RAIB

Rail Accident Investigation Branch

Rail Accident Report

Signal passed at danger on approach to Wootton Bassett Junction, Wiltshire 7 March 2015

Report 08/2016
May 2016

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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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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Signal passed at danger on approach to Wootton Bassett Junction, Wiltshire, 7 March 2015

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Summary

At around 17:25 hrs on Saturday 7 March 2015, train reporting number 1Z67, the 16:35 hrs steam charter service from Bristol Temple Meads to Southend, passed signal SN45 at danger. Signal SN45, which is situated on the approach to Wootton Bassett Junction, was being maintained at danger to protect the movement of a scheduled passenger train. At the time that the incident occurred, this scheduled passenger train had already passed through the junction. No injuries, damage or derailment occurred as a result of the incident.

Train 1Z67 was operated by West Coast Railways and consisted of the steam locomotive ‘Tangmere’ and 13 coaches. Although Tangmere is a heritage locomotive, it is fitted with modern safety systems including the Automatic Warning System (AWS) and the Train Protection and Warning System (TPWS). AWS is intended to warn train drivers if the signal they are approaching requires them to stop or to reduce the speed of their train. AWS also warns drivers of certain speed restrictions. If drivers do not acknowledge AWS warnings within a specified time period then the train’s brakes will automatically apply. TPWS will automatically apply the brakes on a train if it passes a signal fitted with the system when it is set at danger or approaches it above a certain speed. Drivers are required to stop and contact the signaller if either AWS or TPWS intervenes to apply a train’s brakes.

The RAIB’s investigation has found that signal SN45 was passed at danger because the driver did not reduce the train’s speed on approach to the signal. This meant that he was unable to stop the train in time, once he realised it was at danger. The driver had not reduced the train’s speed because he had not seen the preceding signal, which was at caution and should have alerted him that SN45 was at danger. He missed this preceding signal because he had become distracted by activity within the cab and possibly also because he was experiencing a higher workload than normal. This distraction may also explain why he misunderstood the nature of an AWS warning he received and why his knowledge of the junction did not alert him to the fact that he had missed this signal. He may also have misunderstood the nature of the AWS warning because a sign relating to a temporary speed restriction was not positioned correctly.

Train 1Z67 also passed signal SN45 at danger because the TPWS system was unable to reduce the speed of the train by automatically applying the brakes. This was because TPWS had been rendered ineffective by Tangmere’s crew when they had isolated the AWS system in order to by-pass an automatic brake application which had occurred at a speed restriction. Isolating AWS in this way was in contravention of the relevant rules but the RAIB has found that it had almost certainly become an accepted practice among some train crews on this locomotive. This was probably because warnings from AWS were not always apparent to drivers, who were also anxious to avoid delays resulting from brake demands. Measures intended to prevent the misuse of AWS isolations had either not been adopted by West Coast Railways or had not been effectively implemented.

The RAIB found three underlying factors. These were that the AWS system on Tangmere was installed in a way which meant that warnings from the system were not always apparent to drivers. In addition, the investigation found that a speed restriction which was in place on approach to the junction was based on incorrect information and had been implemented in a way which did not conform to the relevant rules and standards. The investigation also found that West Coast Railways had a weak safety culture and that this had affected the way its staff observed rules and instructions.

The RAIB has identified one key learning point. This is that allowing safety critical systems such as AWS and TPWS to function without improper interference is vital to the safe operation of the railway. By-passing safety systems, or isolating them other than in accordance with the requirements of the relevant rules, can have catastrophic consequences.

The RAIB has made five recommendations. One recommendation is addressed to RSSB, working in conjunction with steam train operators and Network Rail, and relates to a review of the arrangements intended to assess, prevent and mitigate the risks associated with steam movements. Three recommendations are addressed to West Coast Railways. These relate to a review of its safety management system and safety culture; the implementation of industry best-practice concerning the management of drivers' knowledge of operating routes; and the arrangements for maintaining on train data recorders. One recommendation is addressed to Network Rail. This concerns the way that emergency and temporary speed restrictions are designed and implemented.

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. Any location mileages given are measured from the zero datum at London Paddington station.

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.

The incident

Summary of the incident

3 At around 17:25 hrs on Saturday 7 March 2015, train reporting number 1Z67, the 16:35 hrs West Coast Railway Company Ltd charter service from Bristol Temple Meads to Southend, passed signal SN45 at *danger*. The incident, which is of a type known as *signal passed at danger* (SPAD), occurred on the approach to Wootton Bassett Junction, Wiltshire (figure 1). The train subsequently came to a stand across the junction.

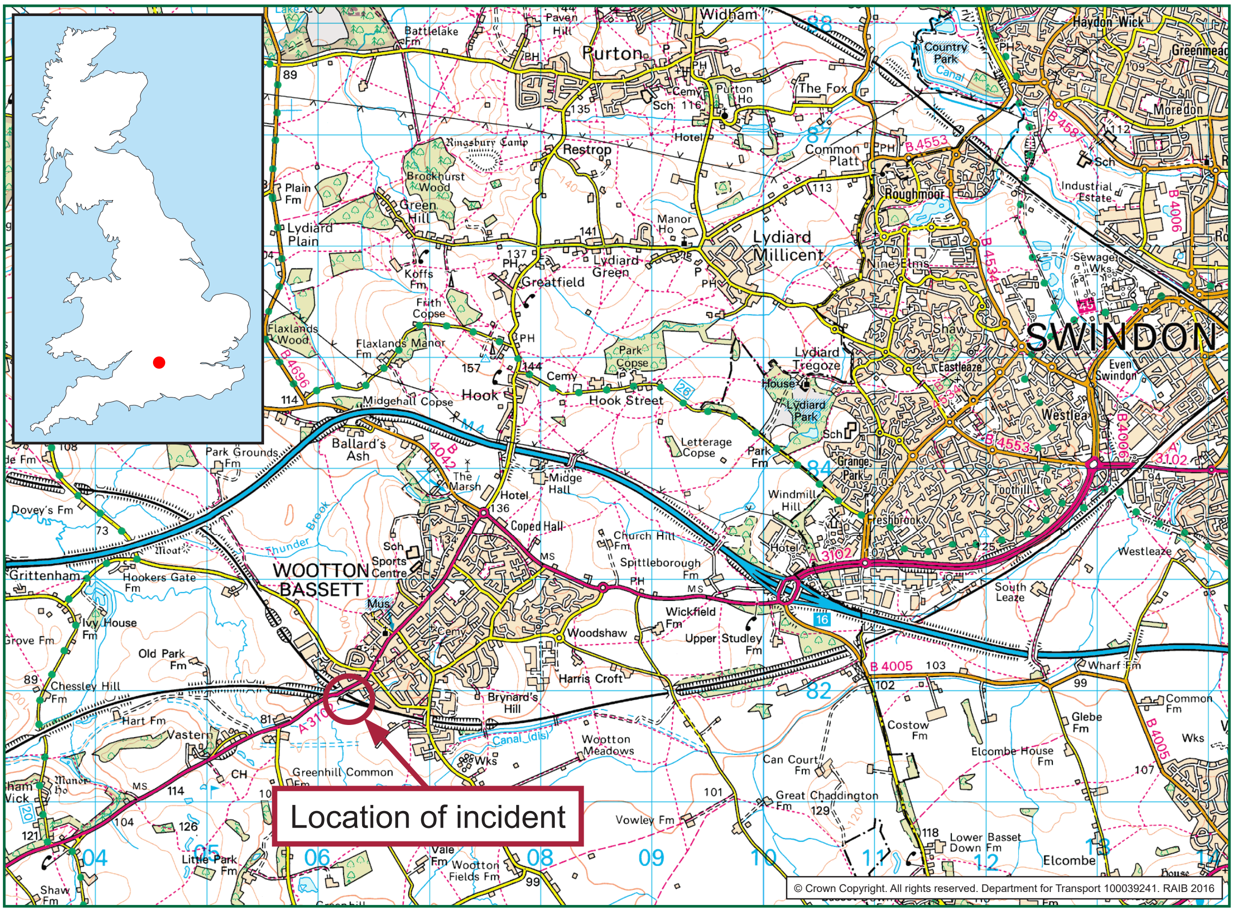

Figure 1: Extract from Ordnance Survey map showing location of incident

4 The signal involved was being maintained at danger in order to protect the junction during the movement of train 1L76, the 15:28 hrs First Great Western service from Swansea to London Paddington. Train 1L76 had passed through the junction around 44 seconds before the SPAD occurred and had continued on its journey. No injuries, damage or derailment occurred as a result of the incident.

Context

Location

5 Wootton Bassett Junction is located between the stations at Chippenham and Swindon. It is a double track high speed junction which joins the up and *down* Great Western main lines which run between Bristol Temple Meads and London Paddington (via Bath) with the Up and Down Badminton lines which run to and from Cardiff. The junction also has two low speed crossovers between the up and down main lines (figure 2).

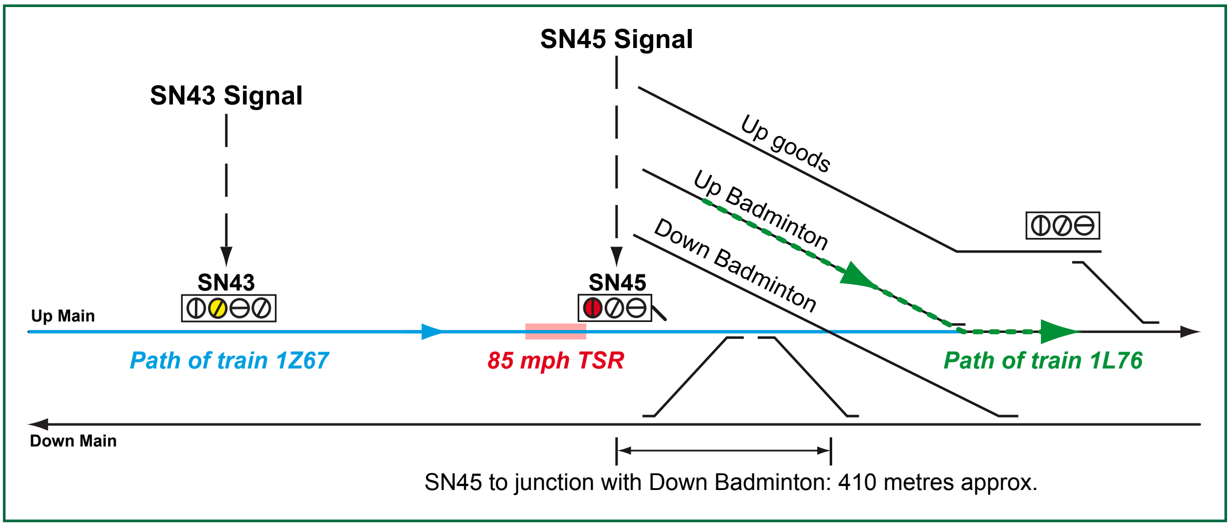

Figure 2: A diagram of the layout of Wootton Bassett Junction – note that some features have been omitted for clarity (not to scale)

6 Wootton Bassett Junction is protected from trains approaching on the up main line from Chippenham by signal SN45, a *three-aspect colour light* signal, fitted with a *junction indicator* (figure 3). SN45 is mounted on a standard cantilever post which places the red aspect around 5 metres above the track and offset towards the *cess* by around 0.9 metres from the left-hand rail.

