RAIB

Rail Accident Investigation Branch

Rail Accident Report

Passengers struck by a flying cable at Abergavenny (Y Fenni) station 28 July 2017

Report 06/2018
May 2018

This investigation was carried out in accordance with:

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

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

Preface

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

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

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

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

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

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

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

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

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Passengers struck by a flying cable at Abergavenny (Y Fenni) station, 28 July 2017

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Summary

At about 18:05 hrs on 28 July 2017, as a northbound passenger train entered Abergavenny (Y Fenni) station, a cable drooping from the station footbridge became caught on the train's roof. The train dragged the cable and caused it to be pulled from the footbridge until its end broke free from a distribution cabinet. Once free, the end of the cable struck a group of passengers on the footbridge stairs and caused minor injuries to three of them. A member of station staff who was on the platform, close to the footbridge, was nearly struck by the cable. The accident also caused damage to cabling running over the footbridge, the station buildings, and a signal at the end of the platform.

The cable, which provided the signal box at Abergavenny with its electrical power supply, had become detached from the cable tray running over the footbridge and was drooping down to the extent that it was foul of the train. It then caught on an antenna fixed to the roof of the rear vehicle. The cable was drooping because the nylon cable ties used to attach it to the cable tray had broken. The RAIB found that the cable had not been inspected periodically as required for electrical installations and the drooping cable was not identified during footbridge inspections. It was not reported during routine station safety checks, or after it was drooping below the bottom of the footbridge. An underlying cause was that Network Rail had no controls in place for the management of low voltage electrical supply cables that cross operational railway lines via its overline structures.

The RAIB has made three recommendations to Network Rail. The first calls for the replacement of the existing cable tray running over the footbridge at Abergavenny with a solution that will reduce the risk of cables hanging down. The second relates to documenting and implementing controls for the management of cables that cross operational railway lines via structures at stations. The third is to identify cables at stations that have the potential to droop over the operational railway and be struck by a train, and ensure that the responsibility for testing and inspecting these cables is documented. The RAIB has also identified two learning points which relate to the importance of staff identifying drooping cables during safety checks and staff reporting any cables they see that are drooping or hanging down over the operational railway.

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 Sources of evidence used in the investigation are listed in Appendix A.

The accident

Summary of the accident

3 At about 18:05 hrs on 28 July 2017, as a northbound train entered Abergavenny station (figure 1), an electrical supply cable drooping from the station footbridge became caught on the train's roof. The train dragged the cable and caused it to be pulled from its remaining fixings until one end broke free from the distribution cabinet that it was connected to.

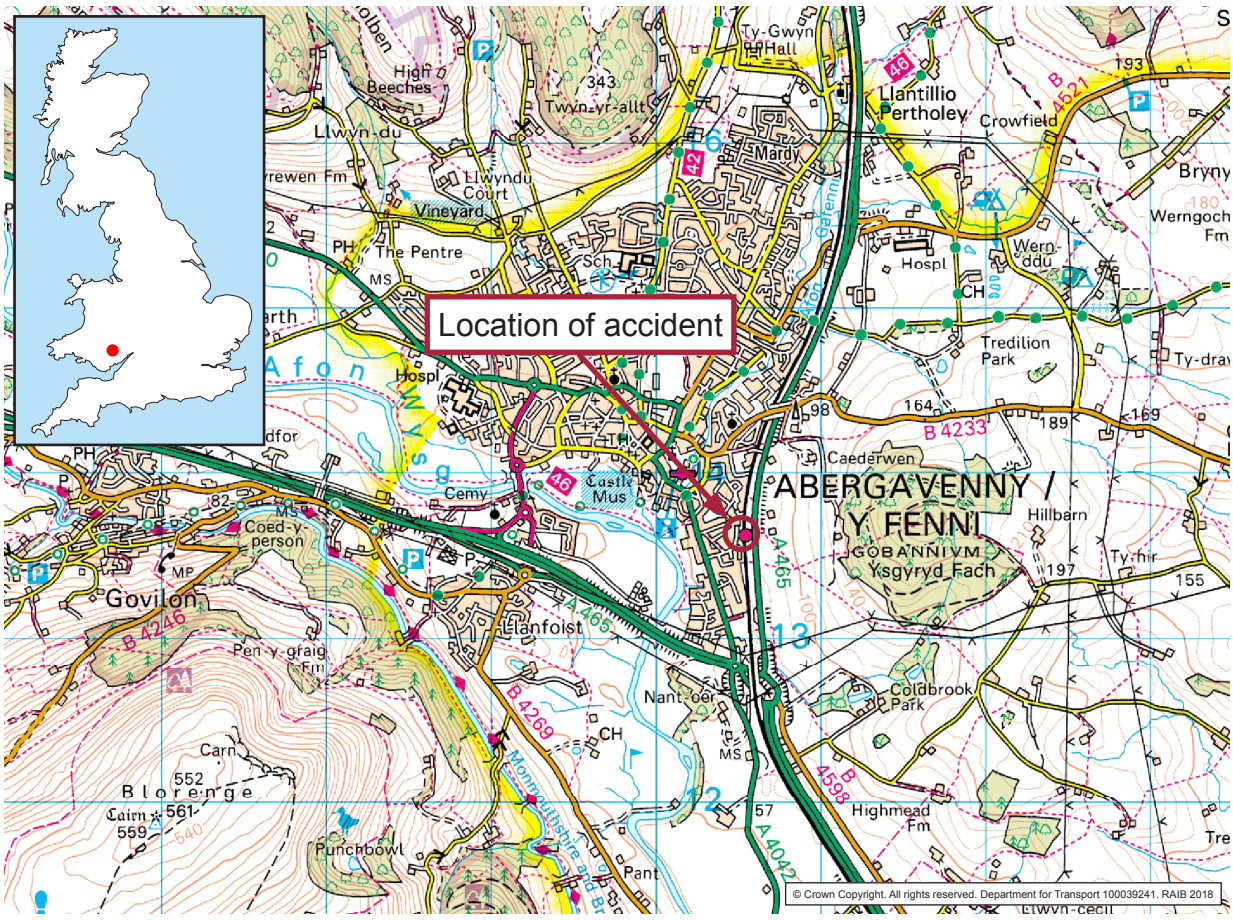


Figure 1: Extract from Ordnance Survey map showing location of accident

4 The free end of the cable whipped round, and it struck a group of passengers on the footbridge stairs and caused minor injuries to three of them. A member of station staff who was on the platform and close to the footbridge, reported hearing a noise as the cable broke free and ducking just as the flying cable end passed over his head. The accident caused damage to cables and the cable tray running over the footbridge, station buildings and to other equipment on the station (figure 2).

Figure 2: Damage to the cable tray running over the footbridge, station buildings and to other equipment on the station (main image courtesy of Network Rail and inset images courtesy of British Transport Police)

Context

Location

5 Abergavenny station is located on the railway line between Newport and Hereford, at 22 miles 63 chains[1] from a zero reference at the former Rotherwas junction, near Hereford. It is part of Network Rail's Wales Route, which manages, operates and maintains the railway infrastructure across Wales and the border counties of England.

6 At the station, the two track railway comprises the Up Main line through platform 1, used by trains travelling towards Hereford, and the Down Main line through platform 2, used by trains travelling towards Newport. For trains travelling from Newport towards Hereford, the approach to the station is straight but after entering the station the railway curves to the right through the platforms (figure 3). Signalling in the area is controlled from the Abergavenny signal box (figure 3). The footbridge connects the south end of the two platforms and also carries a public footpath.

[1] A unit of length equal to 66 feet or 22 yards (20 metres).

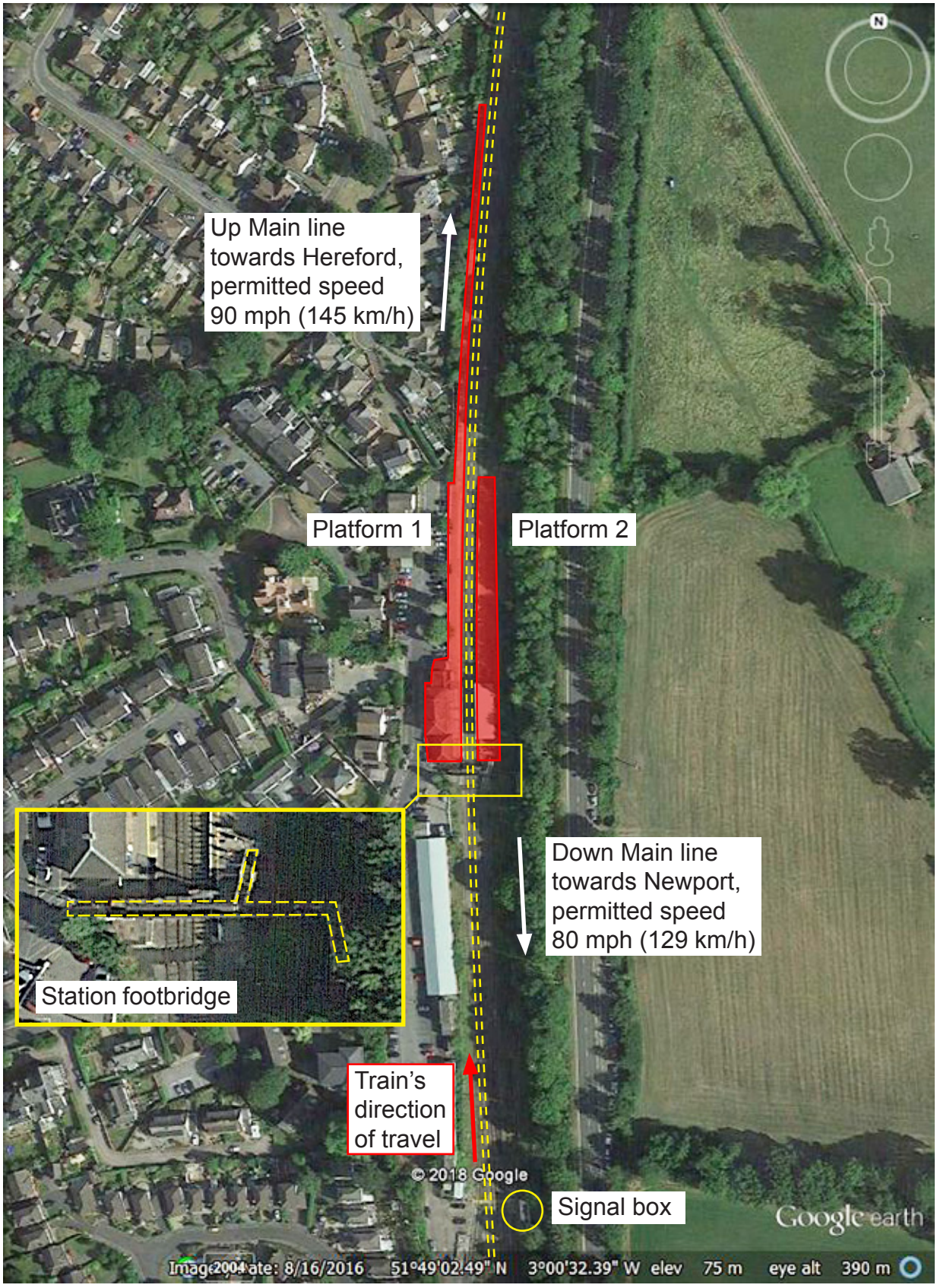


Figure 3: Google Earth image showing overview of Abergavenny station

Organisations involved

7 Network Rail owns the station infrastructure and is responsible for the footbridge structure.

8 The train was operated by Arriva Trains Wales which also employs the train crew. It owns the train's coaches and had hired the locomotive from DB Cargo. Arriva Trains Wales also operates the station through a lease from Network Rail and employs the railway staff who work at the station. The lease includes the footbridge and Arriva Trains Wales is responsible for maintaining parts of the footbridge such as foot step surfaces and hand rails.

