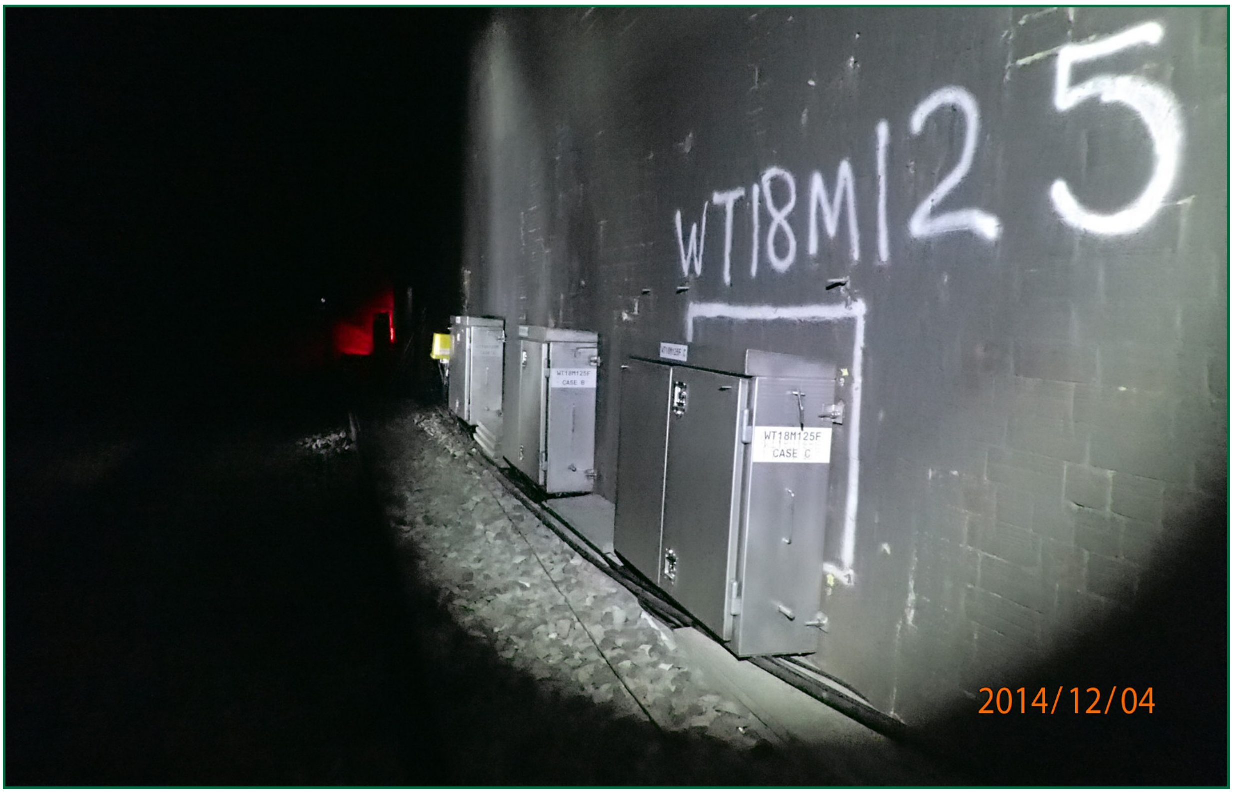


Figure 5: Cabinets A, B and C on the cess side of the up fast line

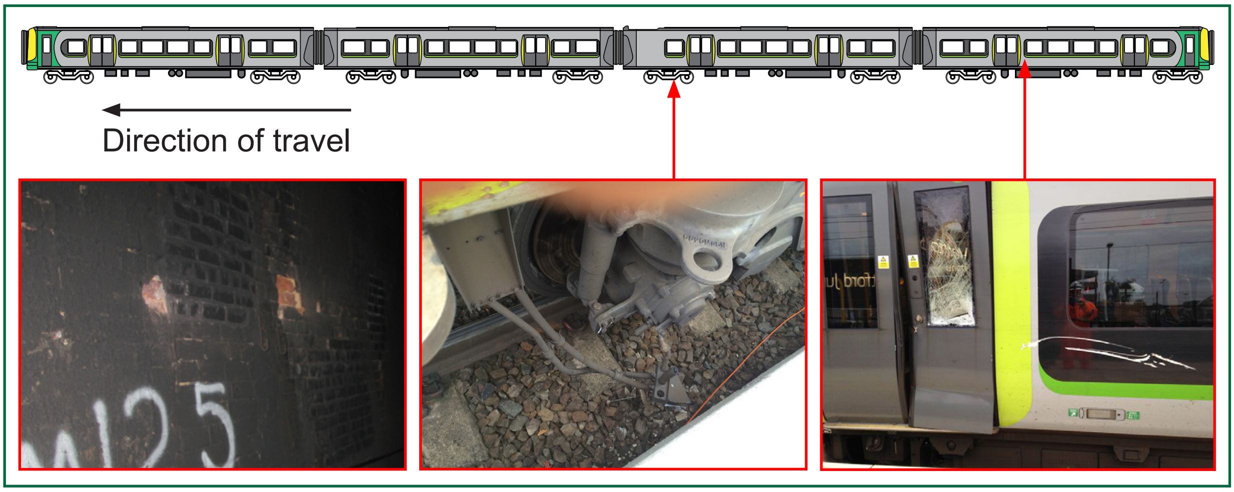
25 The two individuals performing the role of COSS advised the ES that their respective groups and equipment were clear of the line at 05:15 hrs and 05:20 hrs respectively (the ES was based remotely at Siemens' office in Watford) and that they no longer required protection. The ES contacted the *Person in Charge Of the Possession* (PICOP) at 06:23 hrs and the fast lines were handed back to the signaller for trains to run at 06:45 hrs.

Events during the accident

26 Shortly before 07:19 hrs, train 2K00 entered the north end of Watford Tunnel travelling towards London Euston on the up fast line at 88 mph (141 km/h). Carriages 1 and 2 of the train passed Cabinet A without incident. However, as carriage 3 passed Cabinet A, the right-hand door of the cabinet was struck by the train, having opened to become foul of the line (figure 6).

Figure 6: View from the cess adjacent to the up fast line looking towards London showing a reconstruction of the appearance of the door of Cabinet A fully open

27 The leading bogie of the third carriage struck the cabinet door, which detached from its hinges and became airborne. The door struck the tunnel wall (figures 7 to 9), and then bounced between the tunnel wall and the train. It hit the leading set of passenger doors on the fourth carriage of the train, penetrating the door window and causing a shower of glass debris to enter the passenger compartment (figures 10 and 11). The safety circuits on the train detected that the door was no longer properly closed and automatically applied the train's brakes. At the same time, the driver observed a 'door open' indication in his cab.



Figures 7 to 9: (left to right) The initial impact damage on the tunnel wall, the equipment on the leading bogie of carriage 3 and damage to the door and body side of carriage 4

Figures 10 and 11: The damage to the door of carriage 4 and internal CCTV images of the glass entering the passenger compartment

Events following the accident

28 The train stopped beyond the south end of Watford Tunnel and the train driver made an emergency call to the signaller requesting that both lines be blocked. The train driver and conductor examined the train and found the severely damaged doors on the last carriage, which were potentially out of gauge. The driver reported this to the signaller.