7 Signal SN45 is located around 410 metres on the approach to the junction with the Down Badminton line and around 470 metres on the approach to the junction with the up Badminton line. SN45 is equipped with the *Automatic Warning System* (AWS) and the *Train Protection and Warning System* (TPWS). The operation of these systems is explained in more detail in appendix C. The TPWS equipment fitted at SN45 is in a configuration known as '*TPWS+*' and it takes the form of a train stop system (TSS), which is installed at the signal itself, and two overspeed sensor systems (OSS), situated on the approach to the signal. The railway rises on the approach to the signal from Chippenham on an average gradient of 1:660.

8 Signal SN45 is preceded on the up main line by signal SN43, a *four-aspect colour light signal* (figure 4). SN43 is mounted on a standard cantilever post and is also equipped with AWS and TPWS. The normal signalling sequence for a train approaching SN45 at danger is that SN43 signal shows a single yellow *caution* aspect and that the preceding signal, UM85, shows a green *proceed* aspect[1].

[1] Although SN43 is configured as a four-aspect signal, this relates only to the spacing of signals beyond the junction.

Figure 3: A video image of signal SN45 taken shortly after the incident. Inset figure shows an HD video image of the signal head taken in 2012 (images courtesy of Network Rail).

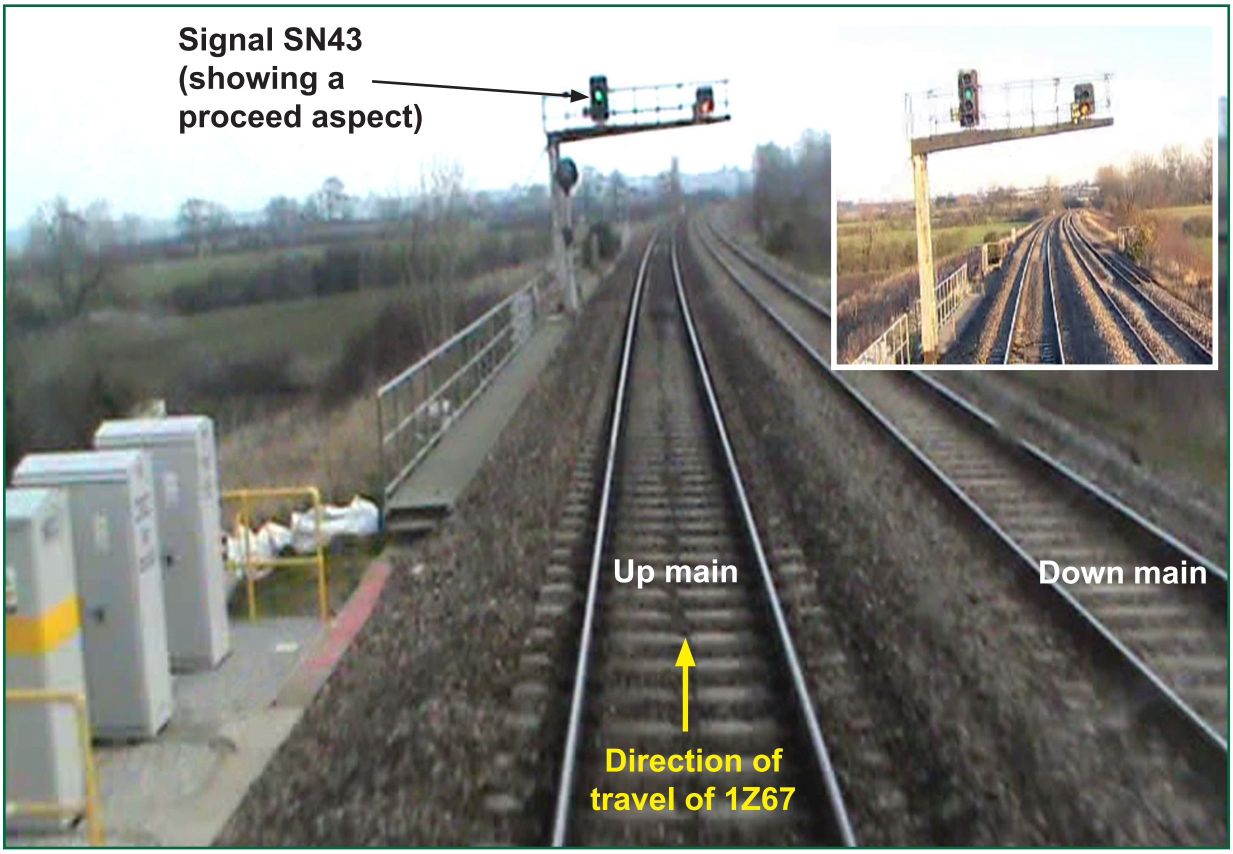

Figure 4: A video image of signal SN43 taken shortly after the incident. Inset figure shows an HD video image of the signal head taken in 2012 (images courtesy of Network Rail).

9 Signals SN43 and SN45 are spaced about 2,000 metres apart. At the time of the incident they were both controlled by Swindon *Power Signal Box* (PSB)[2]. The Great Western Main Line at Wootton Bassett Junction is fitted with equipment to allow the operation of trains using the *Automatic Train Protection* (ATP) system. However, the locomotive hauling train 1Z67 was not fitted (and was not required to be fitted) with equipment that would permit it to operate with the ATP system.

10 Neither signal SN43 nor signal SN45 were recorded as having previously been passed at danger.

11 The maximum permitted line speed for trains approaching Wootton Bassett Junction on the up main line from Chippenham is normally 125 mph (201 km/h). However, on 7 March 2015, a *temporary speed restriction* (TSR) of 85 mph (137 km/h) was in place on the approach to signal SN45, due to the condition of the track. The associated warning board and portable AWS magnet for the TSR had been placed on the approach to signal SN43 (figures 5 and 6). The maximum permitted line speed for trains approaching the junction on the Up Badminton line is 70 mph (113 km/h).

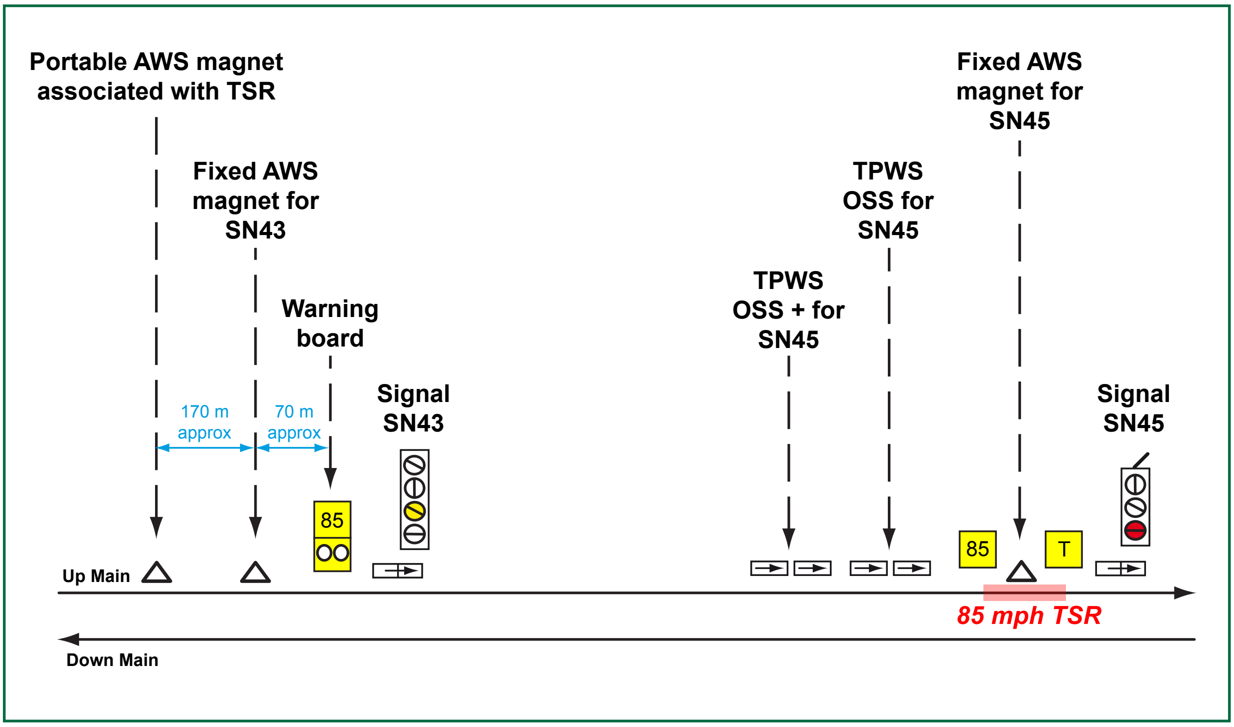

Figure 5: A diagram of the arrangements implemented for the TSR (not to scale)

[2] Swindon PSB closed in February 2016.

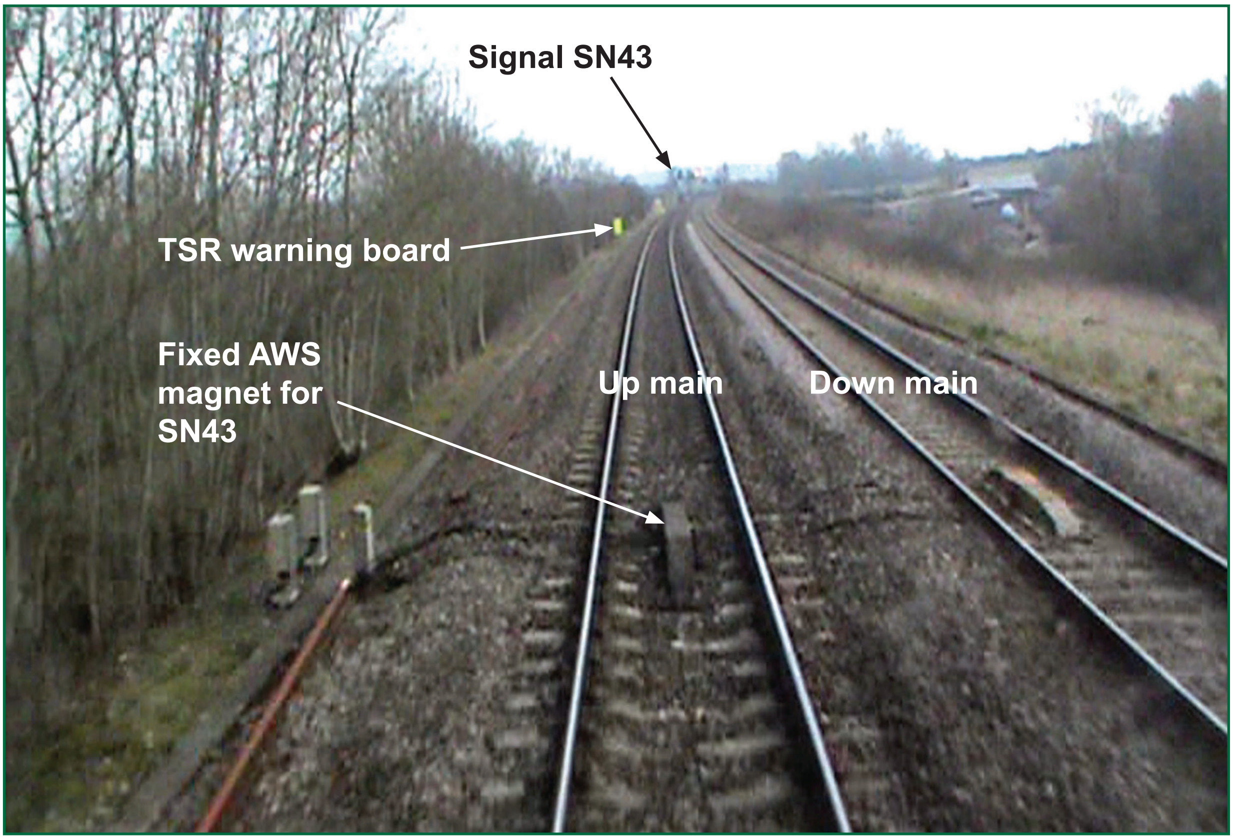

Figure 6: A video image of the warning board taken shortly after the incident (image courtesy of Network Rail)