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

Train involved

10 The train involved was the 17:16 hrs service from Cardiff Central to Holyhead, reporting number 1W96. It consisted of a class 67 locomotive, hauling four passenger coaches, and a driving van trailer[2] (from now on referred to as a DVT) at the rear (figure 4).

Figure 4: Class 67 locomotive, passenger coach and driving van trailer (DVT)

External circumstances

11 The weather was dull and cloudy with rain showers. Nearby weather stations recorded small amounts of rain in the hour before and after the accident. The temperature was 18°C at the time of the accident although at the start of July the weather had been hot and sunny with daily maximum temperatures above 25°C. No external circumstances were identified that directly affected the accident, other than the effects that normal environmental conditions had on the cable and its fixings over time, such as ultraviolet radiation, high and low temperatures, and moisture (see paragraph 42).

[2] A driving van trailer (DVT) is a purpose-built vehicle with a driving cab that allows a driver to operate a locomotive attached to the opposite end of a train. Locomotive hauled trains operating with a DVT remove the need for a locomotive to be attached to the other end of the train when reversing.

The sequence of events

Events preceding the accident

12 The cable that snagged on the train's roof provided Abergavenny signal box with its 240 volt AC electrical power supply. Network Rail could not find any records to show when this cable was installed. It is unlikely that the cable was the same age as the rest of the original electrical installation at the station, as it was attached to the cable tray by nylon cable ties, whereas all the other electrical supply cables were attached to the cable tray by metal cleats. Brand markings on the cable show it was manufactured by a company which had ceased manufacturing cables in 2005.

13 Historic photographs of the footbridge at Abergavenny station show that the original lattice footbridge span was replaced during the 1950s with a plate girder bridge. A photograph from 1977 (figure 5) shows a cable tray running over the footbridge in the same position as at the time of the accident. It is possible that the cable tray was replaced in the early 1990s as a photograph from 1992 (figure 6) shows a brighter silver coloured cable tray standing out against the footbridge background.

Figure 5: Abergavenny station and footbridge in 1977 (image courtesy of Mark Carter)

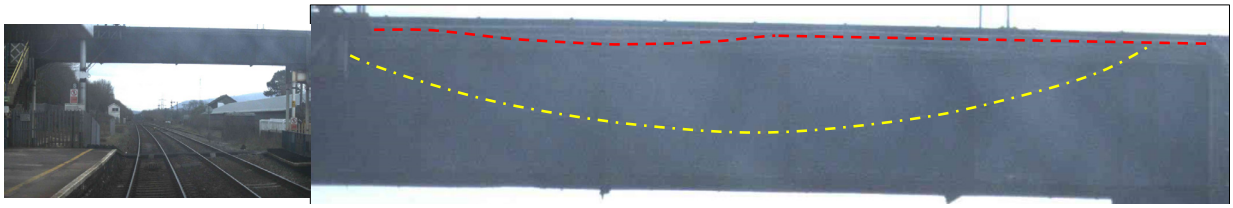
Figure 6: Abergavenny station and footbridge in 1992 (image courtesy of Brian Tucker)

14 Photographs of the footbridge from 2011 onwards show a grey cable increasingly drooping below the cable tray over time. This cable was a telecommunications cable, not the electrical supply cable. The first image found that shows the electrical supply cable starting to droop was recorded by one of Network Rail's infrastructure measurement trains in February 2016. It shows the electrical supply cable drooping by about 0.1 metres from its nominal position, whereas the telecommunications cable was drooping by about one metre. Figure 7 shows images of both cables drooping, starting in February 2016 through to July 2017.

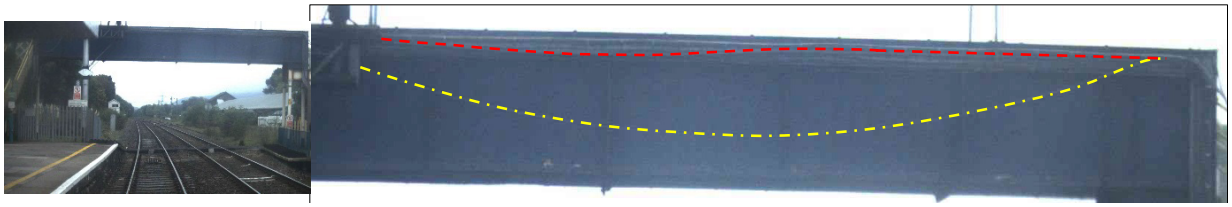
15 The footbridge comprised two spans: a girder span over the operational railway and a lattice span over a disused track bed (figure 8). Network Rail had identified that the lattice span was in a poor condition and required attention so it contracted Centregreat Engineering to remove the lattice span so it could be examined and refurbished. The contract also included installing a corner section at the top of the centre footbridge stairs and building a temporary walkway from platform 2 over the disused track bed to the bottom of the far set of footbridge stairs (figure 8), to maintain the public right of way. This work was scoped during December 2016 and planned to take place during the first half of 2017.

16 The lattice span was lifted out during the night of 15-16 July. Photographs of the footbridge taken before and after this work show that the cable's position had not changed (figure 7). Further work took place during the night of 27-28 July to correct minor issues that had been reported. The only work carried out on the footbridge was to extend the handrails at the top of the central flight of stairs so that they could be attached to the new corner section. The RAIB found no evidence that this work affected the cable tray or the cables attached to it.

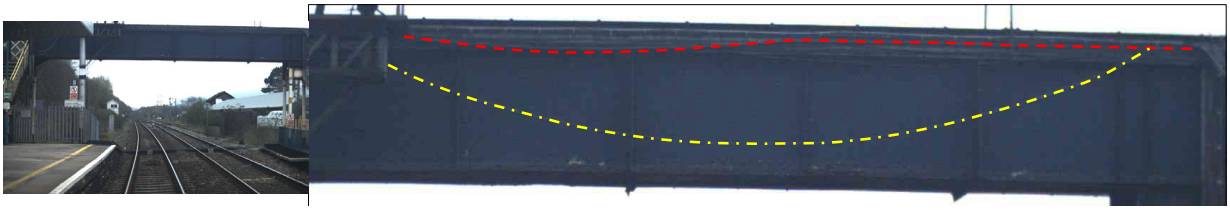
26 February 2016: Image from Network Rail infrastructure measurement train
Cable drooping by ~0.1 metres, telecommunications cable by ~1.0 metres



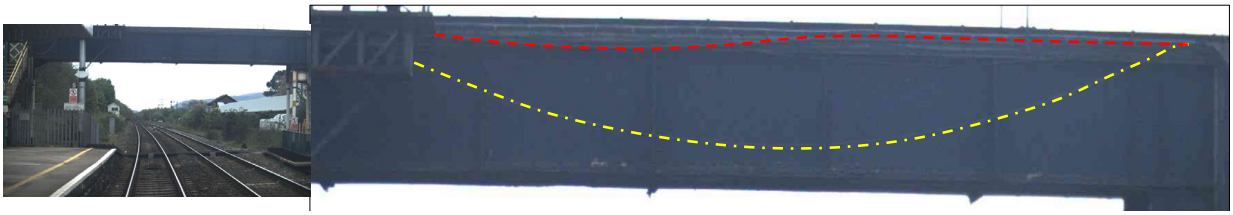
7 October 2016: Image from Network Rail infrastructure measurement train
Cable drooping by ~0.15 metres, telecommunications cable by ~1.0 metres



24 March 2017: Image from Network Rail infrastructure measurement train
Cable drooping by ~0.15 metres, telecommunications cable by ~1.15 metres



21 April 2017: Image from Network Rail infrastructure measurement train
Cable drooping by ~0.17 metres, telecommunications cable by ~1.15 metres



14 July 2017: Image from Network Rail infrastructure measurement train
Cable drooping by ~0.17 metres, telecommunications cable by ~1.15 metres

17 July 2017: Image from Network Rail site visit to station
Cable drooping by ~0.17 metres, telecommunications cable by ~1.15 metres

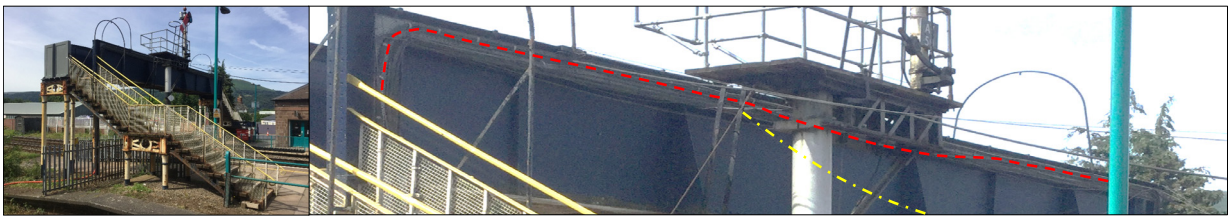


Figure 7: Images of the electrical supply (highlighted in red) and telecommunications (highlighted in yellow) cables drooping from the footbridge from February 2016 to July 2017 (images courtesy of Network Rail)

Figure 8: From top left clockwise: The footbridge lattice span, the footbridge after the lattice span had been removed, the temporary walkway to platform 2 over the disused lines and the footbridge corner section (top left image courtesy of Network Rail)

17 At 17:01 hrs on 28 July, about one hour before the accident, a southbound Arriva Trains Wales service stopped at Abergavenny station. Forward facing CCTV footage recorded by this train shows the cable drooping below the bottom of the footbridge (figure 9). At 17:30 hrs, the last northbound train prior to train 1W96 arrived at Abergavenny station and CCTV footage from this train also shows the cable drooping below the bottom of the footbridge (figure 9).

Events during the accident

18 At about 18:05 hrs, train 1W96 arrived at Abergavenny station on the Up Main line for its timetabled stop. As the locomotive at the front of the train passed under the footbridge, the driver heard a thud on the cab roof. This was the electrical supply cable striking the roof, although the driver reported he thought it was most likely to be something someone had thrown from the footbridge. As the train continued into platform 1, the cable dragged across the roof of each coach. The chef in the restaurant coach also reported hearing banging on the roof as the train pulled into the station.