29 A mobile operations manager attended and examined the fast lines in Watford Tunnel. He discovered that one of the cabinets (Cabinet A) on the tunnel wall adjacent to the up fast line was damaged, and there was a damaged cabinet door in the cess next to the down fast line.

30 At 07:45 hrs the train was taken forward to Watford Junction station, and approximately 120 passengers were de-trained. It was then taken out of service and went first to London Euston station where the damaged door was removed, and then to Northampton depot for examination by the RAIB. The fast lines were reopened at 11:28 hrs.

Key facts and analysis

Identification of the immediate cause

31 **One of the doors of Cabinet A opened to become foul of the up fast line, most likely as a result of aerodynamic forces, as train 2K00 passed through the tunnel.**

32 Figures 12 and 13 show a cabinet of the same type as Cabinet A and the arrangements for securing the door on Cabinet A in the closed position. The securing mechanism consists of a pair of levers which rotate to engage with the cabinet frame when the handle (figure 13) is turned, thus securing the door closed. It is then possible to lock the cabinet with a key.

Figures 12 and 13: (left) A cabinet of the same type as Cabinet A and and (right) the right-hand cabinet door open, showing the securing mechanism

33 Train 2K00 was not equipped with forward facing CCTV, and there is no record of the position of the right-hand door of Cabinet A immediately before the accident. The RAIB has considered three possible scenarios for the condition of the door as train 2K00 approached:

- *The door had been closed and secured with the handle turned*. An examination of Cabinet A, and in particular the levers and door frame, revealed no damage to either. This indicates that the door could not have been properly secured and then wrenched open, because this would have led to damage to the levers and frame. This scenario has been discounted.
- *The door had been left partially open.* If this had been the case, it is likely that the aerodynamic piston effect (the plug of air moved along in front of a train which is particularly pronounced in tunnels where its dispersal is constrained by the tunnel walls) associated with the approach of train 2K00 would have forced the door fully open into the path of the first carriage of the train. However, there was no damage to the front carriage of train 2K00 and the RAIB considers this scenario to be unlikely.

- *The door was closed, but left unsecured (ie the handle had not been turned)*. There are two possibilities: the right-hand door was fully closed, but the handle was not turned or the right-hand door was closed as far as was possible, but still slightly proud of the left-hand door[3], as shown in figure 14. The air flow associated with the movement of train 2K00 through the tunnel would have created a pressure differential at the doors of Cabinet A, which could cause an unsecured door to open after the front of the train had passed. The RAIB considers this to be the most likely scenario. When Network Rail staff examined the cabinet after the accident (paragraph 30), the left-hand door was found to be closed but not secured.

Figure 14: View from the cess adjacent to the up fast line looking towards London showing a reconstruction of the appearance of the right-hand door of Cabinet 'A' slightly proud of the left-hand door

Identification of causal factors

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

- the door of Cabinet A was probably left closed but unsecured when the work undertaken during the engineering possession was completed (paragraphs 36 to 58); and
- the cabinet was positioned such that an open door could be struck by a train (paragraphs 59 to 69).

These two factors are now considered in turn.

The cabinet door left unsecured

35 The right-hand door of Cabinet A was probably left closed but unsecured when the work undertaken during the engineering possession was completed.

36 This causal factor arose due to a combination of at least two of the following factors (factors b and c); factors a and d may also have been causal:

a. the task lighting may have been inadequate, making it difficult for the testers to see that the door had been left unsecured (paragraphs 37 to 39);

[3] Witness evidence shows, and the RAIB observed, that a document tray within the cabinet may have prevented the doors from closing fully (so that they could be secured) without pressure being exerted to push the document tray into the body of the cabinet.

b. the method of work adopted for testing made it more likely that a door would be left unsecured (paragraphs 40 to 43);

c. no-one was allocated the responsibility for checking that the doors had been closed and secured on completion of the work (paragraphs 44 to 50); and

d. the testers may have been suffering from fatigue, increasing the probability of an error being made (paragraphs 51 to 57).

Each of these factors is now considered in turn.

Task lighting

37 On arrival at the engineering possession, the installers and the testers were briefed by the relevant COSS on the *safe system of work*. The task briefing sheet covered the general health and safety risks from their work activities and the environment at the site of work. Because of the dark environment, staff were required to use head or handheld lamps for safety purposes, but these also provided the means of task lighting.

38 Specialist portable task lighting was neither mandated nor was its use normal practice among Siemens testers. Siemens staff (managers and testers) explained that this was because of the amount of other equipment testers needed to have with them, and the nature of the work which required them to move from cabinet to cabinet. As part of its general safety briefing, Siemens had said that if any member of staff considered conditions to be unsuitable for the work to be done, they could stop work until the deficiency had been rectified. The RAIB found no evidence that this had ever happened because of inadequate lighting.

39 A reconstruction undertaken by the RAIB in Watford Tunnel showed that it is probable that, as the two groups of testers walked south (towards Watford) from the site of work, their head torches and handheld lamps did not illuminate the area sufficiently for them to see that the door of Cabinet 'A' was not secured (this would have been indicated by the position of the door handle). It would have been equally difficult to see if the door had not been completely closed (figure 15).

Figure 15: View from the cess adjacent to the up fast line looking north. Note that a door of Cabinet A (further from the camera) is in the same position as that shown in figure 14 and doors on Cabinet B (closer to the camera) are closed.

The method of work

40 Network Rail standard NR/L2/SIG/10064 'Security of Equipment', states that if equipment is fitted with doors or covers, these must be replaced on completion of work and locked where required.

41 Even though the testers were not employees of Network Rail, and the equipment within the cabinets had not yet been commissioned, Siemens briefed its employees to adhere to the Network Rail standard and leave all equipment and sites of work safe and secure. The cabinets could not be locked because the testers had not been issued with the keys, but Siemens believed that the security of the cabinets would be achieved by its staff remembering to properly close the doors on completion of their work.

42 The testers were mostly experienced and all were conscious of their own responsibility to secure cabinet doors after every task and especially on completion of their work. However, witness evidence indicates that the method of work used by the two groups of testers, which involved repeated movement between the various cabinets and trackside equipment in the tunnel, led to the testers frequently deviating from this requirement, and leaving the doors of cabinets open or closed but unsecured between tasks. They did this in the genuine belief that there was no apparent risk, because they would be coming back to the cabinets in due course.

43 The activities within the site of work made the site very busy, as the two groups of testers were overtaking each other, while also working alongside the installers. Although the method of work may have made effective use of time, it may have led to each of the testers assuming that either the installers or one of their colleagues would close and secure both doors of Cabinet A when they left site.

Responsibility for checking the cabinet door was closed

44 The RAIB investigation, supported by witness evidence, identified that a belief existed within the project management and signalling staff of both Siemens and Network Rail that the risk arising from a cabinet door being left open or unsecured was blatantly obvious and that 'you always close doors of any cabinets you work on'. As a consequence, the specific hazard of a door being left open or unsecured did not form part of the Work Package Plan[4] (WPP), task briefing or COSS briefing.