Train involved

12 Train 1Z67 was formed of 13 *Mark 1* and *Mark 2* coaches, hauled by steam locomotive number 34067 'Tangmere'[3] (figure 7). This locomotive was built in 1947 and was withdrawn from mainline railway service by British Railways in November 1963. The driver's slip for the train stated that it was 277 metres in length, weighed approximately 605 tonnes (including the locomotive and tender) and that it had a maximum permitted train speed of 75 mph (121 km/h). Twelve of the thirteen coaches were vacuum braked. The remaining coach, which was the support coach for the locomotive, was air braked.

13 Tangmere is fitted with three separate braking systems. These are the air braking system (which controls the brakes of rail vehicles connected to the locomotive via the *automatic air brake pipe*), the vacuum braking system (which controls the brakes on the locomotive's tender and any other rail vehicles connected to the locomotive via the *automatic vacuum train pipe*) and the steam braking system (which controls only the brakes on the locomotive). These braking systems are connected to each other by a series of *proportional relay valves*. These valves are arranged so that a brake application commanded via the driver's air brake valve will result in an air brake demand with a proportionate brake demand also being created within the vacuum and steam braking systems. A brake application commanded via the vacuum brake controller valve, however, will only apply the brakes within the vacuum and steam braking systems and will not affect the air braking system.

[3] 34067 is Tangmere's historic locomotive number. The locomotive and its tender together are designated by number 98767 within railway computer systems such as TOPS and TRUST.

Figure 7: Locomotive 34067 'Tangmere'

14 Between 2001 and 2004 an extensive programme of work was undertaken to restore Tangmere from a scrap condition so that it could again run on the mainline. Tangmere was fitted with air braking and AWS and TPWS systems as part of this programme. This included the fitting of a combined electronic AWS/TPWS control unit and an electronic AWS audible warning indicator unit. An orange flashing light was also fitted in the cab and connected so that it would flash whenever the AWS warning horn sounded. The operation of the AWS system is explained in more detail in appendix C.

15 At the time of the incident, the AWS audible warning indicator on Tangmere was positioned on the inside of the cab roof, just above the *driving position* (which is on the left-hand side of this locomotive) and towards the rear of the driver's side window. The orange flashing light was also positioned on the inside of the cab roof, slightly higher than the audible warning indicator and to the front of the driver's side window (figures 8 and 9). The AWS visual indicator (commonly called the 'sunflower') is mounted in front of the driving position just above the main driving controls, with the TPWS display panel positioned directly above it (figure 9).

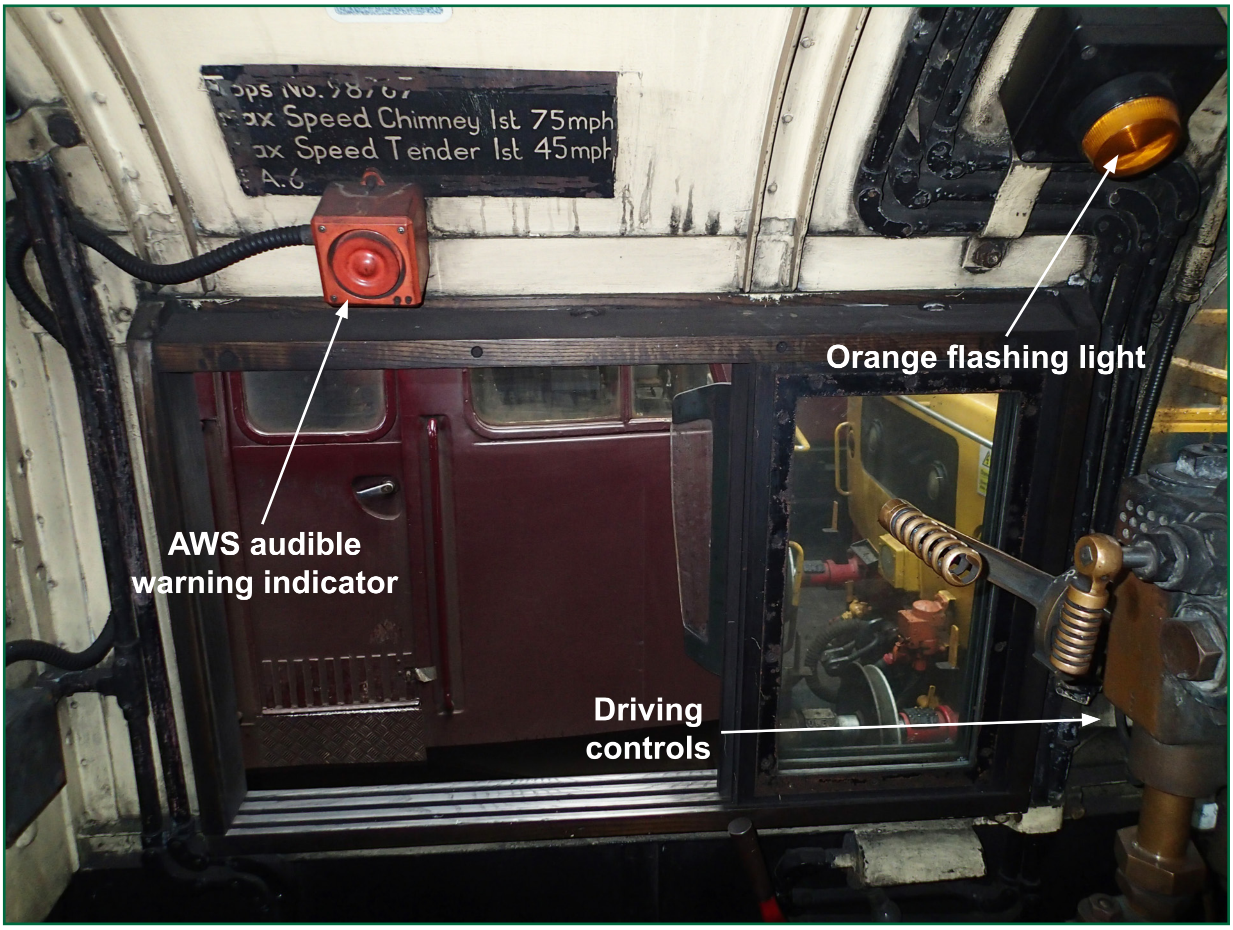

Figure 8: The position of the AWS audible warning indicator unit and flashing light on 7 March 2015

16 Drivers acknowledge AWS warnings on Tangmere by pressing and releasing the AWS reset pushbutton, which is located to the left of the driver's seat (figure 10). The *railway group standards* applicable at the time that Tangmere's AWS system was installed required that the driver be given a period of up to 2.7 seconds to acknowledge warnings. Should a driver not acknowledge an AWS warning within this time period, then the combined AWS/TPWS control unit will generate an AWS brake demand. The relevant standards required that AWS brake demands remain active until the driver acknowledged the warning and that any brake demand continue for at least 59 seconds after this had been done. In the event that an AWS brake demand occurs, the *Rule Book*[4] requires drivers to immediately bring their trains to a stand and then to contact the signaller.

17 The combined AWS/TPWS control unit creates brake applications when required to do so by the function of either the AWS or TPWS systems by de-energising an electro-pneumatic valve. De-energising the valve will cause the automatic air brake pipe to be vented to atmosphere via the *application unit* and the brakes on the train to apply (paragraph 13).

[4] Railway Group Standard GE/RT 8000 Rule Book, Modules S7 'Observing and obeying signalling indications, Train warning systems, Reporting signalling failures and irregularities' and TW1 'Preparation and movement of trains'.

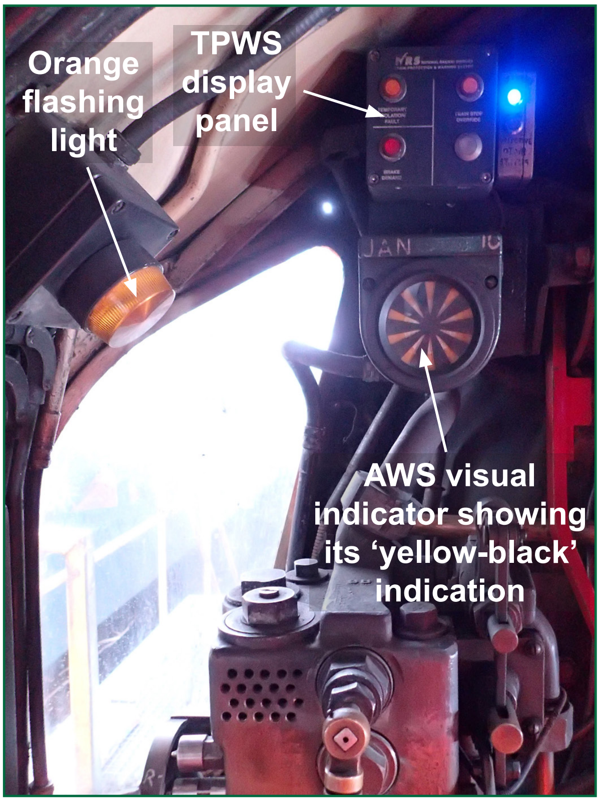

Figure 9: The position of the AWS flashing light, AWS visual indicator and TPWS display panel on 7 March 2015. Note: the blue light next to the TPWS display panel relates to the locomotive's OTDR.