19 A witness standing on platform 1 was watching the train as it arrived and noticed both the electrical supply and telecommunications cables snag on the roof of the rearmost vehicle of the train. Once snagged, these cables were pulled off the cable tray they were attached to. The electrical supply cable was pulled from its fixings on the footbridge stairs and out of a cable trough (figure 10). While being pulled, this cable caused damage to other cables, the cable tray, a signal ladder and a station sign (figure 10). It also moved a wheeled bin which struck and broke a pane of glass in the waiting room door (figure 2).

Figure 9: CCTV images recorded by the last southbound train (top image) and last northbound train (bottom image) at Abergavenny prior to train 1W96 (images courtesy of Arriva Trains Wales)

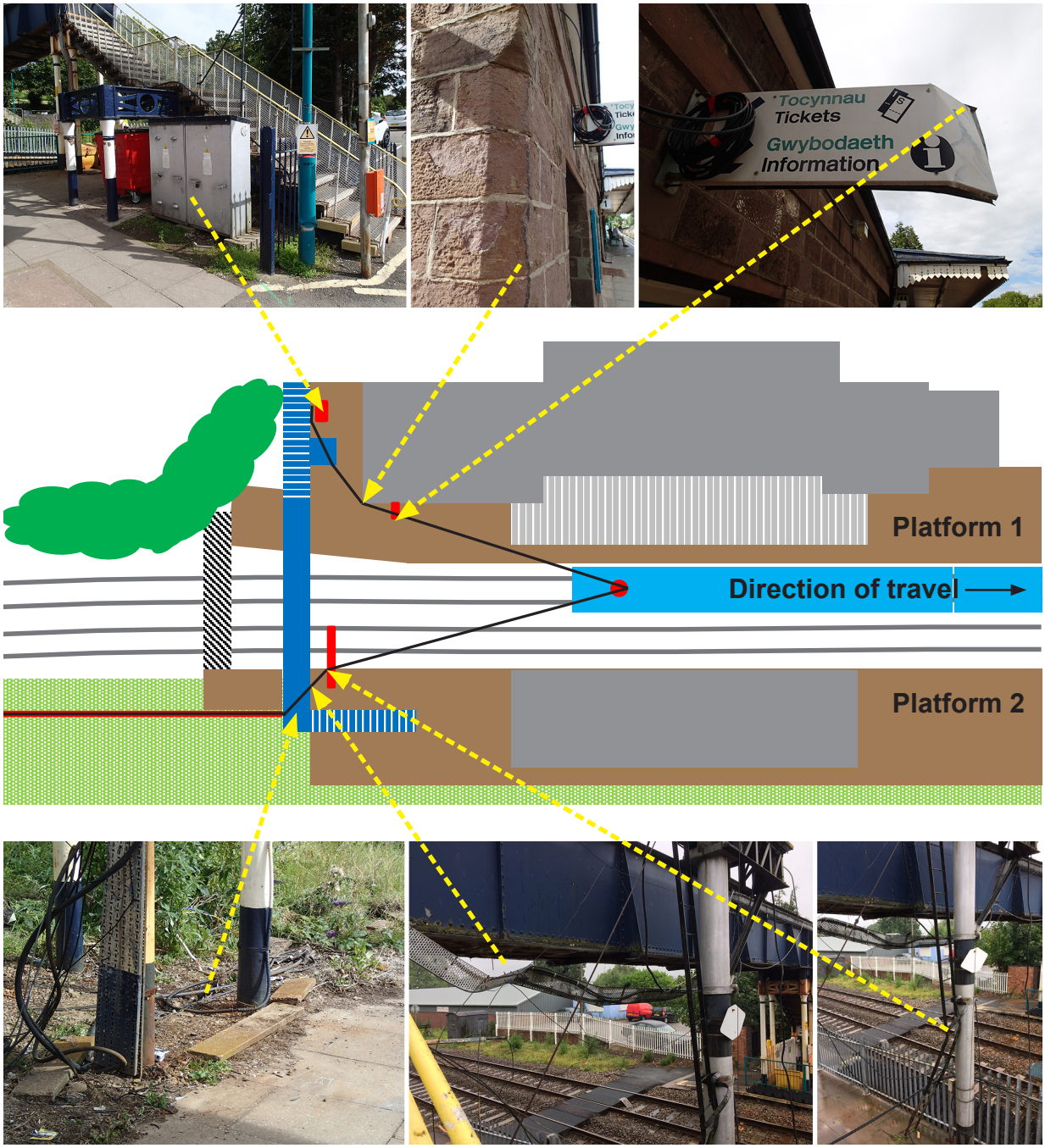


Figure 10: Diagram showing the position of the electrical supply cable as the train pulled it and photographs of the damage caused to various items (bottom middle and bottom right images courtesy of Network Rail)

20 The electrical supply cable was pulled until no further movement was possible, at which point the end of the cable that was terminated within a distribution cabinet at the foot of the footbridge stairs broke free. Once loose, the free end of this cable whipped round and struck a group of passengers on the footbridge stairs (figure 11) causing minor injuries to three of the group. There were no injuries to anyone on the platforms although a member of station staff was nearly struck (paragraph 4). The cable came to rest on the Down Main line next to the train, with its end resting on platform 2 (figure 12). The telecommunications cable snapped during the accident, with a length of it also coming to rest on the Down Main line. This cable is not reported to have injured anyone.

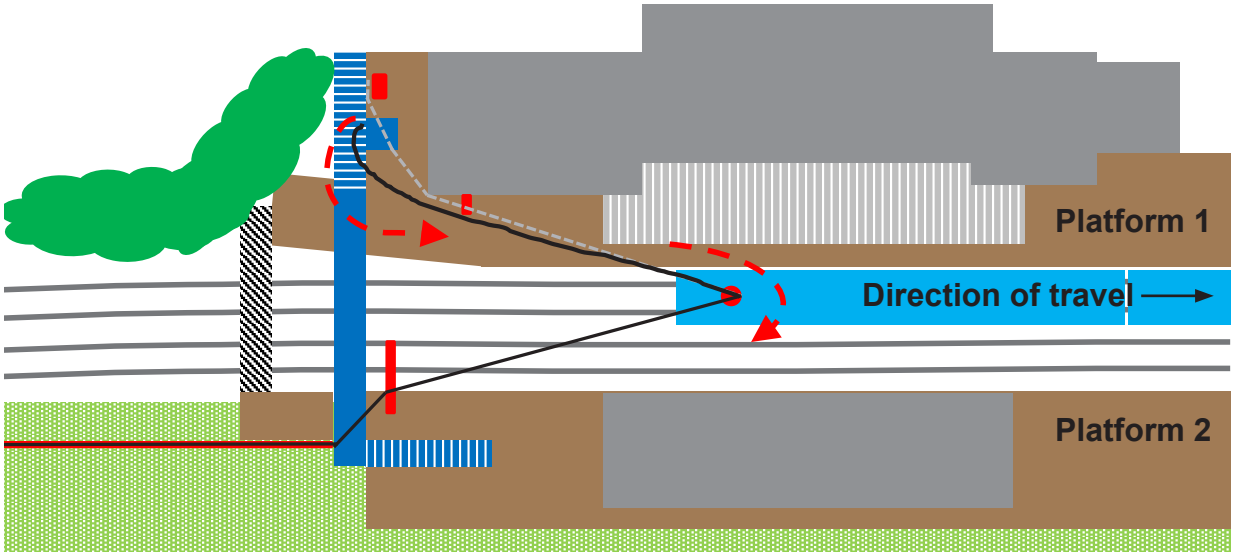


Figure 11: Diagram showing the position of the electrical supply cable once it broke free

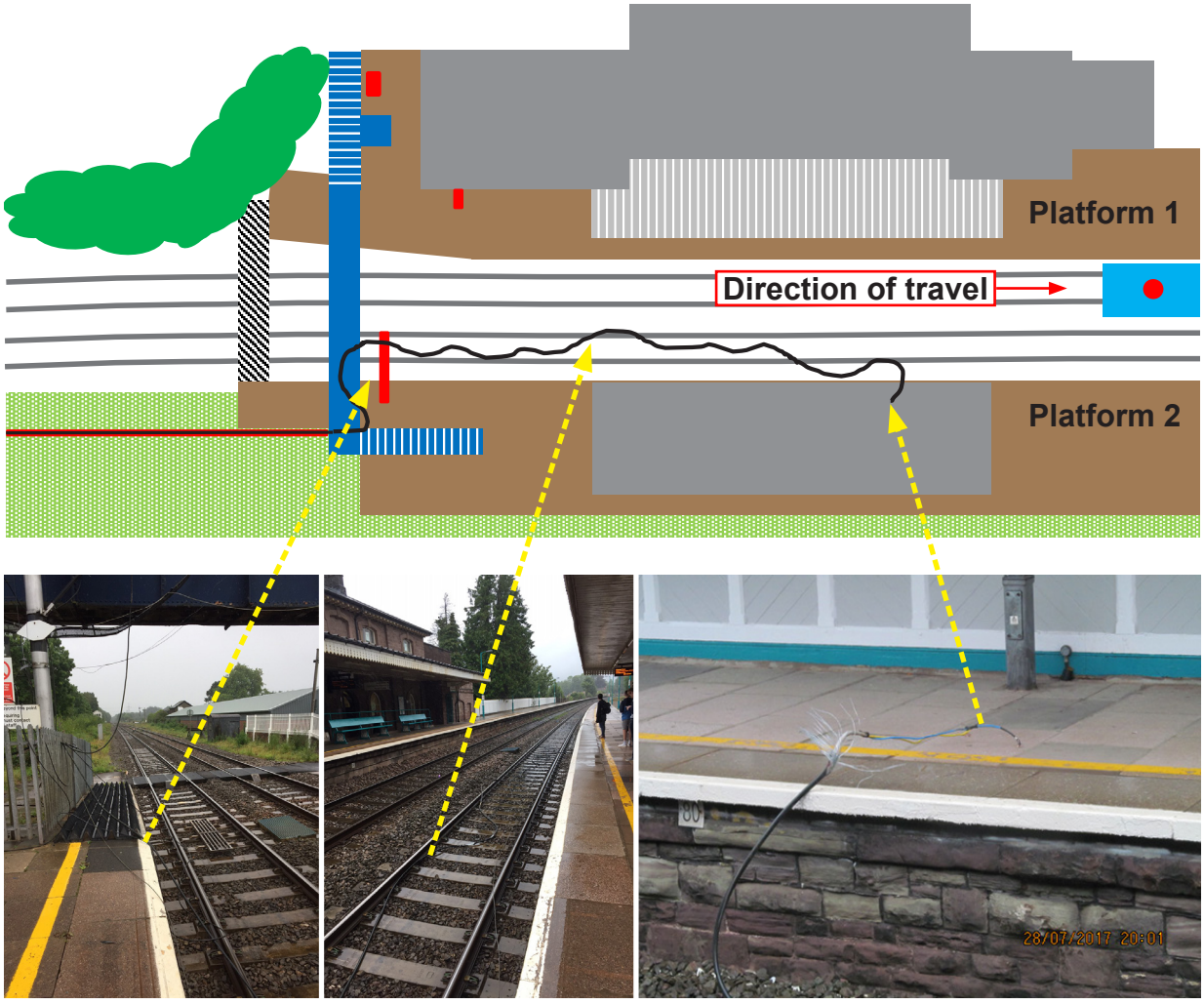


Figure 12: Diagram and photographs showing the position of the electrical supply cable after it came to rest (left and middle images courtesy of Network Rail, right image courtesy of British Transport Police)

Events following the accident

21 Once the train had stopped in platform 1, the guard and another member of the train crew approached the driver to inform him that there were cables lying on the platforms and track next to and behind the train. The driver called the signaller using the locomotive's radio system to report the problem. The signaller was aware that something unusual had happened, having lost the electrical power supply to his signal box just as the train entered the station. The signaller agreed with the driver that train 1W96 could proceed if the driver thought it was fit to do so. The driver checked the train from the platform. There was some very minor damage to an antenna on the roof of one coach and marks left by the cable on some roof mounted equipment but none of this was visible to the driver from the platform.