45 Handbook 1 of the rule book (GE/RT8000), 'General duties and track safety for track workers', required all staff to ensure that tools and equipment were not placed any closer than two metres from the running line, but did not obviously address the hazard of a door that could infringe the gauge being left unsecured at the end of work.

46 Handbook 9 of the rule book, 'IWA or COSS setting up safe systems of work within possessions', required that on completion of work, the COSS contact the ES to advise him that the work group were clear of the line and that protection for staff was no longer needed. This duty related to people rather than equipment.

[4] The WPP (BK40/005 Installation & BK40/014 Test & Commission) were deemed by the Network Rail Infrastructure Projects Signalling team to be Low Risk and therefore the WPP did not require approval from Network Rail. Copies of the WPP were supplied for information to Network Rail.

47 Handbook 12 of the rule book, 'Duties of the Engineering Supervisor (ES)', required the ES, once contacted by the COSS of each group, to confirm that they no longer needed to be on or near the line, and when satisfied that there were no engineering trains or on-track plant left in the work site, to tell the PICOP that as far as he/she was concerned, the line was safe and clear and the work site given up. This affirmation could be given (and frequently was) without the ES being present on site. Thus at Watford Tunnel, the ES was not required to make a physical check that the line was safe and clear (for the operation of trains).

48 The RAIB cannot be sure which member of staff was the last person to work on equipment in Cabinet A. As the installers had already left the site of work, it is likely that it was one of the group of testers. Although Cabinets B and C were closed and secured, no one appears to have checked Cabinet A. Witness evidence suggests that each of the testers had assumed one of their colleagues had closed and secured Cabinet A and neither the COSS nor the lead tester believed that they had a responsibility to confirm that all of the cabinets had been closed and secured.

49 When both groups of testers were clear of the line, the two individuals acting in the role of COSS contacted the ES and confirmed that they no longer required protection for their groups of staff. The ES, once he received confirmation from every COSS working within the work site that they no longer required protection, advised the PICOP that the line was safe and clear.

50 All staff apparently followed the requirements of the rule book, but the line was not safe and clear for the operation of trains, indicating that there was a gap in the process. As originally conceived in the 1980s, work sites generally existed over short distances and the ES would be present on the ground and able to check physically that the line was safe and clear. However, there is now a tendency for work sites to be much longer, eliminating the possibility of an ES performing a physical check. The length of the worksite that encompassed Watford Tunnel on the night of 25/26 October was nearly 15 miles (24 km) and it was not feasible for the ES to physically inspect all of it at the end of the shift.

Fatigue

51 Since 1999, a number of companies within the railway industry have used a 'Fatigue Index'[5] (developed by the Health & Safety Executive) to assess the impact of shift work and rostered working hours on their staff. In 2006, the Fatigue Index was enhanced with the addition of a 'Risk Index', which was intended to enable an assessment to be made of the relative risk of the occurrence of an incident on a particular shift, taking account of the rostered hours. The two indices were combined to form the Fatigue and Risk Index (FRI) spreadsheet-based tool, the latest version of which is version 2.3, introduced in January 2013.

52 A user is able to input details of the hours worked in the preceding weeks for an individual member of staff. The FRI then produces separate scores for fatigue and risk based on a number of parameters which include the time of day, duration of the shift, rest periods and breaks within a shift and a cumulative component in which the individual duty periods are put together to form a complete schedule.

[5] Current version available at http://www.hse.gov.uk/research/rrhtm/rr446.htm.

53 For the fatigue element of the FRI, the result is shown as a value between 0 and 100 and relates to the probability of high levels of fatigue occurring. The Health and Safety Executive deems values up to 30 to 35 for day shifts and 40 to 45 for night shifts to be normal and achievable. Increased scores on the fatigue index are indicative of an increased probability that any individual will experience fatigue (however, it only provides an approximation of the risk and deals with a population average).

54 During the previous two weeks' work, the testers had been working night shifts. The working week routinely started on Sunday night and ran through to Thursday night, with rest days on Friday and Saturday. However, the rosters for the testers who had worked on 25/26 October in Watford Tunnel showed that, with the exception of one individual, they had been routinely working Saturday night as overtime (and thus a six-day week comprised entirely of night shifts). FRI analysis of the testers' working hours for the two weeks leading up to the accident showed cumulative fatigue scores ranging from 52 to 57 on the night of 25/26 October, with the exception of the one individual who had taken leave in the period, and whose fatigue score was 43. Furthermore, the time at which the testers left the tunnel (with the door of Cabinet A unsecured) coincided with the time when it is widely acknowledged that the likelihood of fatigue occurring is at its greatest (between 04:00 hrs and 06:00 hrs)[6].

55 However, the cumulative effect of hours worked is only one factor that can influence fatigue; the distribution of shifts and sleeping patterns also have an effect. The working pattern for three of the four testers in the two weeks leading up to the accident comprised night shifts with only Friday night off. Each individual had to make decisions about how to manage their sleep arrangements during their single rest day (ie continue to sleep during daytime or temporarily revert to sleeping at night). Some of the testers had tried to remain in a 'night shift' working pattern, by staying up late on Friday night or into the early hours of Saturday morning (24/25 October 2014). However due to family activities and other commitments, others had adapted their sleeping patterns to wake at a 'normal' time (08:00 hrs to 09:00 hrs) on Saturday morning and had then stayed awake until returning from their Saturday/Sunday night shift.

56 This had the effect of making their Saturday/Sunday shift the equivalent of a 'first night shift' and meant that some of them had been awake for more than 20 hours by the time they left site on Sunday morning. The RAIB's investigation into the uncontrolled freight train run-back between Shap and Tebay in Cumbria on 17 August 2010[7] highlighted the likelihood of fatigue occurring on a first night shift. In the case of the testers at Watford, they are likely to have been suffering from both cumulative fatigue as a result of the number of shifts worked and short-term sleep deprivation as a result of not having slept for 20 hours.

57 The RAIB's investigation found that Siemens had a policy on managing fatigue, but had not fully implemented it. This is discussed in paragraphs 88 to 90.

[6] See, for example, Hobbs, A., Avers, K.B. and Hiles, J.J. 2011, *Fatigue risk management in aviation maintenance: current best practices and potential future countermeasures*. Report no. DOT/FAA/AM-11/10. (Federal Aviation Administration, Washington, DC).

[7] RAIB report 15/2011.

Positioning of the cabinet

58 The cabinet was positioned such that an open door could be struck by a train.

Background – Network Rail's Governance for Railway Investment Projects (GRIP)

59 Network Rail standard N2/L2/INI/02009 'Engineering Management for Projects' applies when an external contractor carries out work on, over or under Network Rail infrastructure. The standard describes the processes, roles and responsibilities of both Network Rail and Contractor staff responsible for the management of the technical and engineering requirements of the project.

60 The standard is also aligned to the responsibilities within Network Rail standard NR/L2/INI/CP0047 to achieve compliance with the Construction, Design & Management Regulations. Compliance with these standards must be achieved while the project progresses through Network Rail's project management delivery tool / framework as defined within Network Rail's company standard NR/L1/INI/PM/GRIP/100 'Governance for Railway Investment Projects' (GRIP). The GRIP process, which is split into eight key stages, describes how Network Rail manages and controls projects to renew or enhance the national rail network. Dependent on the complexity of the project, a number of stage gate reviews are undertaken to establish that the works that were specified at each stage of the project have been delivered. If the works have been completed, or are in progress and risk to the project is low, the project can proceed to the next stage. It is the responsibility of the Project Manager to demonstrate that the GRIP process for the project has been followed.