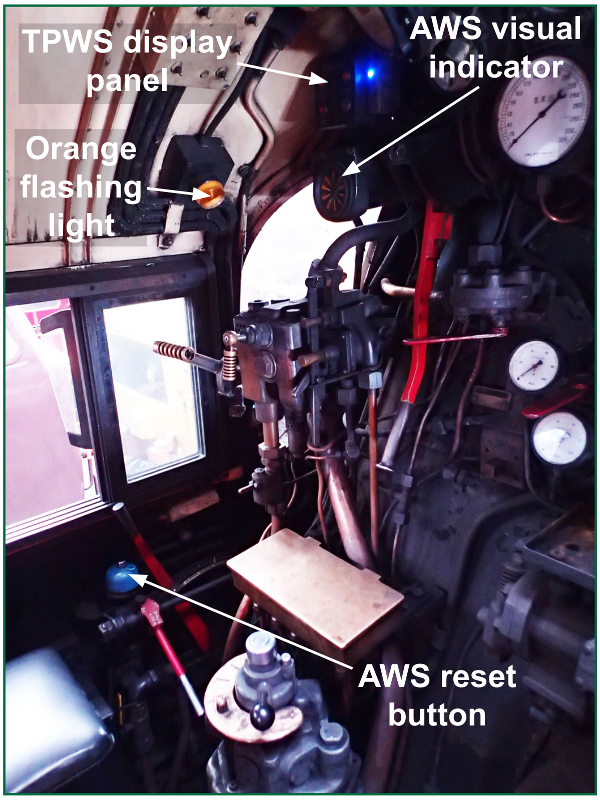

Figure 10: The position of the AWS flashing light, AWS visual indicator, AWS reset pushbutton and TPWS display panel on 7 March 2015

18 An AWS shut down cock is located to the rear of the driver's seat. This is normally left open in service; if closed, it will pneumatically isolate the AWS system and electrically isolate the combined AWS/TPWS control unit. Closing the AWS shut down cock will lead to the loss of all visual and audible indications from the AWS and TPWS systems and will de-energise the electro-pneumatic valve. This will cause the automatic air brake pipe to vent and the train's brakes to apply in the same way as when a brake demand is generated.

19 An AWS isolating cock is also situated to the rear of the driving position, close to the cab floor plates (figures 11 and 12). The AWS isolating cock is normally left closed in service; if opened it will admit air into the electro-pneumatic valve and lock it into the 'ISOLATED' position, regardless of whether it is energised or not. This means that, once the electro-pneumatic valve is locked in this position, de-energising it no longer has any effect on the air braking system and any brake demands generated by the combined AWS/TPWS control unit are rendered ineffective.

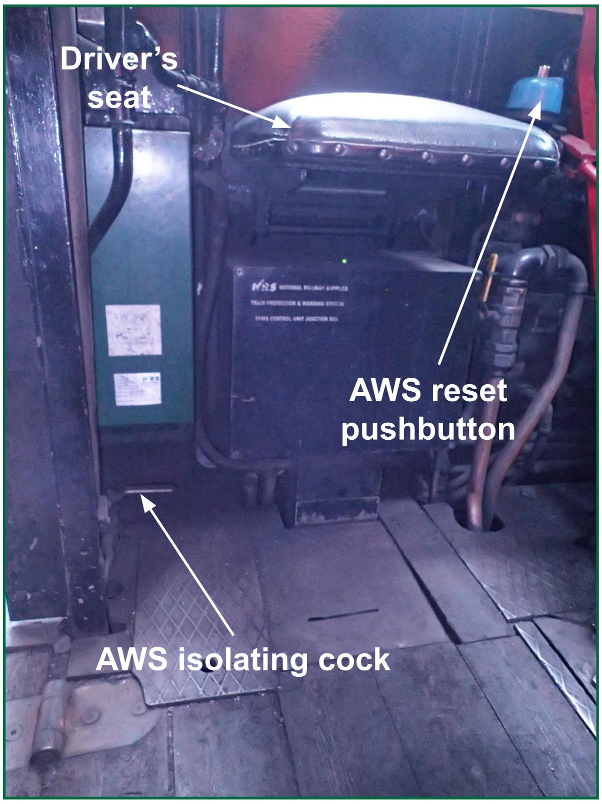

Figure 11: The AWS isolating cock shown in the open position

Figure 12: The AWS isolating cock shown in the closed position

20 The AWS isolating cock is intended to allow Tangmere to maintain a functioning automatic air brake pipe in certain operational circumstances where the AWS shut down cock has to be operated, for example where there has been an AWS system fault or where the locomotive is to be hauled by another traction unit. If the AWS isolating cock is opened without the AWS shut down cock subsequently being closed, the combined AWS/TPWS control unit will lose its ability to command a brake application but the AWS and TPWS systems will otherwise appear to function normally. The design of the AWS system on Tangmere is discussed further in paragraph 141.

21 The vehicle maintenance instruction for Tangmere requires the AWS isolating cock to be sealed and that this seal be checked to ensure it is intact as part of the daily *fitness-to-run examination*. The Rule Book[5] does not allow drivers to enter a train into passenger service if the AWS system is isolated or if an AWS isolating seal is found to be broken. The breaking of an AWS isolating cock seal is intended to provide a visible indication that the AWS system has been isolated at some point; the function of these seals is discussed further in paragraph 132.

22 A TPWS temporary isolation switch is also provided in the cab; if operated, this will isolate only the TPWS functions within the control unit and will leave the AWS system operating normally. The TPWS temporary isolation switch is intended to be used in certain operational circumstances when TPWS is not functioning, such as when working within *possessions*. On Tangmere, this switch is also operated when undertaking *propelling* movements. This is because propelling with a coach as the leading vehicle can lead to spurious TPWS brake demands.

[5] Railway Group Standard GE/RT 8000 Rule Book, Module TW5 'Preparation and movement of trains - Defective or isolated vehicles and on-train equipment'.

Organisations involved

23 West Coast Railway Company Ltd. (trading as West Coast Railways) operates a variety of charter and other services on Network Rail managed infrastructure. West Coast Railways operated Tangmere on a lease and employed the drivers and firemen of trains 1Z21 and 1Z67 (paragraphs 29 and 40) and the *fitness-to-run examiner* who examined Tangmere prior to its entry into service on 7 March 2015.

24 Carnforth Railway Restoration and Engineering Services Limited (CRRES) has been the *entity in charge of maintenance* for Tangmere since 2008, under a contract with West Coast Railways. Although CRRES is a separate organisation from West Coast Railways, it trades under the West Coast Railways name and shares both premises and ownership with the train operator. Some staff at management level work for both CRRES and West Coast Railways.

25 Riley and Son (E) Limited (Riley and Son) took ownership of Tangmere around 2000. It was responsible for returning the locomotive into a condition where it could undertake mainline running and for maintaining the locomotive until it was sold in 2008[6] to a private individual.

26 Resco Railways (Resco) undertook *design scrutiny* of the installation of AWS and TPWS on Tangmere as the *Conformance Certification Body* (CCB). It was also the *Vehicle Acceptance Body* (VAB) responsible for the locomotive's *engineering acceptance*.

27 Network Rail owns, maintains and manages the railway infrastructure at Wootton Bassett Junction. Network Rail also employed the signaller at Swindon PSB and undertook the assessment of overrun risk for signal SN45.

28 West Coast Railways, CRRES, Riley and Son and Network Rail freely co-operated with the investigation. Resco is no longer trading; internal records relating to its activities as a CCB and VAB were sent for storage with RSSB after the company closed. Some records relating to Tangmere were found in this archive, while others were provided by witnesses from their personal records.

Staff involved

The driver of 1Z67

29 The driver of 1Z67 had over 50 years of railway experience. Witness evidence was that he worked as an *engine cleaner* and a *fireman* on steam locomotives during the 1960s and that he continued to work for British Rail as train crew before becoming a driver of diesel traction in 1976. He continued to be employed full-time as a driver on the mainline railway until 2007, when he retired. He then started work for West Coast Railways on a *zero-hours contract*, initially as a driver of diesel locomotives. The driver started training as a mainline steam locomotive driver with West Coast Railways in August 2010 and was assessed as being competent in this role by the company in May 2011. The driver was supervised by an operations manager working from West Coast Railways' Rugby offices.

[6] Although the ownership of Tangmere was not fully transferred to the new owner until 2011, Riley and Son undertook no further maintenance on Tangmere after 2008.

30 While working for West Coast Railways, the driver was also employed as a manager on a heritage railway. He had previously been a volunteer on this railway and had driven steam locomotives of a similar design to Tangmere on its infrastructure. The driver also had experience as a volunteer member of the support crew for another steam locomotive while it was running on the mainline. In late 2013, the driver left his employment on the heritage railway and started working as a driver for Colas Rail, a freight operating company, on a part-time contract. After a period of training, the driver was assessed as being competent to drive on the mainline by Colas Rail in November 2013. The driver continued to work for West Coast Railways after starting to work part-time for Colas Rail.

31 West Coast Railways assesses driver competency on a two-yearly cycle. This includes an annual practical assessment of driving performance undertaken by an assessor using direct observation, with each traction type for which a driver holds a competency (ie diesel, electric or steam traction) being assessed at least once in every two year period. West Coast Railways also requires a written and oral test on the driver's knowledge of the Rule Book every two years and a declaration by the driver of their competency with regard to both *route and traction knowledge* at the same interval. All traincrew, including drivers, are also required to attend an annual safety briefing day.

32 Both West Coast Railways and Colas Rail maintained an *operational safety file* for the driver. These files showed that the last practical assessment of his driving performance prior to the SPAD occurring was undertaken by West Coast Railways in June 2014, on a steam locomotive hauling a train fitted with vacuum brakes. The files also showed that the driver passed his two-yearly Rule Book knowledge test with West Coast Railways in March 2014 and that he attended an annual safety briefing day with West Coast Railways on 5 March 2015, two days before the incident. At this briefing day, the driver signed his *route and traction knowledge card* to confirm that he had retained his *route knowledge* of the route which included Wootton Bassett Junction and his traction knowledge of steam locomotives.

33 The driver was required to undergo an annual examination of medical fitness to undertake driving duties (including his vision and hearing) in accordance with the requirements of Railway Group Standard GO/RT 3451[7]. The driver's operational safety files confirmed that he had been passed medically fit in accordance with these requirements in November 2014.

34 The driver's operational safety files recorded that he had been involved in one previous safety of the line incident, a *Category A SPAD*, in 2005. The cause of the SPAD was given as the driver having failed to react to a signal at caution. Witness evidence was that the driver had not reacted to the signal because he had suffered a loss of concentration as a result of significant difficult events having recently occurred in his personal life. As a result of the SPAD, the driver was placed on the *Specially Monitored Driver Risk Register* by the train operating company for which he then worked.

[7] Railway Group Standard GO/RT 3451 'Train Drivers - Medical Fitness Requirements', Issue 4, dated June 2014.

35 Details of this previous incident were passed to West Coast Railways by the driver's previous employer and his operational safety file shows that he was assessed annually by West Coast Railways to determine if special monitoring was required. These assessments concluded that it was not. The driver's operational safety files show that the driver was not subject to special monitoring by either West Coast Railways or Colas Rail prior to the SPAD of 7 March 2015 and that he was not involved in any further incidents while working for either company.