22 The station staff member was concerned that the cables lying on the platforms could be live. Due to the potential danger to passengers and members of the public, he decided to close the station and informed Arriva Trains Wales staff at the Wales Rail Operating Centre in Cardiff. The guard helped him direct the passengers who had just got off train 1W96 out of the station through the waiting room. Train 1W96 then departed. An off-duty Network Rail employee helped the station staff member evacuate the remainder of the station.

23 Staff at the Wales Rail Operating Centre arranged for train 1W96 to be checked again when it stopped at Hereford. The driver did this and again found no problems with the train so it continued its journey to Holyhead. Network Rail also stopped other trains from passing through Abergavenny due to reports that there was debris on the track and hanging from the footbridge. One train that was approaching Abergavenny returned to Hereford. Network Rail then dispatched a mobile operations manager[3] to Abergavenny and requested British Transport Police to attend. The mobile operations manager arrived at 19:15 hrs and British Transport Police at 19:20 hrs. Network Rail also sent its maintenance staff to attend and from about 19:25 hrs staff from its signalling and telecommunications, track, and electrification and plant departments began to arrive.

24 Arriva Trains Wales called out staff from its contractor for the electrical power supply circuits at the station. Network Rail called Western Power Distribution, which provides the electrical supply to the station, and arranged for its staff to attend too. After arriving at the station at 19:45 hrs, Western Power Distribution staff isolated the electrical supply to the station at a nearby substation. When they opened the distribution cabinet they found damage to an electricity meter and spotted that the electrical supply cable to the signal box had been ripped from its termination point just below a fuse. As this cable had been pulled out from its supply end, it was not live.

25 The various parties on site worked to clear the debris from the track, make temporary repairs to the cables and cable tray, and reinstate the electrical supplies to the station and to the signal box. This work allowed the railway through Abergavenny to reopen at 23:05 hrs.

[3] A Network Rail operations manager who provides its first line response to incidents.

26 After the accident there was confusion about whether anyone had been injured. Immediately after the accident, the member of station staff was focused on reporting what had happened and evacuating the station. He was not approached by any of the injured passengers, and so he was unaware of their injuries. However, within about 20 minutes, the off-duty Network Rail employee who helped to evacuate the station (paragraph 22) had reported to Network Rail staff at the Wales Rail Operating Centre that there were some injuries.

27 About 40 minutes after the accident, Arriva Trains Wales control asked its station staff member to find out who had been injured. While doing this he was approached by a relative of one of the passengers who had been injured. During the evening, family members of three passengers who were struck by the cable, contacted the British Transport Police. As details began to emerge about the number of people that the cable had struck, the British Transport Police informed Network Rail and suggested that the accident be notified to the RAIB, which Network Rail did at 19:56 hrs. By about 21:30 hrs it was confirmed that three passengers had been struck and sustained minor injuries.

Key facts and analysis

Identification of the immediate cause

28 **The drooping electrical supply cable became snagged on the train's roof and was pulled until one end broke free from an electrical distribution cabinet.**

29 CCTV footage recorded by trains in the hour before train 1W96 arrived at Abergavenny station, shows the electrical supply cable drooping about 0.55 metres below the bottom of the footbridge (figure 9). At this height, the cable was able to strike the roof of train 1W96 and then snag on it (paragraphs 18 to 20). The position of the telecommunications cable cannot be seen in the CCTV footage as the image quality was affected by the poor level of ambient light. However, this cable was not reported to have caused any of the injuries.

30 The electrical supply cable ran from the distribution cabinet at the station, over the footbridge, to the signal box. It was a four core steel wire armoured cable (figure 13), rated for 600/1000 V, with a diameter of about 25 mm. A cable of this construction and diameter typically weighs about 1.3 kg per metre length. Its manufacturer estimates it has a breaking load of about 30 kN (about 3 tonnes), which made it more likely that the cable would break at its termination point rather than breaking along its length, when it was pulled.

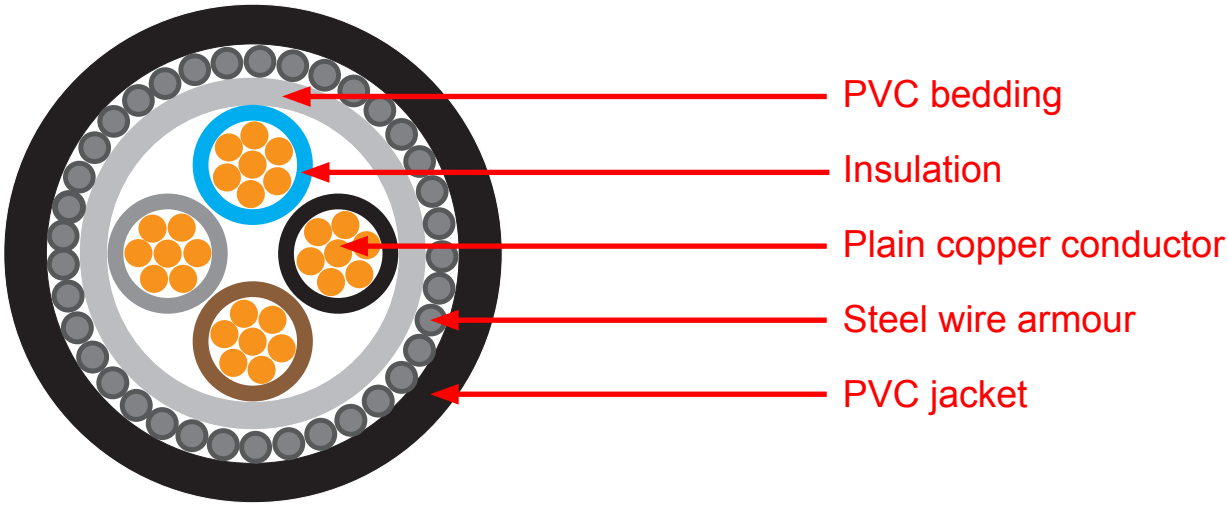


Figure 13: Diagram showing the construction of a steel wired armour cable

Identification of causal factors

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

a. the cable snagged on an antenna fixed to the roof of the trailing vehicle in the train (paragraph 32); and

b. the cable had detached from the cable tray running along the footbridge and was drooping down, foul of the train (paragraph 36).

Each of these factors is now considered in turn.

The train's roof

32 The cable snagged on an antenna fixed to the roof of the trailing vehicle in the train.

33 On Monday 31 July, Arriva Trains Wales maintenance staff carried out an examination of the train at roof level. Staff found no obvious marks on the roof of the locomotive's leading cab but did find minor damage and witness marks on the roofs of the coaches which continued to the DVT at the rear of the train. The final witness mark found was on the radio antenna (figure 14). The shape of the antenna, which was raked forwards in the direction of travel at the time, increased the likelihood of the cable becoming snagged. The antenna is the highest point on the vehicle, mounted just off the centre line of the roof.

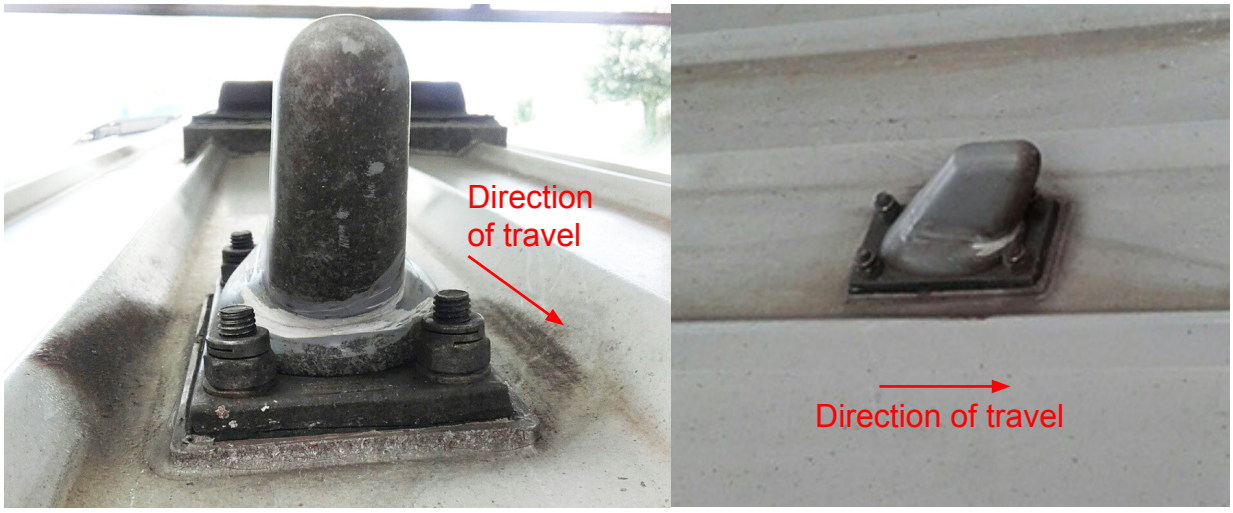


Figure 14: The radio antenna on the roof of the DVT (images courtesy of Arriva Trains Wales)

34 Issue 2 of Railway Group Standard GE/RT8073, 'Requirements for the Application of Standard Vehicle Gauges', was in force when the modifications to fit this radio antenna to the DVT were designed in 2010. GE/RT8073 defines standard profiles that various types of rail vehicle must fit within, which include vehicle heights above rail level. The profile that applied to the DVT defined a maximum static vehicle height of 3.912 metres above rail level.

35 The installation drawing for the modifications made to the DVT when its radio equipment was installed shows the top of the antenna is within the limits of the relevant profile by about 25 mm (figure 15). The height of the antenna was assumed by the designer of the installation to be at the maximum ride height for the vehicle, ie when in tare condition and with new wheels (ie maximum wheel diameter). Therefore the height of the radio antenna was compliant with the requirements of GE/RT8073 and in a normal position relative to the railway's infrastructure.

The drooping electrical supply cable

36 The cable had detached from the cable tray running along the footbridge and was drooping down, foul of the train.

37 Analysis of the CCTV footage, recorded by trains passing through Abergavenny in the hour before train 1W96 arrived, shows that the lowest point of the cable was about 0.55 metres below the bottom of the bridge.