61 Network Rail initiated the Watford re-signalling project in 2009 with engineering options being reviewed and feasibility studies completed. The project was delayed between 2010 and 2012 as other infrastructure projects in the Watford area were afforded a higher priority. The project recommenced in March 2013 when Siemens was appointed as the contractor. Siemens designed a *Location Area Plan (LAP)*, based on the earlier *scheme plan* designed by Network Rail's Signalling Design Group. The initial scheme plan had considered the option of installing cabinets outside the tunnel, but the idea had been rejected because it was deemed to be costly and potentially unreliable due to the distances between the cabinets and equipment in the tunnel.

62 The LAP was submitted in July 2013 for an Inter-disciplinary Design Check (IDC). Standard N2/L2/INI/02009 requires the IDC to be undertaken by the design organisation (Siemens in this case) in consultation with the client (Network Rail). The IDC is a multi-disciplinary meeting to confirm that both parties agree that the information included in the design is compatible with, and conforms to, all of the other engineering and operational requirements that the design is expected to interface with.

63 Standard N2/L2/INI/02009 also requires an Inter-disciplinary Design Review (IDR) to take place. The IDC and IDR can be combined, but the IDR can also be a separate review undertaken by the Network Rail DPE to ensure that the information and details of the design are compatible with other projects and meet Network Rail's requirements. Once comments made at the review(s) have been taken into account, the draft design should be submitted to Network Rail for formal acceptance. Once this has been gained, the project is *approved for construction* (AFC) and can proceed on that basis (see paragraphs 82 to 87).

The positioning of Cabinet A

64 On 1 July 2013 a joint IDC/IDR took place between Siemens and Network Rail. Siemens designers had made reference in the notes section within the LAP that they had proposed to locate the cabinets in the *refuge* spaces within Watford Tunnel. Those refuges had originally been provided at a time when track inspection and maintenance staff worked in tunnels while trains were operating normally. They needed somewhere safe to go to when a train approached. With the imposition in recent years of a prohibition on working within tunnels when trains are operating, it could be argued that the refuges have become redundant (and it is not uncommon to see them used for storing materials). Staff may still work in tunnels when engineering trains are operating, but because those trains are restricted to low speed, the risk of staff being struck by a train is perceived to be lower.

65 Siemens' proposal to use the refuges for housing the cabinets was not based on a recognised need to mitigate any risk associated with gauge clearance, but rather that it would be tidier to have the cabinets tucked away in refuges instead of on the tunnel wall. However, an open door on a cabinet positioned in a tunnel refuge would have been clear of a passing train (figure 16). Siemens did not confirm during the IDC/IDR meeting on 1 July 2013 whether using the refuges was acceptable. The Network Rail DPE did not notice the proposal to site the cabinets in the refuge contained in the notes at the end of the plan. The LAP schematic drawing does not show the exact positioning of cabinets nor the position of tunnel refuges, although Siemens stated that its designers had identified which cabinets were to be positioned in the refuges with a specific 'hash' mark and the note referred to in paragraph 64.

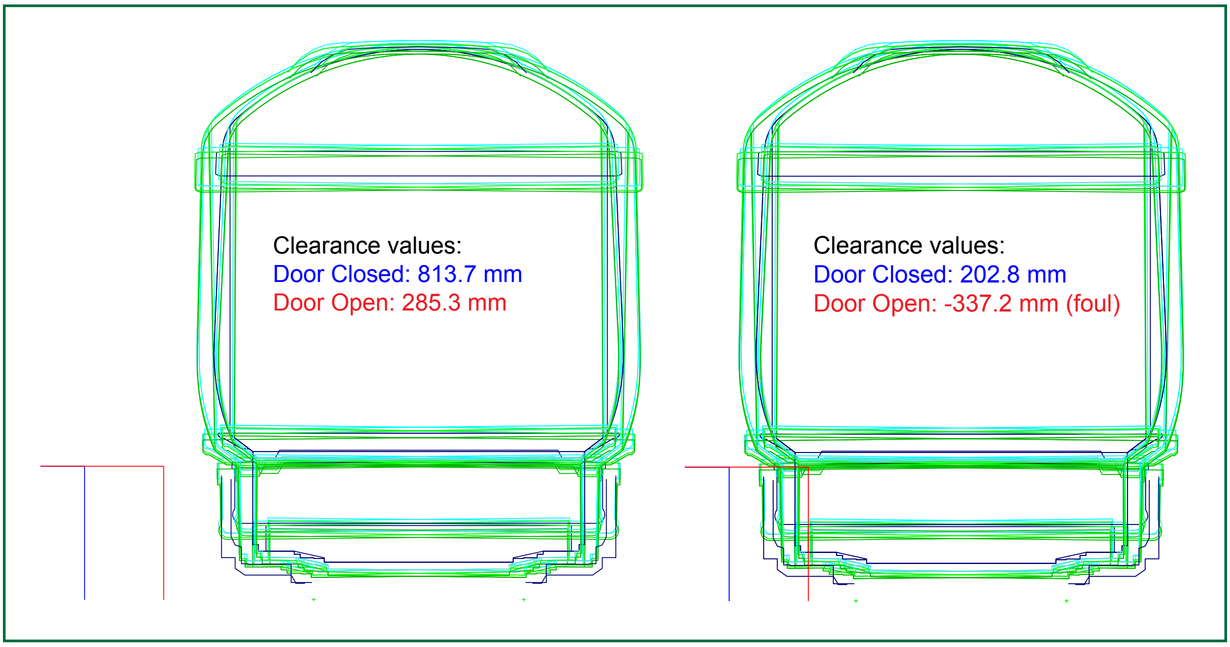


Figure 16 (left) typical clearance values of a slimline cabinet if it had been installed in the refuge (door open) and (right) typical clearance values with the cabinet attached to the tunnel wall with the doors open (diagrams provided courtesy of Network Rail). Note that the open door of a standard cabinet located in the refuge would not have infringed the gauge. The figure shows a number of different rolling stock profiles, but although the values may change from the typical values given, the effect of positioning the cabinet in the refuges and on the tunnel wall does not.

66 Later in July 2013, a routine project progress meeting was held during which the Siemens proposal for siting standard cabinets within the refuges was informally discussed. Network Rail's representative questioned the proposal, as he had not been aware of it until this point and considered that a refuge is normally used to provide a safe space for staff. The Network Rail DPE was contacted and made aware of the proposal. The DPE contacted Siemens' CEM and requested that Siemens submit a Technical Query (submitted on 17 October 2013) so that the issue could be formally reviewed. The issue was also recorded on the design risk log.

67 During October and November 2013, the DPE sought guidance on the issue from a number of sources within Network Rail. A manager within the local maintenance team indicated that they still had a need for the refuges and that they shouldn't be used for siting signalling equipment. Network Rail had no policy or guidance on the siting of equipment in red zone prohibited areas (areas where staff are not permitted to work when trains are running normally) generally, and on the use of tunnel refuges for other purposes in particular.