The fireman of train 1Z67

36 Witness evidence was that the fireman had volunteered on various heritage railways since the mid-1980s and that he had undertaken the duties of both the fireman and driver of steam locomotives on heritage infrastructure. This included firing steam locomotives of a similar configuration to Tangmere. He had also worked from 2003 as a volunteer member of the support crew for Tangmere. In 2009, he was employed on a zero-hours contract by West Coast Railways as a fireman on Tangmere. His operational safety file states that, after training and assessment, he was found to be competent in the role of fireman by West Coast Railways in May 2009.

37 West Coast Railways assesses the competency of firemen on a two-yearly cycle. This is a similar process to that used for drivers, although firemen are not required by West Coast Railways to acquire and maintain route knowledge. The fireman's operational safety file showed that the last practical assessment of his performance prior to the SPAD occurring was undertaken in September 2014. The file also showed that the fireman passed his two-yearly Rule Book knowledge test in May 2013 and that he attended an annual safety briefing day in July 2014.

External circumstances

38 The closest meteorological information available for Wootton Bassett Junction (based on the weather records from RAF Fairford) showed that, when the incident occurred, the weather was mild and clear, with a slight to moderate breeze from the south-west. Twilight was recorded as being just before 18:00 hrs.

The sequence of events

Events preceding the incident

39 Between 5 and 6 March 2015 Tangmere was examined for its fitness-to-run at West Coast Railways' Southall depot. This included an examination of the locomotive while it was in steam. Documents completed by the fitness-to-run examiner during this examination recorded that all of the safety systems on the locomotive (including AWS and TPWS) were found to be functioning correctly and that it was fit to travel over Network Rail managed infrastructure. The examiner stated that no steam leaks were present within the locomotive's cab at this point and that he had applied a numbered red plastic tie seal to the AWS isolating cock during the examination.

40 At 09:36 hrs on 7 March 2015, train reporting number 1Z21, the 07:22 hrs West Coast Railways charter service from Southend East to Bristol Temple Meads, arrived at Southall. Two locomotives were detached there and replaced with Tangmere, which became the sole locomotive on the train. Witness evidence was that the remainder of the outbound journey passed without incident, although the driver of train 1Z21 stated that he experienced occasional condensation on his windscreen, possibly due to a steam leak within the cab. The driver stated that he reported this to a support crew member who was riding in the cab and that, while the condensation meant that he periodically needed to drive with his head out of the driver's side window, the windscreen could be cleared easily by wiping.

41 The condensation on the windscreen was also seen by the fitness-to-run examiner, who spent part of the outbound journey in the cab as a technical rider. This examiner stated that he thought that the condensation was caused by a steam leak from outside the cab and that the problem did not, in his opinion, prevent the driver from seeing through the windscreen. Both the driver of train 1Z21 and the fitness-to-run examiner stated that they could clearly hear the AWS warning horn during the outbound journey.

42 Train 1Z21 arrived at Bristol Temple Meads at 13:11 hrs. Once at Bristol Temple Meads, the train moved as *empty coaching stock* to a nearby siding[8]. The locomotive and its support coach were detached from the train and were then driven to St. Philip's Marsh maintenance depot. Analysis of data from Tangmere's *On Train Data Recorder* (OTDR) showed that, shortly after train 1Z21 had left service and entered the depot, an AWS brake demand occurred at a speed of around 7 mph (11 km/h). OTDR data showed that this brake demand occurred because the driver did not acknowledge an AWS warning within the time allowed (paragraph 16).

[8] Trains 1Z21 and 1Z67 changed reporting numbers for the journeys to and from Bristol Temple Meads station, the siding and the depot. However, for the purposes of clarity, reporting number 1Z21 has been used throughout this report in order to designate the outbound train and its crew and reporting number 1Z67 has been used throughout this report in order to designate the inbound train and its crew.

43 The driver of train 1Z21 stated that he had no recollection of this AWS brake demand having occurred; however witness evidence from the fireman of 1Z21 was that this brake demand caused the train to come to a stand within the depot and that the driver had then asked him to open the AWS isolating cock in order to release the brakes. The fireman stated that he had done this and that the brakes on the train had released. The OTDR channel which monitors the use of the AWS isolating cock was not functioning on the day of the incident; however, data from other OTDR channels showed that the locomotive's brakes were released while the combined control unit was still generating an AWS brake demand, which supports the fireman's statement that the AWS isolating cock was opened. The fireman stated that, as far as he was aware, the AWS isolating cock was not sealed before he opened it. The driver stated that he could not recall whether the isolating cock was sealed or not on this day, because this was not something that he looked at.

44 The fireman of 1Z67 took over his duties on Tangmere in the depot at around 15:00 hrs. Just before the locomotive and support coach left the depot and entered service OTDR data showed that a second AWS brake demand occurred at a speed of around 4 mph (6 km/h). This brake demand occurred because the driver had again not acknowledged an AWS warning within the time allowed. The driver of 1Z21 stated that he was leaning out of the driver's side window while making a propelling movement when this brake demand occurred and that he was initially unaware why the brakes had applied. The driver stated that, once he pulled his head back inside, he was told by someone in the cab that an AWS brake demand had occurred and that they had already opened the AWS isolating cock. Although the driver could not recall who had opened the AWS isolating cock, he stated that he was certain that it had been done without his permission. As with the previous brake demand in the depot, OTDR data supports the AWS isolating cock having been opened at this point in order to release the brakes.

45 The locomotive and support coach left the depot and moved to nearby sidings, where they were attached to the coaches to form train 1Z67. The train then moved to Bristol Temple Meads station, where the driver of 1Z67 took over the train. He stated that no problems with the train were mentioned to him by the driver of train 1Z21 during their handover. However, he stated that he was told during the handover that the support crew had asked that he control the train's brakes using the vacuum brake controller valve and not the air brake valve. He was told that this was because they were worried that using the air brake valve might cause wheel flats to the support coach, which was the only air-braked vehicle within the train. The driver of 1Z67 stated that, although he would normally control the train using the air brake valve, he agreed to this request.

46 Train 1Z67 left Bristol Temple Meads at 16:38 hrs, around 3 minutes late. In addition to the driver and the fireman, two members of the locomotive's support crew were also present in the cab. Witness evidence suggested that the journey to Wootton Bassett Junction was uneventful, with the exception that the driver was experiencing poor visibility forwards through his windscreen. This was partly due to condensation on the windscreen from a steam leak (paragraph 40) but also because the locomotive's exhaust was being blown by the wind towards the left-hand side of the boiler, where it was accumulating and blocking his view. In order to improve his sighting, the driver decided to drive the train with his head positioned outside the driver's side window.

Figure 13: The driver's windscreen on Tangmere. Note that this photograph was taken with the train at a stand within a depot and does not show the driver's forward visibility on 7 March 2015

Events during the incident

47 At around 17:24 hrs, 1Z67 was approaching signal SN43 at 59 mph (95 km/h), when it passed over the portable AWS magnet associated with the TSR (paragraph 10). Around a second after this, an AWS warning occurred. OTDR data showed that it took the driver 4.1 seconds to acknowledge this warning, by which time the combined AWS/TPWS control unit had already generated an AWS brake demand (figure 14).

48 The driver indicated to the fireman that an AWS brake demand had occurred. His expectation was that the fireman would open the AWS isolating cock in order to by-pass the AWS brake demand and release the brakes. The fireman has stated that he believed that he was following the driver's instructions when he subsequently crossed the cab and opened the AWS isolating cock. The fireman stated that the AWS isolating cock was not sealed before he opened it.

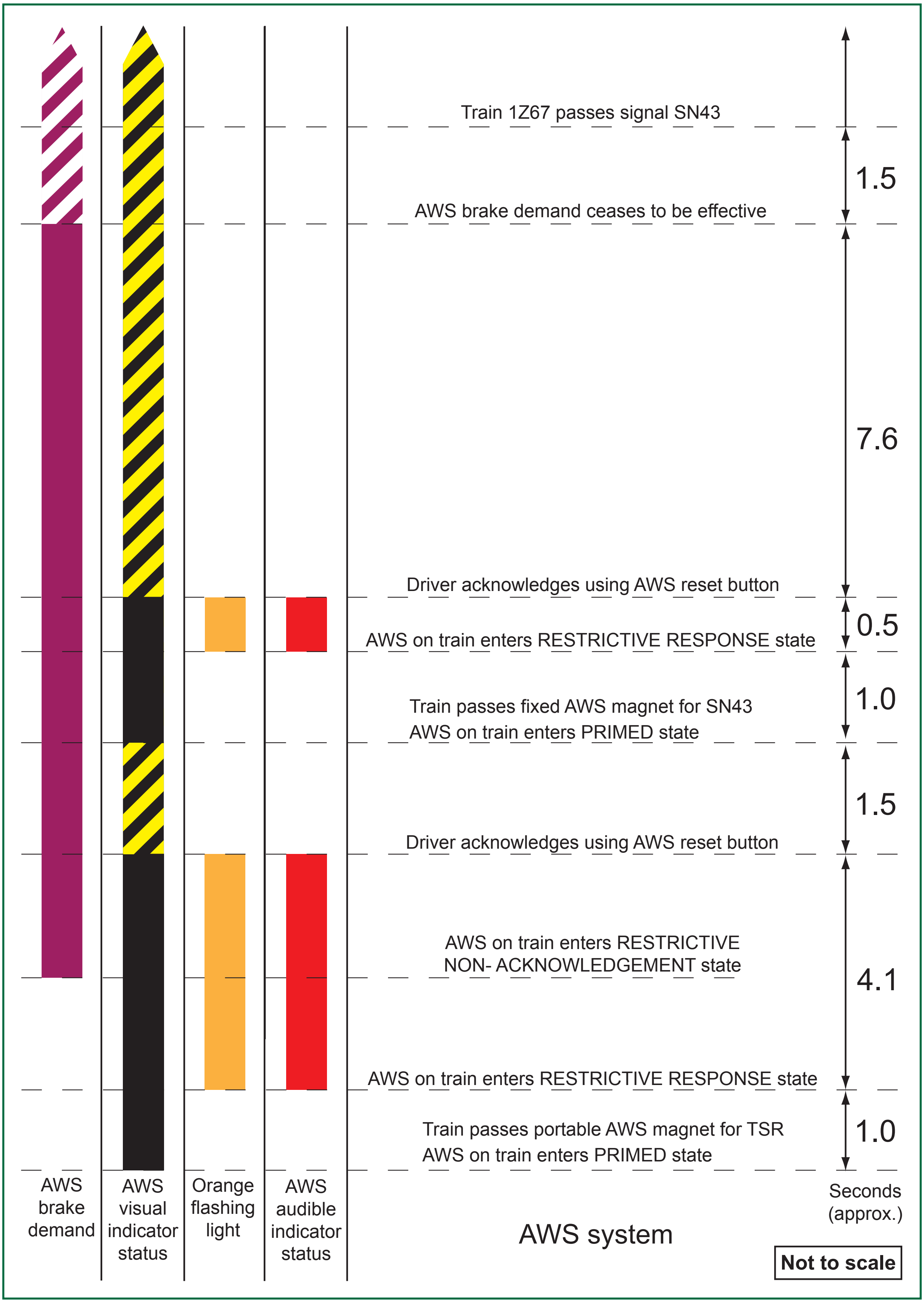

Figure 14: Timeline of events at signal SN43

49 In the event that an AWS brake demand occurs, the Rule Book[9] requires drivers to immediately bring their train to a stand and then to contact the signaller. The Rule Book[10] only permits the drivers of trains which are in service to isolate the AWS system if it has become defective or if it is inoperable due to the configuration of the infrastructure. In these circumstances, the Rule Book requires drivers to immediately bring their trains to a stand and then contact the signaller. Certain conditions must then be met before the train can proceed any further.