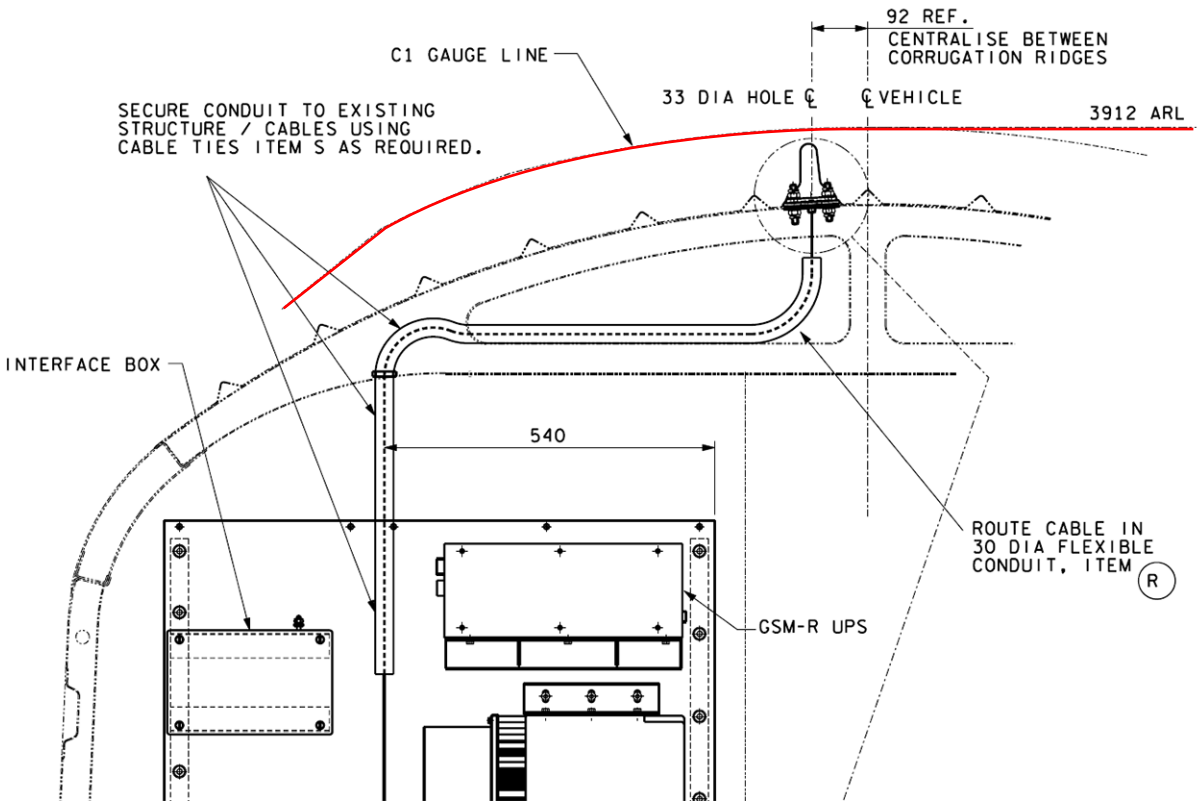
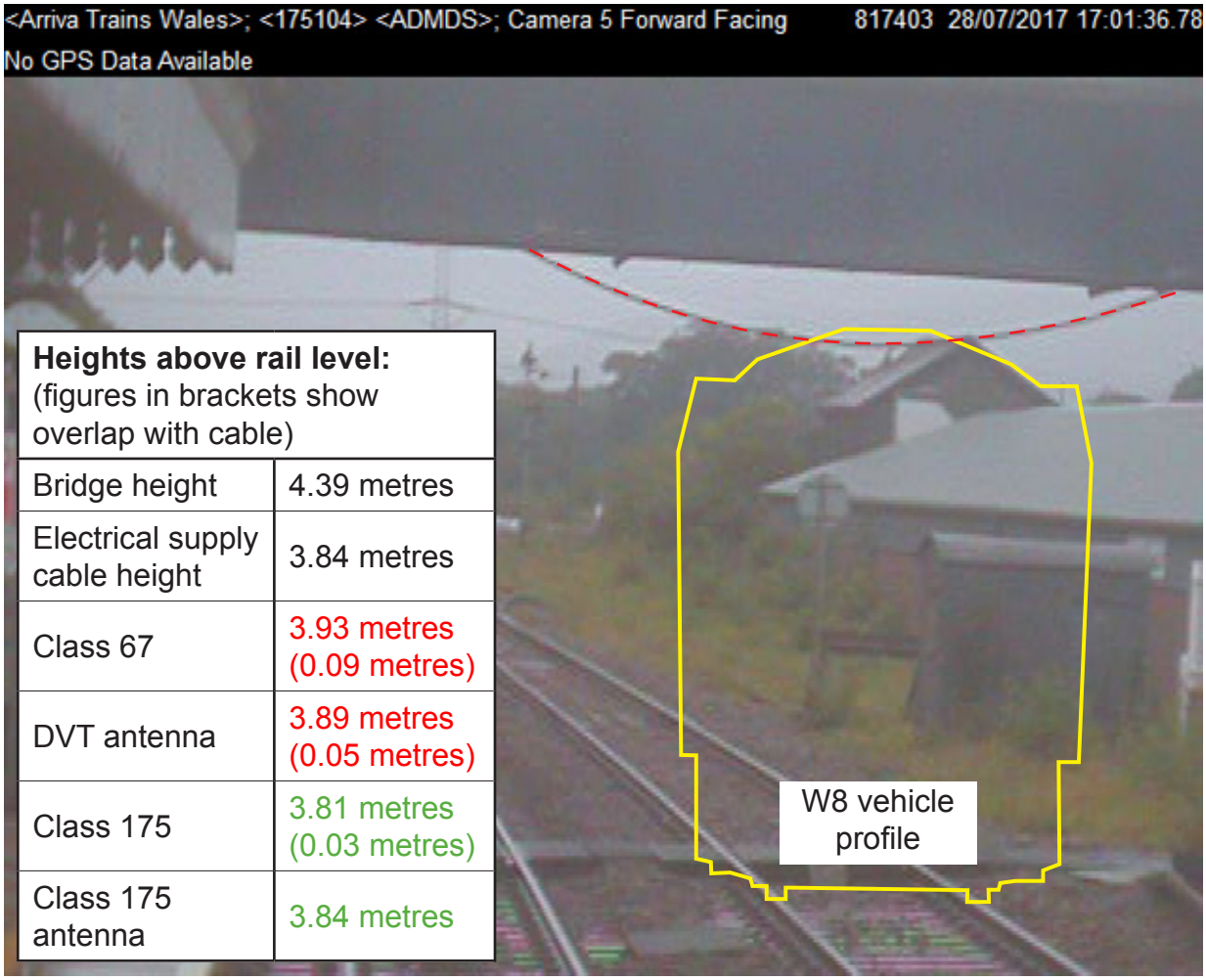


Figure 15: Extract from the drawing for installing the radio antenna to the DVT (drawing courtesy of Network Rail)

38 A Network Rail infrastructure measurement train had last measured the footbridge in 2011 and the data it recorded shows how far the footbridge was from the track and therefore the clearance for trains passing underneath the footbridge. Network Rail reported that this data is unlikely to have changed in the time since the footbridge was last measured. The data shows there was a clearance of about 0.43 metres between the bottom of the footbridge and the top of the relevant vehicle profile (called a W8 profile) at the centre point of the Up Main line. The maximum height above rail level for the W8 profile is 3.965 metres so the bottom of the bridge was about 4.39 metres above rail level.

39 Figure 16 shows the nominal heights above rail level for the locomotive and the DVT. It also shows the nominal height above rail level for a class 175 unit, which was the type of train that had formed the previous passenger services through Abergavenny and had recorded CCTV footage showing the drooping cable (paragraph 15). The lower height of the class 175 unit probably explains why the previous train did not snag the cable as it passed under the footbridge.



Heights above rail level: (figures in brackets show overlap with cable)	
Bridge height	4.39 metres
Electrical supply cable height	3.84 metres
Class 67	3.93 metres (0.09 metres)
DVT antenna	3.89 metres (0.05 metres)
Class 175	3.81 metres (0.03 metres)
Class 175 antenna	3.84 metres

Figure 16: Vehicle heights above rail level in relation to the electrical supply cable drooping from the footbridge (background image courtesy of Arriva Trains Wales)

40 The cable was drooping due to a combination of the following:

a. the fixings holding the cable to the cable tray were unsuitable for their intended use and had broken (paragraph 41);

b. the cable was not inspected periodically as required for all electrical installations (paragraph 48);

c. the drooping cable was not identified by the footbridge inspection regime (paragraph 55);

d. the drooping cable was not identified during routine station safety checks (paragraph 60); and

e. the drooping cable was not reported by anyone after it had begun to hang below the bottom of the footbridge (paragraph 63).

Each of these is now considered in turn.

Cable fixings

41 The cable was attached to the cable tray using 4.6 mm wide black nylon cable ties which were spaced about every 0.4 metres (figure 17). The vertical orientation of the cable tray meant that the cable ties directly supported the weight of the cable (paragraph 30).