68 On 21 November 2013, the DPE advised Siemens that the option of siting the cabinets within Watford Tunnel had been refused on the basis that a refuge may still be used during an engineering possession when on-track plant and engineering trains are operational. Siemens questioned this decision on the basis that:

- the risk to staff working within Watford Tunnel from the use of a small number of refuges for siting cabinets would be minimal as there would still be a large number of unused refuges available;
- engineering trains were required to operate at low speed in work sites and members of staff would therefore have sufficient time to move to an unused refuge or position of safety; and
- a number of refuges within Watford Tunnel were already full of building materials (this was also confirmed by the RAIB after the accident)[8].

69 Network Rail maintained its refusal to grant Siemens' request to use the refuges. Siemens now had to redesign the LAP and find an alternative design of cabinet to fit onto the tunnel wall. The following section describes how the change of design contributed to the occurrence of the accident.

Identification of underlying factors

The risk of cabinet doors being struck by a train

70 **The risk arising from an open cabinet door being struck by a train was not identified and appropriately mitigated.**

71 This underlying factor arose due to a combination of the following:

a. the risk arising from the use of the cabinet in the specific environment of Watford Tunnel was not assessed and mitigated (paragraphs 72 to 77); and

[8] The RAIB examination of Watford Tunnel also identified a number of refuges which were either obstructed by debris or equipment. This was brought to the attention of Network Rail Infrastructure Projects.

b. the cabinet itself had not been subject to a generic risk assessment when the design was modified for use in Watford Tunnel (paragraphs 78 to 87).

Each of these factors is now considered in turn.

Risk assessment and mitigation for use of the cabinet in Watford Tunnel

72 Network Rail standard NR/L2/OHS/047 'Application of the Construction (Design and Management) Regulations' details the process and responsibilities for Network Rail and its contractors to comply with these regulations during construction projects, as part of the GRIP process. Project advice note PAN/PMSE/P/CD/ADV-0081 'Guidance to projects on compliance with the Common Safety Method on Risk Evaluation and Assessment' requires Network Rail and its contractors to maintain an accurate design risk log (paragraph 82). The log may be in the form of a spreadsheet, database, or document which is used to identify, analyse and manage project risk. It must contain details of design and construction hazards and record the control measures that have been implemented to manage the risk to an acceptable level. The log is normally produced prior to the first design decision being made (GRIP 3) and should be maintained through to completion of the project, when it is then forwarded to the maintainer to form part of the health and safety file.

73 After Network Rail instructed Siemens in November 2013 not to use the tunnel refuges for siting the cabinets Siemens set about procuring a suitable product and looked at several design options (figure 17) for 'off the shelf' products that already had *product acceptance* for use on Network Rail's infrastructure.

74 The RAIB understands that some of Siemens' signalling technicians who had previously worked on the Thameslink project identified an alternative design that they had used in Belsize Tunnel which therefore had product acceptance (figure 18). In December 2013, Siemens' design risk log showed that the CEM had recorded that an assessment of the solution for providing tunnel cabinets should be completed, as Siemens intended to use the same cabinets as those used on the Thameslink project, but use of the cabinet would be dependent on a site analysis and an additional IDC. The CEM closed this entry on 21 February 2014 showing that the cabinets would now be mounted on the tunnel wall. The additional IDC did not take place.

Figure 17: The standard cabinet design with lift-off panel

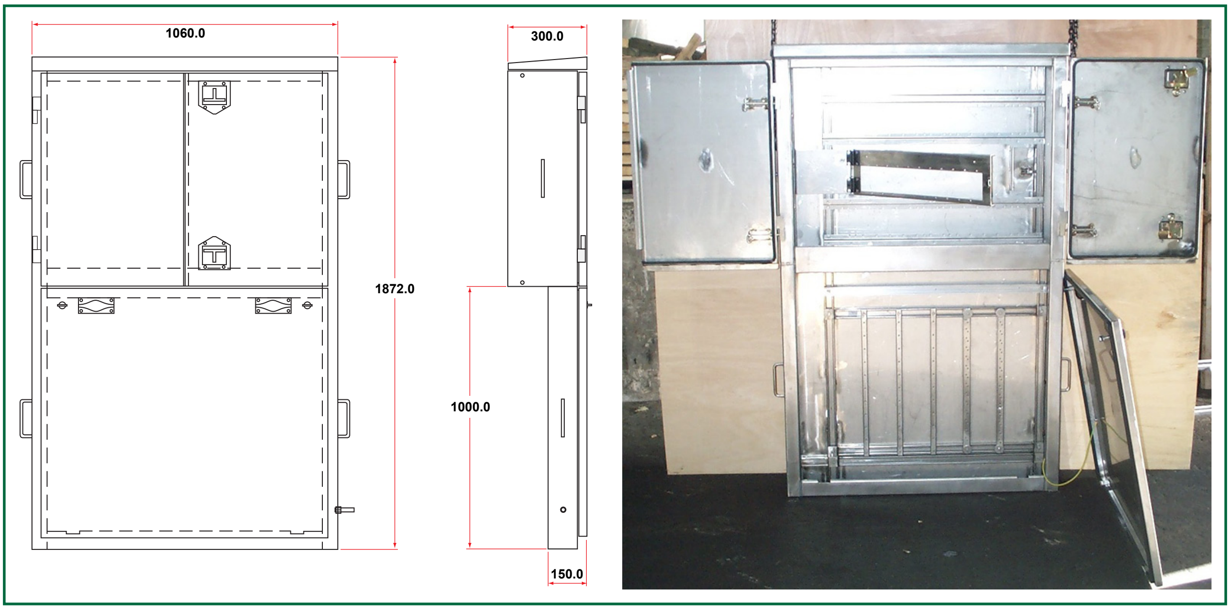


Figure 18: The slimline double chamber cabinet with lift-off panel (bottom) and double doors (top) specifically designed for the Thameslink project (Belsize Tunnel) in 2004 (image supplied courtesy of MGB Engineering, Plymouth)

75 Between February and June 2014, Siemens contacted the Sales Engineer at Henry Williams Ltd asking him to look at the engineering options that were available. The cabinet had been originally designed to meet the specific electrical requirements and gauge constraints in Belsize Tunnel (paragraph 79), and there were other differences in the equipment to be included within the cabinet for its use in Watford Tunnel. Siemens' CDM requested several modifications to the original cabinet design, including a reduction in height. The Belsize Tunnel cabinet was, in effect, two cabinets mounted vertically, but only one was needed for Watford Tunnel. The lower of the two Belsize Tunnel cabinets featured a lift-off panel and the upper cabinet had hinged doors. However, when Siemens modified this arrangement to utilise only a single cabinet, they selected the hinged door version. Had they selected the cabinet with the lift-off door, the accident could not have happened in the same way as it did on 26 October 2014. Although the door could have been left off completely (in which case it would have been blown around the tunnel by the train), the absence of the door would have been much more apparent to the testers.