50 Despite these requirements, train 1Z67 was not brought to a stand and instead continued on its journey. OTDR data showed that the AWS brake demand ceased to be effective around 12 seconds after it was initiated and around 1.5 seconds before the train passed signal SN43. Before it was by-passed this brief brake application reduced the train's speed by a total of 8 mph (13 km/h). Witness evidence and OTDR data showed that the AWS isolating cock remained open during the remainder of the incident; this had the effect of making any subsequent AWS or TPWS brake demands ineffective (paragraph 19).

51 OTDR data also showed that a second AWS warning occurred during the 12 second period in which the AWS brake demand was effective. This was created by the fixed AWS magnet which is located on approach to signal SN43. This second warning was acknowledged by the driver within 0.5 seconds.

52 A few seconds after the AWS brake demand generated at the TSR had timed out, train 1Z67 approached the first of the two TPWS OSS for signal SN45, which was displaying a red danger aspect, at a speed of around 52 mph (84 km/h). This OSS is configured so that, when it is energised, the TPWS system fitted on any passenger train passing it at a speed greater than 65 mph (105 km/h) will demand a brake application. Because the train was travelling more slowly than this set speed, the TPWS system on Tangmere did not generate a brake demand at this OSS.

53 Train 1Z67 then passed over the second OSS at a speed of around 53 mph (85 km/h). This OSS has a set speed for passenger trains of 45 mph (72 km/h). The TPWS system on Tangmere correctly identified that train was travelling over the set speed and the combined control unit generated a brake demand. However, because the AWS isolating cock was still open, this demand had no effect on the train's braking systems (paragraph 19).

54 At some point on the approach to SN45, the driver of train 1Z67 saw that the signal was at danger and he fully applied the train's brakes. The OTDR channel which monitors the vacuum braking system was not functioning on the day of the incident; however analysis of OTDR data from other channels showed that the earliest point which the driver could have applied the brakes would probably have been around 220 to 230 metres on approach to the signal. Analysis of video images shows that signal SN45 would probably have been visible from this point, depending on the driver's forward visibility.

[9] Railway Group Standard GE/RT 8000 Rule Book, Modules S7 'Observing and obeying signalling indications, Train warning systems, Reporting signalling failures and irregularities and TW1 Preparation and movement of trains'.

[10] Railway Group Standard GE/RT 8000 Rule Book, Module TW5 'Preparation and movement of trains - Defective or isolated vehicles and on-train equipment'.

55 By the point where the driver applied the brakes, there remained insufficient distance to bring the train to a stand at signal SN45. The train subsequently came to a stand around 550 metres beyond the signal, standing on both the crossovers and the Up and Down Badminton lines, at just after 17:26 hrs.

56 Once the train ahead had cleared the junction points, the signaller at Swindon had set the route for train 1Z67 in anticipation of its movement across the junction. However, because train 1L76 had not cleared the *overlap* of the signal beyond SN45 at the time that the SPAD occurred, signal SN45 remained at danger. The setting of the route by the signaller meant that the points across the junction had already normalised to the correct position for the passage of train 1Z67 when this train passed over them. This meant that no damage was sustained by either the train or the infrastructure as a result of the SPAD.

Events following the incident

57 Once the train had come to a stand, the driver of train 1Z67 contacted the signaller at Swindon PSB as required by the Rule Book[11], using the locomotive's GSM-R radio. Witness evidence and the recording of this GSM-R radio call show that the driver of 1Z67 was aware that a SPAD had occurred at SN45 and that the signal had been displaying a danger aspect as the train approached it. The driver reported to the signaller that the SPAD had occurred due to an irregular aspect sequence, specifically that the signal immediately preceding SN45 was showing a green proceed aspect and not the single yellow caution aspect which would normally be expected (paragraph 8). Witness evidence was that, while the driver was calling the signaller, the fireman closed the AWS isolating cock on his own initiative. After he had spoken with the signaller, the driver contacted West Coast Railways' duty manager to report the incident.

58 Witness evidence and GSM-R voice recordings show that the signaller at Swindon PSB was initially unaware that a Category A SPAD had occurred. This was because his panel was not fitted with a SPAD alarm and the points at the junction were not showing the *out-of-correspondence* indication which the signaller would have expected to see had the points been *run-through*. For these reasons, and due to the nature of the driver's report, the signaller worked with the driver over the radio to complete a signalling irregularity reporting form, rather than the SPAD reporting form they were required to complete by the Rule Book. The signaller then treated SN43 as a defective signal and Network Rail arranged for it to undergo *wrong-side failure* testing.

59 The driver of 1Z67 was subsequently authorised by the signaller to proceed with the train as far as Swindon station. Further investigations by Network Rail indicated that a Category A SPAD had occurred and the driver was relieved of duty once the train arrived at Swindon at around 19:00 hrs.

[11] Railway Group Standard GE/RT 8000 Rule Book, Module S5 'Passing a signal at danger'.

Key facts and analysis

Background information

Role of the support crew

60 At the time of the incident at Wootton Bassett, the support crew for Tangmere was composed of volunteers provided by the locomotive's owner whose role, under the instruction of the *responsible officer,* was to help to prepare and dispose of the locomotive before and after service and to assist in its maintenance. Support crew members were required to hold the *personal track safety* competence. Although they were not members of Tangmere's train crew, West Coast Railways rules allowed a single support crew member or a representative of the locomotive's owners holding the appropriate cab pass to ride in the cab in normal circumstances in order to give technical advice on the working of the locomotive to the train crew.

61 Despite this rule, there were two members of the support crew present in Tangmere's cab when the SPAD occurred. However, witness evidence was that the presence of the support crew member in the cab did not distract or hinder the train crew and that neither support crew member played any role in the incident.

Identification of the immediate cause

62 **Train 1Z67 approached signal SN45 at too high a speed to stop before passing the signal at danger and coming to a stand across Wootton Bassett Junction**.

Identification of causal factors

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

a) The driver of train 1Z67 was not aware of the caution aspect being displayed by signal SN43 and did not reduce the train's speed appropriately as it approached signal SN45 (paragraph 64).

b) The TPWS system on board Tangmere was unable to reduce the speed of train 1Z67 on approach to signal SN45 and prevent it from over-running Wootton Bassett Junction. This was because TPWS brake demands had been rendered ineffective by the train crew's earlier use of the AWS isolating cock (paragraph 102).

Each of these causal factors is now considered in turn.

The driver of train 1Z67 did not take account of signal SN43

64 **The driver of train 1Z67 was not aware of the caution aspect being displayed by signal SN43 and did not reduce the train's speed appropriately as it approached signal SN45**.

65 Witness evidence and the GSM-R call made to the signaller after the SPAD (paragraph 57) indicate that the driver of train 1Z67 was not aware that signal SN43 had been displaying a caution aspect or that he had missed the signal. This meant that he had not reduced the speed of the train in anticipation of signal SN45 being at danger and was consequently unable to stop the train in time to prevent an overrun across the Up Badminton line, where it potentially could have conflicted with the movement of train 1L76 (paragraph 4).

66 The driver was not aware that signal SN43 was displaying a caution aspect or that he had not seen the signal due to a combination of the following factors:

a) the driver did not see signal SN43 as train 1Z67 passed it (paragraph 67);

b) the AWS warning relating to the signal did not alert the driver that he had passed signal SN43 and that the signal was displaying a caution aspect (paragraph 80); and

c) the driver did not realise that he had missed signal SN43 even though it was an important feature of the route on the approach to Wootton Bassett Junction (paragraph 89).

Each of these factors is now considered in turn. Discounted factors relating to the driver not taking account of signal SN43 are discussed in paragraphs 92 to 96.

The driver's observation of signal SN43

67 **The driver did not see signal SN43 as train 1Z67 passed it.**

68 The driver of train 1Z67 did not recall seeing signal SN43. He said that he thought that he had not seen it because, at the time the train passed it, his attention was focused within the cab, particularly on stopping the AWS brake demand which had resulted from the TSR (paragraph 48). This is supported by OTDR data which showed that the AWS brake demand was still in the process of being by-passed on the immediate approach to the signal (paragraph 50).

69 Because the driver's attention was focused inside the cab, neither the sighting of signal SN43 nor the poor forwards visibility from the driver's windscreen (paragraph 46) played a direct role in the driver's failure to observe the signal. Drivers are required by the Rule Book[12] to reduce speed if they cannot see signals or lineside indicators soon enough to react to them and there is no evidence that the driver of train 1Z67 felt that his visibility meant that he needed to reduce speed in order to observe this requirement. However, the driver stated that the poor visibility during the journey from Bristol had meant that he needed to focus more intently than usual on his driving tasks. Although the driver stated that this did not distract him, it was evident from witness accounts that the driver felt that there had been an increase in his workload because of the reduced visibility. This higher workload may have made it more likely that the driver would make an error during the journey.

[12] Railway Group Standard GE/RT 8000 Rule Book, Module TW1 'Preparation and movement of trains'.

The driver's workload

70 The RAIB has considered whether the incident could have been avoided had the driver been assisted by a competent person who could have aided him with sighting the signal or otherwise have reduced his workload.

71 Steam operations on the mainline are required to comply with Railway Group Standard GO/RT 3440[13]. This requires that movements involving steam locomotives are crewed with a minimum of a driver and a fireman, in order to mitigate against the absence of safety features such as *drivers' safety* or *vigilance device*. The crewing level of Tangmere met this minimum requirement on 7 March 2015.

72 Witness evidence was that the fireman of train 1Z67 had not been asked by the driver to assist him in sighting signals on the approach to Wootton Bassett Junction and that (apart from briefly crossing to the driver's side of the cab to operate the AWS isolating cock (paragraph 48)) he was fully occupied with firing the locomotive during the incident. The fireman stated that it was not in any case possible to look forwards out of his own windscreen from the firing position and that he was unaware which signals were being passed or the aspect that they were displaying. It is doubtful that, given these circumstances, the fireman would have been able to assist the driver with sighting signals or otherwise have reduced his workload, even had he been asked to do so.

73 GO/RT 3440 also requires train operators undertaking steam movements to assess proposed routes in order to identify signals and lineside signs which may be difficult to see from a steam locomotive's cab. Where signs or signals have been assessed as being difficult to see, train operators are required to provide the driver with additional assistance. This standard states that this assistance can take the form of the fireman or an additional person provided within the cab.