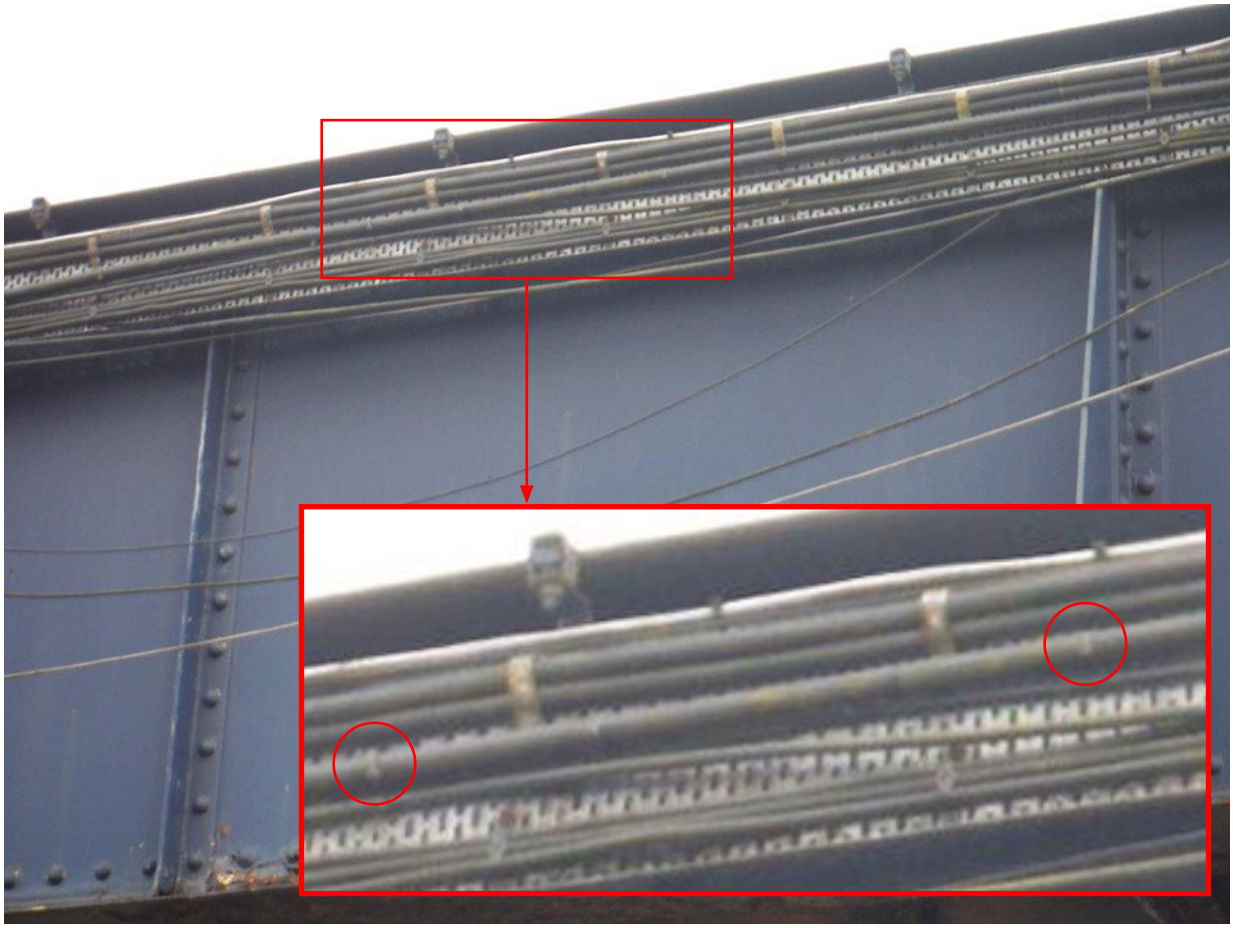


Figure 17: Photograph taken in December 2016 showing the electrical supply cable attached to the cable tray by cable ties (image courtesy of Centregreat Engineering)

42 Advice from the manufacturers of nylon cable ties often states that this type of cable tie is not suitable for outdoor applications. This is because the ties become brittle over time when used in an outdoor environment, because the nylon degrades when subjected to ultraviolet radiation, temperature cycles and moisture.

43 Once one cable tie had broken, the cable ties either side would have had to support a greater weight. The increased load on these cable ties would have caused them to break, probably more quickly than the first, leading to the successive failure of the cable ties, and the cable drooping further with each failure.

44 The installation of the cable did not comply with the requirements in British Standard BS7671:1992, 'Requirements for Electrical Installations', commonly referred to as the 16th edition of the Institution of Engineering and Technology wiring regulations. The 16th edition of the wiring regulations applied from 1991[4] to 2007; it is thought that a replacement cable tray was installed in the early 1990s (paragraph 13). The installation was also not compliant with the current (17th) edition of the standard which has applied since 2008. BS7671 is not prescriptive about what cable fixings should be used for an electrical installation, but within chapter 52, section 522 covers the selection and erection of wiring systems[5] in relation to external influences. In section 522.11, titled 'Solar radiation and ultraviolet radiation', paragraph 522.11.1 states 'Where significant solar radiation or ultraviolet radiation is experienced or expected, a wiring system suitable for the conditions shall be selected and erected or adequate shielding shall be provided'. The installation did not comply with this requirement as nylon cable ties are not suitable as fixings when exposed to ultraviolet radiation and these fixings were not shielded.

45 Network Rail company standards[6] for low voltage electrical installations[7] make no reference to the use of cable ties. Standards that cover the installation, inspection or maintenance of electrical installations make reference to complying with BS7671. However, this is in relation to the requirements for electrical protection of cables rather than the suitability of their fixings. The standards do not contain any specific instructions or guidance about whether or not it is acceptable for cable ties to be used as the primary method of supporting electrical supply cables in an outdoor application.

46 The use of cable ties is mentioned in Network Rail company standards for signalling but only for the management of cables and not for supporting them. Cable ties can be used to manage signalling cables by bundling the cables together in relay or equipment rooms. There is no mention of using cable ties for signalling cables in an outdoor application. Cable ties are also referred to in a Network Rail company standards relating to the installation of telecommunications cables at stations (see paragraphs 70 and 71).

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[4] The 16th edition of the wiring regulations was first published 1991 and was adopted as a British Standard in 1992, when it was renamed to BS7671:1992.

[5] BS7671 defines a wiring system as 'An assembly made up of cable or busbars and parts which secure and, if necessary, enclose the cable or busbars'. Chapter 52 of BS7671 clarifies that it applies not just to cables and conductors, but to their associated supports or suspensions too.

[6] 'Network Rail company standards' is the generic term for the documents that specify requirements and provide guidance directed towards securing the safe and efficient operation of the rail infrastructure. They support the overall company assurance system by specifying how Network Rail controls its principal health and safety risks, and how the organisation complies with Technical Specifications for Interoperability (TSIs), domestic legislation, Railway Group Standards and Network Rail Business Critical Rules.

[7] Relevant Network Rail standards for low voltage electrical installations include:

- NR/SP/ELP/27242 'Specification of low voltage electrical installations on railway premises';
- NR/GN/ELP/27247 'Guidance note of low voltage electrical Installations on railway premises'; and
- NR/SP/ELP/40042 'Periodic inspection and testing of electrical installations, appliances and equipment'.

47 The investigation considered practice on London Underground to see if there were useful lessons to be learned. London Underground has standards for cable management which also refer to installing cables to the requirements of BS7671 and which are more prescriptive than Network Rail's in relation to fixings. London Underground standard S1069, 'Low Voltage Electrical Installations', included a specific requirement that nylon cable ties shall only be used on horizontal runs where the weight of the steel wired armoured cable is supported directly by the cable tray and the cable has a cross sectional area that is less than 50 mm^2 (ie less than 8 mm in diameter). This requirement means that the cable ties only hold the cable in place and do not support its weight. In all other circumstances, London Underground requires steel wired armoured cables to be attached to the cable tray using aluminium hook cleats on horizontal cable runs, and claw cleats or two bolt fixing cleats on vertical cable runs (other electrical supply cables in the footbridge cable tray at Abergavenny were secured with cleats (paragraph 12)).

Cable inspection and testing

48 The cable is part of an electrical installation so it must comply with the requirements for periodic inspection and testing that are defined in BS7671. The 17th edition of BS7671 states that the frequency of this periodic inspection and testing should be determined by factors such as the type of installation and the external influences it is subjected to. Prior to this, the 16th edition of BS7671 defined the standard periodicity for the inspection and testing of a commercial property as five yearly.

49 Network Rail carries out the inspection and testing of the electrical installation at Abergavenny signal box every five years. The last time this took place was in April 2013. The test records show that Network Rail's inspection and testing activities for the signal box electrical installation started at the distribution board in the signal box where the incoming electrical supply arrives. This inspection and testing did not include the cable providing the incoming supply (ie the cable involved in this accident) because Network Rail considered this cable to be part of the electrical installation for the station, which Arriva Trains Wales was responsible for inspecting and testing.

50 Arriva Trains Wales carried out its periodic inspection and testing of the station electrical installation to comply with BS7671 using a contractor to carry out this work every five years. The last time the station installation was inspected and tested was in October 2013. The test records show that the inspection and testing started at the distribution boards inside the cabinet at the bottom of the footbridge stairs, which is where the incoming supply from Western Power Distribution arrives.

51 The Arriva Trains Wales test records show there are twelve power supply circuits available at the main distribution board (figure 18). Six circuits provide electrical supplies to the station buildings and platform lighting. Three circuits are spare and the remaining three feed Network Rail assets. One of these three is to the signal box. The remaining two provide electrical power supplies to Network Rail relocatable equipment buildings (usually referred to as REBs) which house signalling equipment, and are located opposite the signal box (figure 19).

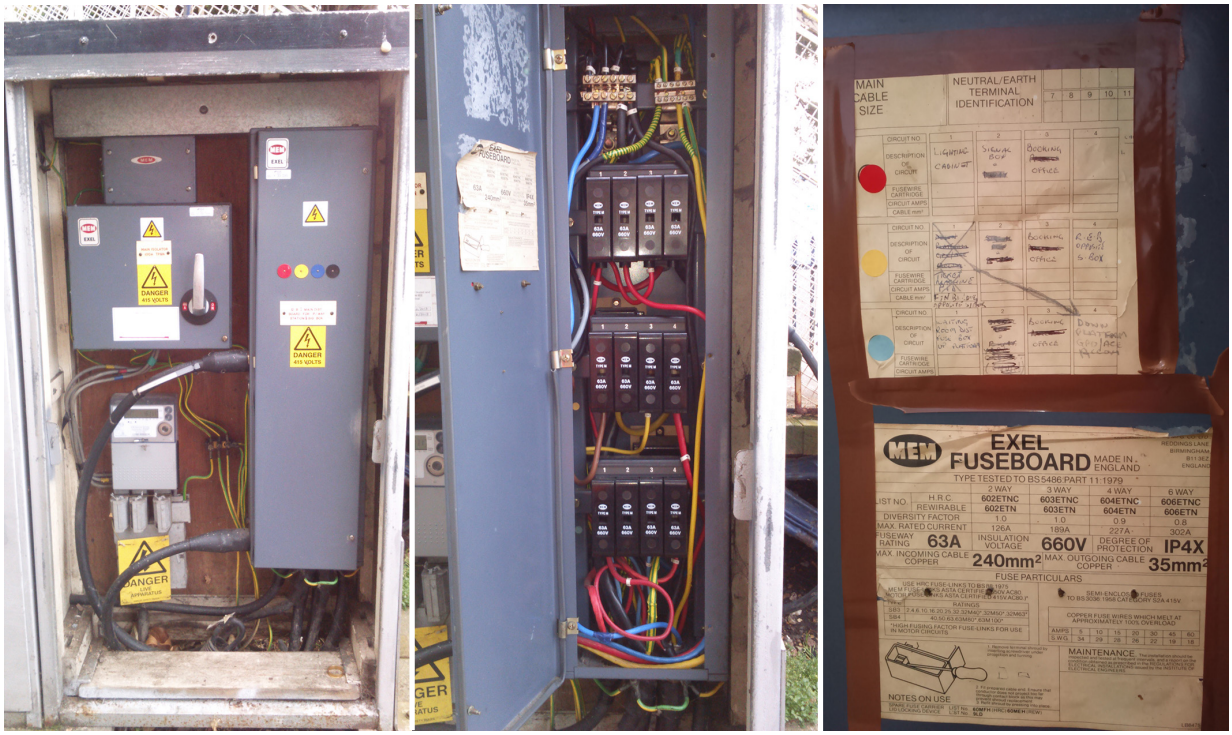

Figure 18: Photographs showing the main distribution board in the distribution cabinet (images courtesy of Arriva Trains Wales)