76 The design risk log shows that in April 2014 Network Rail requested Siemens to raise an additional Technical Query to risk assess the mounting specification for the new cabinets. Contractors acting on behalf of Siemens undertook a site visit to inspect how the new cabinets would be sited and mounted on the wall. The additional risk assessment for the mounting was completed in July 2014 and the response to the Technical Query (including a cabinet specification) was submitted on 14 July 2014 and authorised by the DPE on 31 July 2014. Witness and documentary evidence show that although the risk from aerodynamic forces was considered, it was confined to consideration of the cabinet in normal condition (ie with doors closed and secured).

Figure 19: The modified slimline cabinet

77 A review of the design risk log showed that the decision to relocate the cabinets and identify a suitable solution had been recorded. However, witness evidence indicates that the risk arising from the cabinet being positioned where an open door could be struck by a train was never identified. Siemens considered that the delay in Network Rail declining its request to place standard cabinets in tunnel refuges (paragraphs 63-67) resulted in limited time being available to review the implications of alternative designs of cabinet. Had an additional IDC or IDR (paragraph 74) and risk assessment been undertaken, it is possible that the problems associated with open doors on the design of cabinet chosen would have been identified.

Risk assessment of the cabinet design

78 During 2003/2004, Henry Williams Ltd had been asked to design and manufacture a new 'bespoke' cabinet for use within the Belsize Tunnel, as part of the Thameslink project (paragraph 74). The finished cabinet was tested within the tunnel environment and a risk assessment was completed by the project. It identified the risk from a door being inadvertently left open. The mitigation was to place notices on the cabinet to alert staff to close the door when they had finished their work.

79 Although the cabinet was bespoke to the Thameslink project, it was given a 'generic' product acceptance in January 2004 enabling its use across the entire railway network. No conditions of use (such as the requirement for a risk assessment for each subsequent use of the cabinet, taking account of its new environment) were identified. The certificate provided the document references for both the independent and engineering assessments that had been completed on the original cabinet design for use in Belsize Tunnel, but the details of the risk assessment carried out did not accompany the product details on the *Parts and Documentation System* (PADS).

80 Henry Williams Ltd was sent the product acceptance certificate but the engineering assessment, which included the risk assessment documentation that had identified both the risk and the mitigation for the design, was not provided. The company was therefore unaware of the specific risk of the cabinet door being struck that had been identified by the Thameslink project. The manufacturer did not request the documents referenced on the certificate from Railtrack (predecessor to Network Rail) and therefore could not undertake its obligations under the European Product Safety Directive[9] to retain a comprehensive technical file on the product.

81 The engineering assessment documents completed for the Thameslink project in 2004 (which had identified the risk from the original design) were not readily available on the PADS system and had to be obtained via the archives. If they had been available, Siemens might have been prompted to undertake a risk assessment. However, there is no guarantee that Siemens' risk assessment would have identified the door being inadvertently left unsecured as a hazard, and if it had done, whether the adopted mitigation measures would have prevented the accident.

82 Network Rail standard NR/L2/INI/02009 mandates the following roles and responsibilities of the CEM and CRE:

- Section 6.2.4.6 requires the CEM to approve the AFC design following completion of an IDC and the acceptance process confirming that the design meets, or has met all the requirements of the standard;
- Section 6.2.4.7 requires the CEM to implement a risk management process that identifies and mitigates risk and communicates details of unmitigated risk (which must be included within the design risk log) to Network Rail and the contractor (Siemens); and
- Section 6.3.3.8 requires the CRE to ensure that no product, material, equipment, infrastructure or other system in their design is used without the agreement of the DPE. This requirement should ensure all products are approved for use in accordance with Network Rail acceptance standards.

83 When Siemens identified the slimline cabinet manufactured by Henry Williams Ltd as potentially being suitable for use in Watford Tunnel, it approached the manufacturer with its requirements. The CDM asked Henry Williams Ltd's Sales Engineer to research various engineering options as Siemens required changes to be made (paragraph 75). Between February and May 2014 the manufacturer produced a modified design of cabinet. The Sales Engineer identified that if the design was modified, the original product acceptance certification might be invalidated. Although he had knowledge of the product acceptance process he did not raise the issue while he was employed by the company (in his position as Sales Engineer, his primary responsibilities related to matters before contract award rather than after), and no-one else within the company identified the problem.

[9] The European Product Safety Directive requires manufacturers to retain a technical file on the products manuafactured: http://www.hse.gov.uk/work-equipment-machinery/technical-file.htm.

84 Witness and documentary evidence shows that Siemens' CEM and CDM had justified their choice of the slimline cabinet on the basis that it had product acceptance. However, they had the knowledge and experience to realise that the modifications they had requested from the manufacturer from the outset would have required new product acceptance and should have been subject to an additional IDC/IDR prior to the design being approved for construction.

85 Documentary evidence shows that Siemens' CDM had contacted Network Rail (DPE and Route Asset Manager) making them aware of the proposal and the potential lead time for a modified design of cabinet. However witness evidence indicates that although the DPE had been sent the images of the original cabinet design, he may not have realised that Siemens intended to remove the lower half and retain the part with hinged doors. The DPE did not later query these issues.

86 Although the 'Approved for Construction' document for the modified design had been prepared and checked by the CRE in April 2014, no additional IDC/IDR took place as a precursor to the modified design becoming formally approved for construction. An IDC/IDR might have alerted the involved parties that the modified design had not been subject to the formal acceptance process contained within Standard NR/L2/INI/02009 and may have highlighted the need for product acceptance. Had product acceptance processes been applied, the associated risk assessment might have identified the same hazard of a door being left open that had been identified by the Thameslink Project in 2004. Even so, there is no guarantee that had they adopted the same risk mitigation measure (stickers on the door), it would have prevented the door being left unsecured on the night of 25/26 October 2014.

87 Communication between Network Rail and Siemens during the project was ineffective at times. Network Rail's managers did not undertake detailed scrutiny of the technical details produced by Siemens. Initially there was little discussion between Siemens and Network Rail about the positioning of the cabinets within the refuges, which resulted in a significant delay before Network Rail and Siemens finally agreed that they should be positioned elsewhere in the tunnel. This created pressure to make rapid progress in finding an alternative design of cabinet that was suitable for the new location.

Siemens' management of fatigue

88 **Siemens had not fully implemented its policy on managing the risk from fatigue. This is a possible underlying factor.**

89 Paragraphs 52 to 57 describe the reasons why the testers may have been suffering from fatigue. Siemens has responsibility for managing fatigue in its staff working on the railway under regulation 25 of the *Railways and Other Guided Transport Systems* (Safety) Regulations 2006. The ORR (see appendix A for definition) has issued guidance to the railway industry on the management of fatigue risk in its staff[10], which describes the components of a *Fatigue Risk Management System*.

[10] 'Managing Rail Staff Fatigue', available at http://orr.gov.uk/data/assets/pdffile/0005/2867/managingrailfatigue.pdf..