74 West Coast Railways managers stated that they had not undertaken the assessments of the signals and signs required by the standard and that they did not routinely assign an additional person (such as a second driver or a *traction inspector*) to steam movements in order to assist the driver in sighting signals. However, West Coast Railways managers stated that they expected that a fireman would be able to assist a driver with sighting signals, even if they were not required to have the necessary route knowledge (paragraph 37). This was because a driver would normally know when an approaching signal was difficult to sight and would be able to instruct the fireman to assist him as needed.

75 A signal sighting committee convened following the SPAD concluded that neither signal SN43 nor signal SN45 were difficult to sight[14]. Even if other signals on the route taken by train 1Z67 had been assessed as being difficult to see, the preceding paragraph indicates that West Coast Railways would have almost certainly concluded that the fireman was a suitable person to assist the driver. This means that even had the route been assessed by West Coast Railways as required by GO/RT 3440, this would not have resulted in additional staff being available to assist the driver of train 1Z67.

[13] Railway Group Standard GO/RT 3440 'Steam Locomotive Operation', Issue 2, dated October 2009.

[14] The committee noted that having a four-aspect signal placed amongst three-aspect signals may raise an issue of interpretation.

76 West Coast Railways managers stated that, in addition to the driver and fireman, traction inspectors may also be present in the cab during some steam movements, although this would normally only be during activities such as the practical assessment of train crew. West Coast Railways stated that it had, in the past, assigned a traction inspector to all steam movements because this had previously been standard practice within British Rail. Witness accounts and correspondence from former British Rail managers indicated that British Rail assigned traction inspectors to all movements involving steam locomotives for a number of reasons. These included providing technical advice, maintaining safety discipline, managing support crew or owner's representatives who are present in the cab and liaising with external parties, such as station staff.

77 West Coast Railways managers stated that they had discontinued the practice of using traction inspectors on all steam movements some years previously. This was because the company's train crews often operated steam traction and this meant that they were familiar with it. In addition, West Coast Railways managers also stated that they tended to recruit very experienced drivers, who needed less support. This change in the use of traction inspectors was documented in a 2012 risk assessment. Although this risk assessment acknowledged that there was a need to monitor safe operation, ensure footplate discipline and to manage support crew, it concluded that this role could be fulfilled either by a traction inspector, if one was present, or otherwise by the driver. The assessment does not seem to have considered the requirements of GO/RT 3440 with respect to sighting, the effect that placing extra responsibilities on the driver might have had on their workload or if a driver alone would be able to maintain the required safety discipline.

78 Evidence from managers at another operator of mainline steam services was that they continued to appoint traction inspectors to all steam movements. Managers stated that this was effectively a continuation of British Rail practice and intended to meet the same objectives. It was also, however, intended to assist drivers with sighting signals.

79 Because the fireman was occupied with firing and because no other competent person was available in the cab, the driver of train 1Z67 was not assisted in his sighting of signals or in undertaking other driving duties on the approach to Wootton Bassett Junction. Had the driver been assisted by a competent person then it is possible that signal SN43 would have been seen and the incident avoided. It is also possible that having effective assistance could have reduced the driver's workload and thereby decreased the chance of him making an error.

The AWS warning which related to signal SN43

80 The AWS warning relating to signal SN43 did not alert the driver that he had passed signal SN43 and that it was displaying a caution aspect.

81 Once it had passed over the AWS magnet for the TSR (paragraph 47), train 1Z67 passed over the fixed AWS magnet which was associated with signal SN43 (paragraph 51). This signal was displaying a single yellow caution aspect and, as a result of this, the driver received another AWS warning. This warning started around a second after the train passed over the fixed magnet and was acknowledged by the driver within 0.5 seconds (figure 14).

82 OTDR data showed that the driver received a number of visual and audible indicators that he had received a second AWS warning. As well as the warning horn, the AWS visual indicator is recorded as having briefly returned to its 'all-black' indication and the orange flashing light which is connected to the warning horn would also have illuminated. Witness evidence suggested, however, that the driver was unaware that he had received two separate AWS warnings. He instead believed, erroneously, that he had received only a single AWS warning and that this was associated solely with the TSR. This meant that the AWS warning relating to signal SN43 did not alert the driver either that he had passed signal SN43 or that it was displaying a caution aspect.

83 The AWS warning for signal SN43 occurred before the AWS brake demand resulting from the TSR had been by-passed (paragraph 48). It is possible that the driver did not distinguish between the two AWS warnings because he was distracted at that moment by the activity in the cab relating to this brake demand (paragraph 68) or because his workload was higher than normal and this may have made it more likely that he would make an error (paragraph 69).

84 The driver stated that he thought that the warning was associated with a TSR because he had seen a warning board as he received the AWS warning. Analysis of video images showed that the warning board for the TSR had been placed between the fixed AWS magnet for SN43 and the signal itself (figure 5). This suggests that the driver saw it during the second AWS warning, which related to signal SN43 and not to the TSR.

85 The relevant rules and standards relating to TSRs do not allow warning boards to be placed between fixed AWS magnets and the signal to which they apply. Had this rule been correctly observed then it is possible that the driver might have realised that the second AWS warning did not relate to a TSR and that he was approaching a signal showing a restrictive aspect. The rail industry's formal investigation found that the non-compliance with regard to the warning board had not been reported by the drivers of other trains which had passed through the TSR in the preceding months. This may mean that the incorrect placement of the warning board was not found by other drivers to be something which caused them concern or confusion. The design and implementation of the TSR is discussed further as an underlying factor in paragraph 168.

86 As with the sighting of signal SN43 and the driver's workload (paragraph 79), it is possible that the assistance of a competent person (such as a traction inspector) might have been able to alert the driver that he had received two separate AWS warnings and that one of them related to a signal showing a restrictive aspect.

The driver was unaware that he had missed signal SN43

87 **The driver did not realise that he had missed signal SN43 even though it was an important feature of the route on the approach to Wootton Bassett Junction.**

88 Signal SN43 is located on the approach to a busy, high-speed junction. It is therefore an important feature of the route on the approach to Wootton Bassett Junction and one which a driver with adequate route knowledge should have been both looking out for and been aware of having missed.

89 The driver signed his route and traction knowledge card to confirm that he had adequately retained his route knowledge of Wootton Bassett Junction two days before the incident (paragraph 32). He stated that he was satisfied with his route knowledge of the junction on the day of the SPAD and that, while he would expect to be broadly aware of the signals and junctions on a particular route as part of his route knowledge, he would not normally expect to know every signal, unless he worked the route daily. Witness evidence, discussions with managers at West Coast Railways and operational safety files also confirmed that the driver probably had an adequate level of route knowledge of the junction on 7 March 2015. The way the driver acquired his route knowledge and the manner in which it was assessed are discussed further in paragraph 211.

90 Despite probably having adequate route knowledge, witness evidence and the GSM-R call made to the signaller after the SPAD (paragraph 57) indicated that the driver of train 1Z67 was unaware that he had missed signal SN43 on approach to Wootton Bassett Junction. Had he realised that he had missed the signal, he could have reduced the speed of his train accordingly and this may either have avoided the SPAD or reduced the extent of the overrun.

91 There is no clear evidence as to why the driver did not apply his route knowledge effectively on the approach to Wootton Bassett Junction on 7 March 2015, although it may again be the case that he was distracted by the activity in the cab (paragraph 68) or because his workload was higher than normal and this may have made it more likely that he would make an error (paragraph 69).

Discounted factors relating to the driver's reaction to SN43

The status of the signalling system

92 Network Rail undertook wrong-side failure testing of signal SN43 following the SPAD. No fault was found with the signal as a result of this testing. Signalling system monitoring equipment recorded that, as train 1Z67 passed, signal UM85 had been displaying a green proceed aspect, signal SN43 had been displaying a single yellow caution aspect and that signal SN45 had been displaying a red danger aspect.

The effects of drugs, alcohol and prescription medication

93 Railway Group Standard GE/RT8070[15] and its associated guidance require railway companies to immediately test staff for the presence of drugs and alcohol when they are carrying out safety critical tasks (such as train driving) and where their actions may have played a role in a serious incident. This requirement is reflected within West Coast Railways management procedures.

94 Despite these requirements, the driver of 1Z67 was not tested for drugs and alcohol by West Coast Railways following the SPAD. Witness evidence was that this was because the West Coast Railways duty manager on 7 March 2015 was working on his own and was unable to arrange drugs and alcohol testing while also travelling to meet the train and driver and organising other post-incident activities. The driver was subjected to post-incident screening by Colas Rail 11 days after the incident and this test found that neither drugs nor alcohol were present. Although the driver was not tested immediately after the incident, there is no evidence that he was impaired by drugs and alcohol when the SPAD occurred.

[15] Railway Group Standard GE/RT8070, Issue 3, 'Testing Railway Safety Critical Workers for Drugs and Alcohol', December 2012.

95 The driver was taking medication prescribed by his doctor. Witness evidence was that he was suffering no side-effects from this medication that could have impaired his driving. The driver's operational safety files showed that the medication he was prescribed had been discussed during his most recent medical (paragraph 33) and that the doctor examining him had declared that he remained medically fit to drive trains while taking it. The RAIB consulted with an independent competent pharmacist as to the likely effects of this medication on the driver's capability to undertake his duties. The pharmacist confirmed that the driver would have remained fit to undertake his normal duties while taking the medication.

The effects of fatigue

96 West Coast Railways required drivers working for other operators to maintain and submit a record of hours worked for both companies. Analysis based on these records, and on witness evidence regarding the driver's recent working and travelling hours, suggested that when the SPAD occurred, the risk of him being involved in an incident due to fatigue was probably no greater than average and that he was probably also at a relatively low risk of feeling sleepy. There was also no witness evidence that the driver of train 1Z67 was subject to the effects of fatigue when the SPAD occurred.

The effectiveness of the train's brakes compared to their expected performance

97 Following the SPAD, West Coast Railways undertook post-incident testing of Tangmere and reported that its braking systems were found to be functioning correctly. It undertook a post-incident test of the twelve vacuum braked coaches from the train, connected as a set, and reported that the vacuum braking system was also functioning correctly.

98 Because the driver of train 1Z67 was controlling the train using the vacuum brake controller valve (paragraph 45) the brakes on the support coach, which were connected only to the air braking system (paragraph 12), did not contribute any braking force during the full brake application made by the driver as the train approached signal SN45 (paragraph 54).

99 The OTDR channel monitoring the vacuum braking system was not functioning on 7 March 2015 so it has not been possible to precisely measure the braking performance of the train during the incident. However, analysis of OTDR data from other channels showed that, adjusted for the rising gradient, the train's brakes probably achieved an average mean retardation of around 3.6%g[16] during its brake application on approach to signal SN45. This mean retardation is less than the typical braking characteristics of modern trains. The RAIB's investigation into a near miss at Didcot North junction on 22 August 2007 (RAIB report 23/2008), for example, found that the Class 43 High Speed Train involved achieved an average mean retardation of around 9%g following an emergency brake application.

[16] The value of an acceleration (or deceleration) expressed as a percentage of that achieved by a freely falling object, which is taken to be 9.81 m/s².