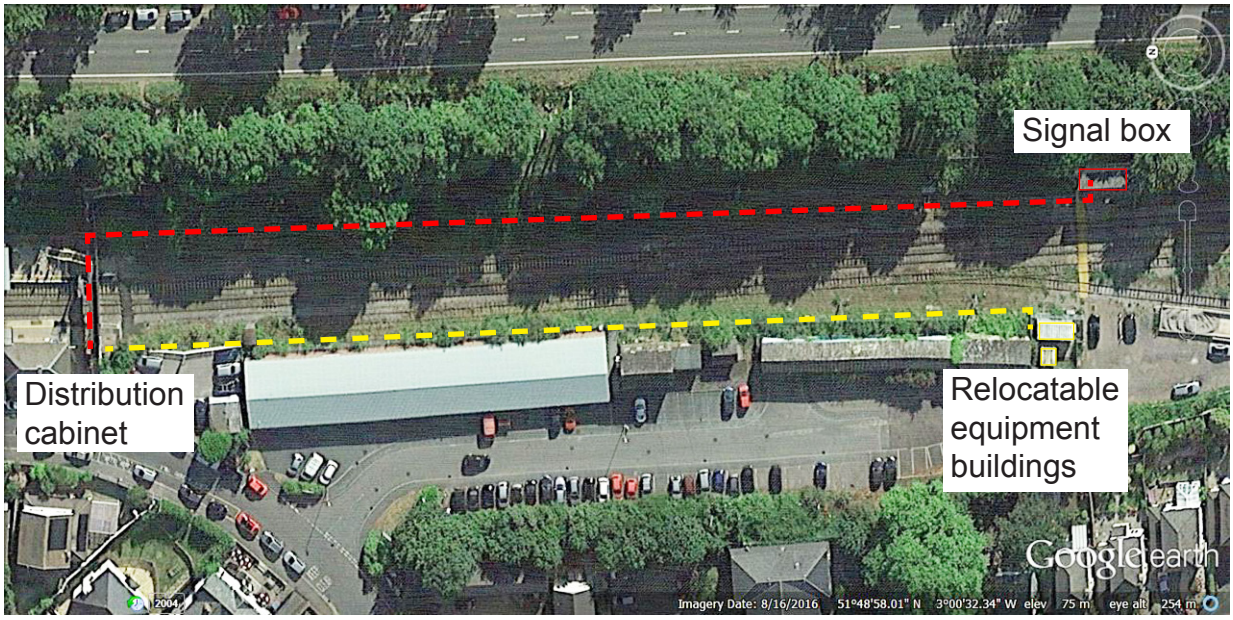

Figure 19: The routes taken by the electrical supply cables going to the Network Rail assets

52 The Arriva Trains Wales test records show that the circuits going to the Network Rail assets were not inspected or tested as these were not used by Arriva Trains Wales. The records for these cables were all marked with an 'L' to show that a limitation was imposed, indicating that the item was not inspected or tested.

53 The evidence from both the Network Rail and Arriva Trains Wales test records indicates that the cable running from the distribution cabinet at the bottom of the footbridge stairs at the station to the signal box (ie the cable involved in the accident) was not being inspected or tested by either organisation.

54 One of the requirements within the inspection activities required by BS7671, under the heading 'distribution circuits', is to check and record that 'Cables correctly supported throughout their run'. Although the cable was not inspected by either Network Rail or Arriva Trains Wales during the inspections in 2013, it was not drooping at that time (paragraph 14). However, had it been inspected, it is possible that the person responsible for the inspection and testing might have identified and recorded that the cable's fixings were inappropriate for supporting this type of cable in this orientation and environment, and action might have been taken to replace the cable ties with a more robust type of fixing.

Footbridge inspection regime

55 The footbridge structure at Abergavenny forms part of the station lease between Network Rail and Arriva Trains Wales (paragraph 8). This meant that it was subject to a detailed operational property inspection by Network Rail every five years, with yearly visual inspections in between. The last detailed inspection took place in May 2016, no visual inspection has taken place since then.

56 A photograph taken during the last detailed inspection in May 2016 (figure 20) shows the cable had begun to droop. It was drooping by about 0.1 metres from its normal position, over a length of about 3 metres. The telecommunications cable can be seen drooping about one metre from the top edge of the footbridge.

Figure 20: Photograph of the footbridge taken during the last detailed inspection in May 2016 with drooping electrical supply (red) and telecommunications (yellow) cables (image courtesy of Network Rail)

57 The requirements for an operational property inspection are defined in the Network Rail structures examination handbook, NR/L3/CIV/006. Part 1B of NR/L3/CIV/006 explains the types of examination regime, part 7A covers the requirements for the examination of operational property structures and part 11B explains the recording and reporting process for these examinations. Part 7A of NR/L3/CIV/006 explains the requirements for examining a footbridge that is classified as operational property, calling up part 2A as it defines the structures examination requirements for a bridge.

58 Neither part 2A nor part 7A makes reference to inspecting any items that might be attached to the footbridge, such as a cable tray. However, part 1B does state that where an ancillary structure is attached to the primary structure, where practicable, the connection and interface between them shall be included in the detailed examination of the structure. For an item of electrical containment such as a cable tray, the scope of its examination would be limited to looking at how the cable tray was attached to the structure. It would not include looking at the cable tray itself or any cabling within it.

59 The records from the last detailed operational property inspection in May 2016 included three defects related to how the cable tray was attached to footbridge. Brackets that fasten the cable tray to the footbridge were found to be corroded and broken (figure 21).

Figure 21: Photographs of the cable tray bracket defects found during the last detailed inspection in May 2016 (images courtesy of Network Rail)

Station safety checks

60 While Network Rail is responsible for the footbridge structure, Arriva Trains Wales is responsible for checking and maintaining the footbridge fixtures, such as handrails, and wear items, such as step surfaces (paragraph 8). These items are inspected every month as part of a planned station safety check that is carried out by a member of Arriva Trains Wales staff. The monthly checks follow an audit questionnaire which lists questions about items to be checked and provides space to note any defects that are found.

61 The questionnaire includes a section related to public areas, such as the platforms, overbridges, underpasses and waiting rooms. Within this section, an intended question, 'No obvious defects in visible cables wiring' is asked. Records of the previous three safety checks show no cable defects were recorded in response to this, but it was answered 'Yes' in May, 'Not applicable' in June and 'No' in July 2017, indicating some uncertainty about how the question should be answered.

62 The last monthly inspection before the accident was on 21 July. At that time the cable was drooping by about 0.17 metres (figure 7) and the telecommunications cable was drooping by 1.15 metres. This telecommunications cable had been drooping since at least 2011 (paragraph 14) but staff carrying out the last three safety checks had not reported any cables drooping from the footbridge cable tray.

Lack of reporting just prior to the accident

63 On weekdays, Arriva Trains Wales rosters a member of staff to work at Abergavenny station, primarily in the booking office, from 05:45 to 18:45 hrs. The member of staff who was on duty that day was on the platform when the accident happened (paragraph 4). He did not report the cable drooping below the bottom of the footbridge. Earlier that day, a person who worked in the station café had seen the cable drooping below the bottom of the footbridge, but had not told the member of railway staff.

64 The drooping cable was also not reported by any train drivers that day. It is likely that the cable was not drooping quite low enough to have struck the cab roof of the previous trains to pass through the station (paragraph 39 and figure 16). However, the forward facing CCTV footage recorded by these earlier trains does show that the cable would have been visible to train drivers.

65 In Rule Book module TW1 (GERT8000-TW1, 'Preparation and movement of trains'), section 43 covers the actions to be taken by a driver when a train is put in danger. When a driver sees an obstruction or something wrong which could put a following train in danger, section 43.2 tells a driver that 'you must not proceed beyond the next stop signal until you have told the signaller'. When a driver sees something wrong which will not put trains in immediate danger, section 43.4 requires a driver to tell the signaller at the first available opportunity. No reports were made by any train drivers to signallers about the drooping cable at Abergavenny prior to the accident.

Identification of underlying factors

Cable management

66 Network Rail had no controls in place for the management of low voltage electrical supply cables that cross operational railway lines via its overline structures.

67 Network Rail's company standards require that its low voltage electrical installations comply with BS7671. While the company standards contain some details about how to meet specific requirements in BS7671 relating to installation, inspection and testing, they include no reference to cable management for low voltage electrical supply cables. Within these standards, there are no controls that:

- ensure compliance with BS7671 when the wiring system is installed;
- check compliance with BS7671 for the inspection of the wiring system, in particular how a cable is supported including the suitability and condition of the fixings used to support it;
- define good practice for cable management by its staff and contractors;
- define what cable fixings are appropriate for installations that cross an operational railway line via a structure;
- define how to determine a suitable risk based inspection regime; and
- prevent poor practices such as the use of nylon cable ties in an outdoor environment without adequate mitigations.

68 The following evidence indicated that many of the cables running over the footbridge at Abergavenny did not follow good practice for cable management (figure 22):

- there was no separation of the different types of cable, with cables for signalling, telecommunications, the public address system and electrical power supply all mixed together within the same cable tray;
- various types of cable fixings were used to attach the cables to the cable tray, with some cables held in place by cleats while others were attached by nylon cable ties; and
- some cables were not attached to the cable tray, but instead to other cables by nylon cable ties.

69 Requirements for cabling that crosses the operational railway underneath the track are set out in Network Rail company standard NR/SP/SIG/19812 'Cross Track Cable Management'. Network Rail had identified that it needed to manage the risks associated with the installation of cables passing under the track, primarily to ensure track, and in particular its geometry, can be maintained appropriately. There is no directly equivalent standard to manage the risks associated with routing cables over the operational railway via structures.

Figure 22: Photograph of the cables and cable tray running over the footbridge at Abergavenny station on 19 July 2017 (images courtesy of Centregreat Engineering)

70 The RAIB found one Network Rail company standard that considers some of the issues associated with routing cables over footbridges at stations, but this was only applicable to telecommunications cables. NR/L2/TEL/30151, 'Design and installation of station cabling', specifies the requirements applicable to 'all parties engaged in the design or installation of new works on telecommunications cables or cable routes over which services are operated on station infrastructure that is managed or leased by Network Rail, including franchised stations'.

71 NR/L2/TEL/30151 states that where cable ties are used to secure telecommunications cables to a cable tray, they shall be evenly spaced so as to maintain the secured cables or conduits in an even line that follows the line of the cable tray. This implies that the cable is supported by the cable tray and the cable ties are used to keep the cable in place. NR/L2/TEL/30151 also states that cabling which requires installing over footbridges shall be run through a cable containment route. The RAIB could not find a standard that contained equivalent requirements for electrical supply cables, which often have a larger diameter, are heavier and operate at higher voltages.

Previous occurrences of a similar character

72 The RAIB has not investigated any previous occurrences of a similar character to this accident at Abergavenny, and has not made any previous relevant recommendations.