90 Siemens' arrangements for managing fatigue are described in its document, 'Management of working time and fatigue[11]'. It incorporates good practice in fatigue management:

- Section 5.1 of the document indicates that the FRI can be used to predict indicative fatigue patterns as part of a planning system for weekend and commissioning working. It states that the FRI is to be used when it appears that the fatigue values defined as good practice in section 5.2 of the document are likely to be exceeded. The good practice fatigue levels identified in section 5.2 are 40-45 for night shifts. As indicated in paragraph 55, these levels were exceeded for three of the testers, but the FRI had not been used to evaluate the shifts[12].
- Another factor defined as good practice in Section 5.2 of Siemens' document is providing adequate rest between shifts or blocks of shifts. The document states that *'this is especially important for night shifts where it is recommended that 48 hours rest be provided following a block of nights'*. The testers were not given 48 hours rest after their block of night shifts that ended on Friday morning, 24 October 2014.
- Section 7 of the document indicates that working hours exceeding the fatigue levels identified as indicative of good practice in Section 5.2 should not be planned, except in exceptional circumstances. Section 7.2 of the document states that *'for each identified exceedance (from the guidelines in section 5.2) the Manager must ensure that an authorisation form is fully completed as a record both of the assessment and of any mitigation required to reduce the risk as far as practicable…'*. This had not been done in this case.

Siemens explained that the reason why various provisions of its document on managing working time and fatigue had not been implemented was because it had not been briefed and fully understood by relevant staff.

Factors affecting the severity of consequences

91 The likelihood of the cabinet door causing a derailment was low and an examination of the train and door mechanism showed there was no possibility that the impact could cause the damaged train door to become detached.

92 No injuries were reported from the shower of broken glass that entered the passenger compartment from the window in the damaged door. However it is possible that an injury might have occurred had the cabinet door struck and penetrated a passenger side window.

[11] CP/OSHE/022, Rev 2, 14 April 2014.

[12] The FRI is a useful tool, but it has limitations and the fatigue levels contained within it should be treated with caution. However its use was mandated within Siemens' document on managing fatigue.

Previous occurrences of a similar character

93 There have been two similar incidents in Watford Tunnel recorded in the last 25 years:

- A cabinet door was struck by a train in 1991. The immediate cause was identified as a panel which had been left unsecured. No information could be obtained from the historical British Rail Incident Management System and the RAIB has been unable to find any details of an investigation into this incident.
- On 29 May 2000, a train struck the open door of a cabinet while running on the up fast line in Watford Tunnel. A short time later, another train also struck an object on the opposite down fast line. Engineering work had been taking place through the tunnel overnight. The RAIB has been unable to find any details of an investigation into this incident and no-one involved in the re-signalling project in the period 2009 to 2014 appeared to have any knowledge of it.

Summary of conclusions

Immediate cause

94 One of the doors of Cabinet A opened to become foul of the up fast line, most likely as a result of aerodynamic forces, as train 2K00 passed through the tunnel (**paragraph 31**).

Causal factors

95 The causal factors were:

a. The right-hand door of Cabinet A was probably left closed but unsecured when the work undertaken during the engineering possession was completed. This causal factor arose due to a combination of at least two of the following factors (factors ii and iii); factors i and iv may also have been causal:

   i. the task lighting may have been inadequate, making it difficult for the testers to see that the door had been left unsecured (paragraphs 37 to 39, **Learning point 1, Recommendation 1**);

   ii. the method of work adopted for testing made it more likely that a door would be left unsecured (paragraphs 40 to 43, **no recommendation**);

   iii. no-one was allocated the responsibility for checking that the doors had been closed and secured on completion of the work (paragraphs 44 to 50, see paragraphs 98(ii)**,** 99**, Learning point 1 and Recommendation 2**); and

   iv. the testers may have been suffering from fatigue, increasing the probability of an error being made (paragraphs 51 to 57, **Recommendation 3**).

b. The cabinet was positioned such that an open door could be struck by a train (**paragraph 58,** see paragraph 98(i) and **Recommendation 4)**.

Underlying factors

96 The risk arising from an open cabinet door being struck by a train was not identified and appropriately mitigated (**paragraph 70**). This was due to a combination of the following factors:

a. the risk arising from the use of the cabinet in the specific environment of Watford Tunnel was not assessed and mitigated (paragraphs 72 to 77, **Learning point 2**); and

b. the cabinet itself had not been subject to a generic risk assessment when the design was modified for its use in Watford Tunnel (paragraphs 78 to 87, see paragraph 100 and **Learning point 2, Recommendations 5 and 6**).

97 A possible underlying factor was that Siemens had not fully implemented its policy on managing the risk from fatigue (**paragraph 88, Recommendation 3**).

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

Network Rail

98 Network Rail has:

i. recommended (in its own investigation into the Watford Tunnel incident) the establishment of a policy on the use of refuges within tunnels (paragraph 95b);

ii. issued a safety alert to brief staff and contractors on the immediate cause of the accident and to remind them to make sure they close and lock lineside equipment on completion of work (paragraph 94a(ii)); and

iii. commenced a ‘Product Acceptance Improvement Plan’ (2014), in which it plans to publish a clear scope of product acceptance for its contractors and review the effectiveness of the process to improve efficiency and communications. In the medium to long term, it plans to make improvements to the online web based system for product acceptance to ensure that the process and documents linked to product acceptance certificates and associated documents (eg risk assessments) are accessible. The review was ongoing at the time of writing this report.

Siemens

99 Siemens has:

i. in conjunction with the safety alert published by Network Rail (paragraph 98ii), placed notices warning staff to close and lock doors on all cabinets installed by Siemens (figure 20);

ii. introduced a new checklist for signalling technicians to complete after they had finished work to ensure that the line is handed back safe for trains to run;

iii. annotated all construction and design drawings for cabinets to incorporate padlocks and included the requirement to place notices on the cabinets warning staff to close and lock cabinet doors (paragraph 95a(iii));

iv. re-briefed its senior managers and construction design engineers (CDM/CRE) on their role and responsibilities when working within construction projects requiring compliance with Network Rail’s GRIP process and Construction (Design and Management) Regulations (paragraph 96), highlighting the need to ensure safety risks are identified and effective communication takes place between the contractor and the client to efficiently resolve outstanding safety issues; and

v. commissioned an independent review of its health and safety culture and Fatigue Risk Management System. The associated report is due be published in September 2015.

Figure 20: The cabinets within Watford Tunnel with safety notices placed on the doors

Henry Williams Ltd

100 Henry Williams Ltd has:

i. contacted the Network Rail product acceptance services department and is currently applying for a new product acceptance certificate for the modified design of the slimline cabinet; and

ii. re-briefed all its sales and design staff on the product acceptance processes to ensure all products manufactured or modified by the company for the railway infrastructure have the necessary product acceptance (paragraph 96b).

Learning points

101 The RAIB has identified the following key learning points[13]:

1. All staff involved in installation, maintenance, repair and inspection activity in tunnels need to be made aware of:
   - the limitations of head and handheld lamps, and the desirability of risk assessments undertaken at the time of the planning of work specifically considering the need for task lighting[14] (paragraph 95a(i)); and
   - the need for staff on site to reach a clear understanding about who will be responsible for closing cabinet doors (paragraph 95a(iii)).

2. It is important that project managers employed by Network Rail or its contractors who are working to Network Rail's standards for project management:
   - conduct adequate risk assessments in order to identify and mitigate/ eliminate the risk arising from the installation of new or redesigned products as part of the Interdisciplinary Design Check (IDC) and/or Interdisciplinary Design Review (IDR)[15];
   - ensure that involved parties work to a proper 'Approved for Construction' design when one is required;
   - consider ergonomics, human factors and incidents of a similar nature within the assessment process; and
   - ensure all new or modified products have been subject to Network Rail's product acceptance process (paragraph 96a and 96b).

[13] '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.

[14] Guidance from HSE on lighting at work available at http://www.hse.gov.uk/pubns/priced/hsg38.pdf may be a useful reference for those planning work.

[15] This is also a requirement under the Construction (Design and Management) Regulations 2015.

Recommendations

102 The following recommendations are made[16]:

1 *The intent of this recommendation is for Network Rail to eliminate by design, or mitigate, the risk from lineside cabinets fouling the gauge.*

Network Rail should mandate a requirement in its company standards for a design of cabinet that removes by design the risk of an open door infringing the gauge where the cabinet needs to be located in an area of limited clearance. Where this is not practicable, the design of cabinet should alert staff to an unsecured door (paragraph 95a(i)).

2 *The intent of this recommendation is for Network Rail to make explicit its processes for handing back a work site to reduce the risk arising from the railway not being safe and clear for the passage of trains.*

Network Rail should implement a means to meet the rule book requirement for the designated person (Engineering Supervisor or *Safe Work Leader*) to confirm to the PICOP that the railway is safe and clear for the passage of trains when that designated person is not present on site (paragraph 95a(iii)).

3 *The intent of this recommendation is for Siemens to arrange for an independent review of the way in which it manages the risk to safety critical staff working on infrastructure projects.*

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 (paragraphs 95a(iv) and 97).

continued

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

Additionally, for the purposes of regulation 12(1) of the Railways (Accident Investigation and Reporting) Regulations 2005, these recommendations are addressed to the Office of Rail Regulation (also known as 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.

4 *The intent of this recommendation is for Network Rail to reduce the risk arising from equipment that has the potential to foul the gauge.*

Network Rail should establish a policy and guidance on managing the risk from lineside equipment that can foul the gauge, with specific consideration of the siting of equipment in areas of limited clearance and, for example, the use of refuges in tunnels for that purpose (paragraph 95b).

5 *The intent of this recommendation is for Henry Williams Ltd to conduct a review of its railway industry products to assure itself that it has current, appropriate and complete certification.*

Henry Williams Ltd, in conjunction with Network Rail as necessary, should review its current range of railway products to ensure that it has full details of the certification associated with each item, and take action as appropriate to rectify any deficiencies found (paragraph 96b).

6 *The intent of this recommendation is for Network Rail to take action to reduce the risk of equipment being installed without contractors being aware of existing limitations on, or conditions of, its use.*

Network Rail should, in consultation with its suppliers, make improvements to its systems for product acceptance to ensure that all relevant information associated with those products, such as risk assessments, is accessible to potential users. The exercise should consider including a facility to enable each user to include information on its own application of the product that may be beneficial to future users (paragraph 96b).

Appendices

Appendix A - Glossary of abbreviations and acronyms

AFC	Approved for Construction
CDM	Contractor's Design Manager
CEM	Contractor's Engineering Manager
COSS	Controller of Site Safety
CRE	Contractor's Responsible Engineer
DPE	Designated Project Engineer
ES	Engineering Supervisor
FRI	Fatigue and Risk Index
GRIP	Governance Requirements for Infrastructure Projects
IDC	Inter-disciplinary Design Check
IDR	Inter-disciplinary Design Review
LAP	Location Area Plan
ORR	Until 1 April 2015 ORR was known as the 'Office of Rail Regulation'. It has used the name 'Office of Rail and Road' for operating purposes with effect from 1 April 2015. Legal force is expected to be given to this name from October 2015
PADS	Parts and Documentation System
PICOP	Person In charge of the Possession
WPP	Work Package Plan

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.

Approved for Construction	Design that has been prepared, checked and approved by competent persons in accordance with contract requirements and standards which has been subject to an Interdisciplinary Check and Review (IDC / IDR) and successfully completed the acceptance process and been approved for construction by Network Rail.
Cess	The part of the track bed outside the ballast shoulder that is deliberately maintained lower than the sleeper bottom to aid drainage, provide a path and sometimes (but not always) a position of safety.*
Controller of site safety	A person certified as competent to implement a safe system of work for a group of persons on Network Rail controlled infrastructure.
Down (line)	Direction of northbound trains away from London.
Engineering possession	A section of the line which is under exclusive occupation of an engineer for maintenance or repairs.
Engineering Supervisor	The person nominated to manage the safe execution of works within an Engineering Worksite. This includes arranging the Marker Boards, authorising movements of trains in and out of the work site and managing access to the site by Controllers of Site Safety (COSS)*.
Fatigue Risk Management System	A system used by companies who have a responsibility for managing fatigue in staff working on the railway staff, under regulation 25 of the Railways and Other Guided Transport Systems (Safety) Regulations 2006.
Gauge	The maximum permissible dimensions of rail vehicles and the minimum permissible dimensions of line side structures which the trains pass.
Location Area Plan	Design plan used by Network Rail to identify details of rail infrastructure.
Location cabinet	A cabinet usually located at the trackside housing equipment modules connected to signals and telecommunications.
On-train data recorder	Equipment fitted on the train which records the train's speed and the status of various controls and systems relating to its operation.
Person in charge of the possession	The competent person nominated to manage the protection for the possession, establishment of work sites within the possession and liaison with the signaller for the passage of the engineering trains in and out of the possession.

Product acceptance	A Network Rail standard that defines products or equipment that has been tested and risk assessed for use on Network Rail infrastructure.
Parts and Documentation System	A database containing information relating to the product certificate of acceptance. The database includes specific conditions and restrictions for the use of the product, interoperability compliance, and any other requirements that apply to the product.
Refuge	A recess, platform or handrail provided in areas of Limited Clearance to allow staff to stand clear of passing Trains.*
Rule book	The publication detailing the general responsibilities of all staff engaged on the railway and the specific duties of certain types of staff such as train drivers and signallers.*
Safe System of Work	Arrangements to make sure a workgroup that is required to walk or work on or near the line is not put in danger by the movement of trains.
Safe Work Leader	A role introduced by Network Rail for work site safety. A SWL will be an employee of Network Rail or the principal contractor for the work and will be accountable for task and operational risk and undertake the rule book duties previously known as COSS.
(Signalling) Scheme plan	A plan that describes the proposed alterations to an existing signalling system by means of standard signalling symbols and a standard colouring convention.*
Worksite	The area within an engineering possession that is managed by an Engineering Supervisor (ES). A worksite may contain sites of work, controlled by a Controller of Site Safety (COSS).

Appendix C - Investigation details

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

- interviews with witnesses;
- information from the on-train data recorder from train 2K00;
- internal Closed Circuit Television recordings taken from train 2K00;
- site photographs and measurements;
- inspection of Watford Tunnel;
- inspection of the damaged cabinet and door;
- inspection of the damaged doors on train 2K00;
- task briefing documentation;
- Network Rail and Siemens project management documents;
- Network Rail product acceptance documents and processes;
- Henry Williams Ltd documents and company standards; and
- a review of previous reported occurrences at the location.

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

Telephone: 01332 253300
Fax: 01332 253301
Email: enquiries@raib.gov.uk
Website: www.gov.uk/raib