73 The RAIB obtained data, from a railway industry database that records safety related events, on previous incidents of trains striking cables drooping from structures. The data covered the period from 1992 to 2017 and included fourteen incidents that involved a train striking one or more cables drooping from a structure such as a footbridge or an overbridge. One of these was a previous incident at Abergavenny station in May 2002 when a train struck a cable drooping from the footbridge. This was reported to the signaller at Abergavenny signal box and all trains were stopped from passing through the station until maintenance staff attended and reattached the cable to the footbridge.

74 The data also included a similar incident that had happened in July 2009 at Bicester North station. A non-passenger train struck a cable drooping from the station footbridge, causing damage to the train. However, no passengers were injured as the incident happened in the early hours of the morning. When staff responded and arrived at the station, they found eleven cables hanging down from the footbridge and it was identified that these cables were for the station electrical power and lighting.

75 The RAIB also searched the system used by rail industry control centres to log day to day events for incidents of cables found hanging down from structures. Between August 2015 and August 2017, 22 events were found. They included five events involving electrical supply cables, eight events for signalling, telecommunications or CCTV cables, and six events for redundant cables. There was insufficient detail to determine the type of cable for the remaining three events. The records indicate that issues related to poor cable management practices are not just limited to cables for low voltage electrical installations.

Summary of conclusions

Immediate cause

76 The drooping electrical supply cable became snagged on the train's roof and was pulled until one end broke free from an electrical distribution cabinet (paragraph 28).

Causal factors

77 The causal factors were:

a. The cable snagged on an antenna fixed to the roof of the trailing vehicle in the train (paragraph 32, no recommendation).

b. The cable had detached from the cable tray running along the footbridge and was drooping down, foul of the train (paragraph 36). This causal factor arose due to a combination of the following:

i. The fixings holding the cable to the cable tray were unsuitable for their intended use and had broken (paragraph 41, **Recommendation 1**).

ii. The cable was not inspected periodically as required for all electrical installations (paragraph 48, **Recommendation 3**).

iii. The drooping cable was not identified by the footbridge inspection regime (paragraph 55, no recommendation).

iv. The drooping cable was not identified during routine station safety checks (paragraph 60, **Learning point 1**).

v. The drooping cable was not reported by anyone after it had begun to hang below the bottom of the footbridge (paragraph 63, **Learning point 2**).

Underlying factor

78 The underlying factor was that Network Rail had no controls in place for the management of low voltage electrical supply cables that cross operational railway lines via its overline structures (paragraph 66, **Recommendation 2**).

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

79 On 17 August 2017, the RAIB issued urgent safety advice (appendix B) which explained that drooping or hanging cables in close proximity to running lines can become snagged by passing trains and pose a real hazard (electrocution and being struck by the cables) to the travelling public and staff at stations and level crossings and to staff working near the line. It advised infrastructure managers, station operators and train operating companies to:

- encourage staff to report any drooping cables that could come into contact with trains, for immediate remedial action;
- check that existing cabling at stations over running lines remains securely fastened and include such cables in routine safety checks; and
- check that new installations or reinstallations of electrical supply cables over running lines are robustly fastened.

80 Also on 17 August 2017, Network Rail Wales Route issued a safety bulletin to inform its staff about the accident. The bulletin raised discussion points for staff about cables crossing the railway, the use of cable ties, the inspection regimes for cables, using alternative routes for cables and reporting loose cables.

81 After the accident, Network Rail made temporary repairs to support the cable tray using rope so that the railway could reopen that evening. Network Rail carried out further work during August to provide new brackets to support the cable tray. However, these repairs resulted in the cable again being fixed to the cable tray using nylon cable ties (figure 23).

Figure 23: The repairs made to the footbridge cable tray after the accident

82 Network Rail has reported that it is planning to carry out further work at Abergavenny. Work is being considered to reroute the electrical supply cable to the signal box by running it alongside the Up Main line until it is opposite the signal box, and then underneath the track to the signal box via an existing cable route.

83 Network Rail is planning to replace the cable tray on the footbridge with a new electrical containment during the 2018/2019 financial year. The new containment will run underneath the footbridge, with all of the cables supported by it and fully enclosed within it. Access to the cables within the containment will be via the footbridge floor. However, Network Rail's plans for this work are linked to decisions about how to progress the work to refurbish the lattice span (paragraphs 15 and 16).

84 As a result of the accident, Network Rail Wales Route carried out a review of cable and cable containment running over its station footbridges. It reviewed its inspection photographs for 85 station footbridges and identified that 55 of these had cables running over them. Of these, nine had cables attached to the external structure of the footbridge; in eight of these cases the cable routing was contained within the footbridge structure such that the cable could not droop significantly if any fixings broke. The only example found of a cable with the potential to droop was the footbridge at Helsby station (figure 24). Network Rail has reported to the RAIB that work is underway to refurbish this footbridge and that the cables will be rerouted during this work.

Figure 24: Cables routed on the outside of the footbridge at Helsby station (image courtesy of Network Rail)

85 Following the review carried out by Wales Route, the Office of Rail and Road (ORR) asked all of the other Network Rail routes to advise it on what actions they were taking to prevent a similar occurrence. The ORR asked each route to provide details of any work it had undertaken to review cable and cable containment running over station footbridges and to confirm that any issues identified during this work were being addressed. Each route has provided a response but the ORR has asked some of the routes to provide further information about the actions they have taken. This work is ongoing.

Recommendations and learning points

Recommendations

86 The following recommendations are made[8]:

1 *The intent of this recommendation is to reduce the risk of another accident happening at Abergavenny station due to electrical supply cables hanging down from the footbridge and being snagged by passing trains.*

Network Rail should continue to completion its work to replace the existing electrical containment that carries cables across the footbridge at Abergavenny station, and/or reroute cable(s), in order to reduce the risk of cables becoming unsupported and hanging down from the footbridge (paragraph 77b.i).

2 *The intent of this recommendation is to reduce the risk from cables hanging down from overline structures around stations, snagging on passing trains and causing injury to the public and staff.*

Network Rail should, in consultation with station operators, document and publish controls for the management of cables that cross operational railway lines via overline structures at stations. These controls should cover installation, inspection and testing of the cables, and include details of:

a. approved methods for supporting interior and exterior cables, taking into account environmental effects on fixings; and

b. determining, based on risk, appropriate inspection and testing periodicities for cables and their fixings (paragraph 78).

[8] 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 reduce the risk of cable inspections being missed due to lack of clarity about who is responsible for those inspections.*

Network Rail, in conjunction with station operators, should at every station:

a. continue to completion its work to identify cables that cross above the operational railway at stations via overline structures and have the potential to droop and be snagged by a train; and

b. ensure that the organisation responsible for the ongoing testing and inspection of those cables identified in part (a), and any installed in the future, is clearly and correctly documented (paragraph 77b.ii).

Learning points

87 The RAIB has identified the following key learning points[9]:

1 Organisations responsible for carrying out regular safety checks at stations are reminded of the importance of:

- briefing staff that carry out the safety checks to report any cables passing over the operational railway that are drooping or hanging; and
- making sure that the checklists used for the safety checks include looking out for hanging or drooping cables (paragraph 77b.iv).

2 This accident highlights the importance of staff reporting any cables they see that are drooping or hanging down over the operational railway. In the first instance, staff should report the cable and its location to their control or the controlling signal box and their manager (RAIB Urgent Safety Advice 01/2017) (paragraph 77b.v).

[9] '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 - Investigation details

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

- information provided by witnesses and in reports made by the staff involved at the time of the accident;
- CCTV recordings taken from trains passing through Abergavenny in the hour before the accident;
- CCTV recordings from Network Rail's infrastructure measurement trains;
- voice recordings of conversations between the staff involved;
- site photographs and measurements;
- historical and recent photographs showing the footbridge (both public and industry images);
- information about the work related to the removal of the lattice bridge span;
- information about the lease for the station and footbridge and the inspection regime for these assets;
- maintenance inspection reports for the train's roof;
- maintenance documents for the electrical inspection and testing carried out at the station;
- the Rule Book, Railway industry standards, Network Rail company standards and British Standards;
- data for previous incidents and accidents held on rail industry databases;
- weather reports and observations at the site; and
- a review of previous RAIB investigations that had relevance to this accident.

Appendix B - Urgent Safety Advice

URGENT SAFETY ADVICE

1. INCIDENT DESCRIPTION			
LEAD / INSPECTOR		CONTACT TEL. NO.	
INCIDENT REPORT NO	924	DATE OF INCIDENT	28 July 2017
INCIDENT NAME	Dangerous occurrence at Abergavenny station		
TYPE OF INCIDENT	Train snagged and severed a drooping power cable.		
INCIDENT DESCRIPTION	At around 18:05 hrs on 28 July 2017, train 1W96, the 17:16 hrs Cardiff to Holyhead was entering Abergavenny station when an armoured power cable which was hanging from the station footbridge became caught on the roof of the train. The cable had an outside diameter of approximately 25 mm and supplied electrical power to an adjacent signal box. It was connected to a local mains supply point, housed in a cabinet adjacent to platform 1, and crossed the railway by attachment to a vertically mounted cable tray along the footbridge using cable ties. The cable snagged on the train's roof and was dragged, causing it to be pulled from its remaining fixings, until it broke, after which it recoiled back. The recoiling cable caused minor injuries and distress to persons at the station and damage to the station buildings, to the train and to other equipment on the station.		
SUPPORTING REFERENCES	Figure 1: Drooping power supply cable prior to the event.		

2. URGENT SAFETY ADVICE	
USA DATE:	17/08/2017
TITLE:	Securing of overhead power cables at and around railway stations.
SYSTEM / EQUIPMENT:	Power cables, infrastructure.
SAFETY ISSUE DESCRIPTION:	Hanging cables are vulnerable to being snagged by trains with consequent risk of injury to people around a station and damage.
CIRCUMSTANCES:	The train involved comprised a Class 67 locomotive, 4 Mk3 coaches and a Driving Van Trailer (DVT), The item of roof equipment which snagged the cable appears to have been the GSM-R aerial on the trailing DVT. The train was moving slowly at the time as it came to a stop at the station.
CONSEQUENCES:	It is possible that passengers and staff could have been seriously injured by the power cable as it snaked around after being severed by train 1W96. It is also possible that the severed cable could have remained live for a time and posed an electrical hazard to people at the station.
SAFETY ADVICE:	Drooping or hanging cables in close proximity to running lines can become snagged by passing trains and pose a real hazard (electrocution and being struck by the cables) to the travelling public and staff at stations and level crossings and to staff working near the line. Therefore Infrastructure Managers, Station Operators and TOCs/FOCs should: • encourage all staff, including train crew, to report any cables which are drooping sufficiently low above the line that they could come into contact with trains, for immediate remedial action; • check that that existing over-line cabling at stations remains securely fastened and include such cables in routine safety checks; and • check that new installations or reinstallations of electrical service power cables over running lines are robustly fastened using only railway approved methods and fastenings.

Figure 1: FFCCTV footage from a preceeding train, showing the drooping power cable.

USA SIGN-OFF*			
INSPECTOR NAME:		CI / DCI NAME:	
INSPECTOR SIGNATURE:		CI / DCI SIGNATURE:	
DATE:	17 August 2017	DATE:	17 August 2017

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

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