100 The braking performance of train 1Z67 nevertheless met the requirements of Railway Group Standard GM/RT 2041[17] which requires a minimum retardation of around 3.4%g when braking from 55 mph (89 km/h) when running on lines with signals spaced to accommodate the braking performance of both freight and passenger trains (as was the case on the Great Western Main Line approaching Wootton Bassett Junction). It is of note that a train achieving an average mean retardation of around 3.6%g during braking would not, however, meet the requirements of GM/RT 2041 on lines where signals are more closely spaced (eg on lines where lower maximum permitted line speeds apply to freight trains[18]). Trains with this level of braking performance would only be allowed to operate over such lines if a lower speed restriction was imposed on them.

101 Analysis undertaken by the RAIB shows that, if a train whose brakes just complied with this minimum braking characteristic of 3.4%g had triggered a TPWS brake application at the second OSS at 55 mph (89 km/h) on approach to signal SN45, then it would come to a stand foul of both the Up and Down Badminton lines. This means that a train whose brakes complied with the relevant standards could have come into conflict with movements from the Up Badminton line, had the TPWS system been fully functional. The intended effectiveness of TPWS is discussed further in paragraph 240.

The TPWS system on board Tangmere had been rendered ineffective

102 The TPWS system on board Tangmere was unable to reduce the speed of train 1Z67 so as to prevent it from over-running the signal and Wootton Bassett Junction. This was because TPWS brake demands had been rendered ineffective by the train crew's earlier use of the AWS isolating cock.

103 Following the SPAD, West Coast Railways undertook post-incident testing of Tangmere and reported that its AWS and TPWS systems were found to be functioning correctly.

104 Signal SN45 is equipped with two TPWS OSS (paragraph 8). Train 1Z67 passed the first OSS below its set speed (paragraph 52) but passed the second OSS above its set speed (paragraph 53). OTDR data showed that the combined AWS/TPWS control unit on Tangmere correctly generated a TPWS brake demand on passing the second OSS, which is located approximately 350 metres on the approach to signal SN45.

105 Analysis of OTDR data suggested that the train achieved a braking distance of no more than around 770 metres following the full braking application made by the driver on approach to SN45 (paragraphs 54 and 99). This resulted in the train over-running the signal by 550 metres and coming to stand on both the crossovers and the Up and Down Badminton lines (paragraph 54).

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[17] Railway Group Standard GM/RT 2041 'Braking System Requirements and Performance for Trailer Coaching Stock', Issue 2, April 2000.

[18] Differential speeds of this kind apply on many lines on the former Southern Region where some types of freight train are limited to around two thirds of the maximum permitted line speed.

106 Had the TPWS brake demand made at the OSS resulted in a full brake application, as it should have done, then a similar braking performance would have resulted in a shorter overrun of the signal of around 420 metres. This would have placed the train in a position where it was still foul of the crossovers and possibly also the Down Badminton line. However, the train would have stopped clear of the Up Badminton line and therefore would have not been in conflict with the movement of train 1L76.

107 This indicates that a functioning TPWS system on the train would have removed the possibility of a collision between trains 1Z67 and 1L76. The ability of the TPWS system to apply the brakes had, however, been rendered ineffective because the AWS isolating cock was open, having previously been used by the driver and fireman to by-pass the AWS brake demand resulting from the TSR (paragraph 48). Using the AWS isolating cock in this way was a clear contravention of the relevant rules (paragraph 16).

108 West Coast Railways operational safety files showed that both the driver and fireman of train 1Z67 had been tested for their knowledge of the Rule Book within the required interval (paragraphs 32 and 37). The files also showed that the driver had correctly answered questions regarding the actions to be taken after AWS brake demands during his last test and that both he and the fireman had attended West Coast Railways annual safety briefings in 2014, where the relevant requirements of the Rule Book had been discussed. Witness evidence also confirmed that the driver understood that he was required to bring his train to a stand following an AWS brake demand.

109 The AWS isolating cock was opened in contravention of the relevant rules due to a combination of the following factors:

a) the driver had not acknowledged the AWS warning associated with the TSR within the required period and this caused an AWS brake demand (paragraph 110);

b) the driver did not want the train to come to a stand as a result of the AWS brake demand (paragraph 118); and

c) the driver and fireman had a low perception of the risk of using the AWS isolating cock to by-pass the AWS brake demand (paragraph 121).

Each of these factors is now considered in turn.

The driver's acknowledgement of the AWS warning from the TSR

110 **The driver had not acknowledged the AWS warning associated with the TSR within the required period and this caused an AWS brake demand**.

111 The driver of 1Z67 responded to the AWS warning for the TSR in approximately 4.1 seconds (paragraph 47), around 1.4 seconds longer than the maximum response period that the standards relating to the system allowed. This resulted in an AWS brake demand being generated (paragraph 16).

112 Some form of speed restriction had been present intermittently on the approach to Wootton Bassett Junction since at least November 2013 (paragraph 169). The driver's initial recollection of the events of 7 March 2015 was, however, that he had been unaware of the TSR until the associated AWS warning occurred. The driver subsequently informed the RAIB that he had been aware of the TSR on the day of the incident because he had driven other trains over the junction after speed restrictions had been introduced. Documentary and witness evidence confirmed that the driver had worked trains over the junction during the period concerned (paragraph 213).

113 The driver should also have been aware of the TSR because its details had been published in the relevant *Weekly Operating Notice* (WON) since early January 2015 (paragraph 178). Both the Rule Book[19] and West Coast Railways instructions required drivers to have received and read a copy of the relevant WON and other notices before starting duty. The driver of train 1Z67 stated, however, that although he normally read the WON before starting duty, he could not recall doing so before starting duty on 7 March 2015.

114 Witness evidence was that train crews operating Tangmere sometimes found it difficult to distinguish the AWS warning horn over the relatively high level of ambient noise present in the cab. Witnesses stated that this was a particular issue when the level of ambient noise was increased, for example, if the locomotive was working hard or when the *injectors* were used. Witnesses also stated that most other steam locomotives were fitted with either air or vacuum warning horns which were louder and easier to distinguish than the electronic audible warning indicator fitted to Tangmere (paragraph 14). The audibility of the AWS warning horn is discussed in more detail in paragraph 141.

115 In addition to the AWS warning horn, AWS warnings on Tangmere were signified by an orange flashing light, positioned on the inside of the cab roof, just above the driving position (paragraph 15). Witness evidence was that this flashing light was out of the vision of the fireman when he was positioned for firing and that it was also sometimes out of the vision of drivers, either because the driving position adopted meant that their head was positioned below it or because they were driving with their head out of the driver's side window. There was also witness evidence that the orange flashing effect of the light could on occasions blend in with the light from the *firebox*, if the firebox doors were open.

116 On the day of the incident, some witnesses stated that the AWS warning horn could be heard clearly during both the outbound (paragraph 41) and inbound journeys. There was also evidence from OTDR data that the driver of train 1Z67 acknowledged an AWS warning which occurred after the TSR within the response period allowed (paragraph 81). However, witnesses stated that the cab of Tangmere was relatively noisy on the approach to Wootton Bassett Junction and that the driver had his head out of the driver's side window because of his poor forward visibility (paragraph 46). This driving position almost certainly affected the driver's ability to both hear and see that an AWS warning had occurred. This is supported by the AWS brake demand which occurred earlier in the day, when the driver of 1Z21 failed to acknowledge an AWS warning while driving in a similar position during a propelling movement which took place at a much slower speed (paragraph 46).

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[19] Railway Group Standard GE/RT 8000 Rule Book, Module TW1 'Preparation and movement of trains'.

117 The driver's reduced ability to hear and see that an AWS warning had occurred probably explains why he did not acknowledge the warning associated with the TSR within the required response period.

The driver did not want the train to come to a stand

118 **The driver did not allow the train to come to a stand as a result of the AWS brake demand.**

119 The AWS brake demand resulting from the TSR lasted 59 seconds and should have resulted in train 1Z67 coming to a stand. However the driver did not allow the train to do this and continued onwards. Witness evidence was that this was because he knew that it would take some time to start the train moving again due to it being steam-hauled and that this would probably delay other trains.

120 Witness evidence suggested that the need to avoid delays of this nature (and the associated costs) was a particular concern to train crew operating steam locomotives, possibly due to their knowledge of previous incidents where AWS brake demands had brought steam trains to a stand and caused protracted delays. The incident near to Doncaster station on 2 October 2015 where a fireman by-passed a TPWS brake demand in order to save time (paragraph 250) may provide further evidence that the train crew of steam locomotives were particularly concerned about causing delays.

The driver and fireman's perception of the risk of by-passing AWS demands

121 **The driver and fireman had a low perception of the risks of using the AWS isolating cock to by-pass the AWS brake demand.**

122 Witness evidence regarding the actions of the driver and fireman of train 1Z67 on 7 March 2015 suggested that they had a low perception of the risks of using the AWS isolating cock in order to by-pass the AWS brake demand associated with the TSR (paragraph 48). Witness evidence was that neither the driver nor the fireman fully understood that opening the AWS isolating cock would also effectively disable the TPWS system and this lack of understanding may have in part helped to create this perception.

123 The RAIB spoke to a number of witnesses familiar with the operation of Tangmere who stated that the incident on 7 March 2015 was not the only occasion on which the AWS isolating cock was used to by-pass an AWS brake demand on this locomotive. While some witnesses denied that it had become accepted practice by train crews on Tangmere to do this, others estimated that the isolating cock was used in this way at a frequency which ranged from virtually every journey to two or three times over a period of several years.

124 West Coast Railways provided copies of all of the OTDR downloads available which related to the operation of Tangmere on the mainline railway. Because West Coast Railways was not undertaking routine download and analysis of OTDR data prior to the incident (paragraph 137) this meant that, in addition to the files which related to 7 March 2015, West Coast Railways could only provide downloads of data which covered three additional days when Tangmere was operating on the mainline, prior to the day of the incident.

125 Analysis of this data revealed that the OTDR channels which monitor the vacuum braking system and the use of the AWS isolating cock had not been functioning since at least 26 April 2014. However, analysis of other OTDR channels showed that (once depot and hauling movements were discounted) the AWS isolating cock had been used to by-pass an AWS brake demand on two out of the three days for which data was available.

126 Analysis showed that, on one of the days, the AWS isolating cock was used to by-pass an AWS brake demand on a single occasion. OTDR timings indicated that this occurred while the locomotive was in passenger service. Data from the second day showed two occasions when the opening of the isolating cock allowed AWS brake demands to be by-passed, as well as a further instance where the isolating cock was apparently used to allow Tangmere to run for a short period with both the TPWS and AWS systems fully isolated. OTDR timings indicated that all three of these occurrences took place while the locomotive was in passenger service.

127 Witness evidence indicated that the fireman of train 1Z67 on 7 March 2015 was part of the train crew on some of the occasions when AWS brake demands were by-passed. However witness evidence and the events of 7 March involving train 1Z21 (paragraph 42) clearly showed that this practice also extended to other members of train crew employed by West Coast Railways.

128 West Coast Railways did not know why OTDR downloads had been obtained for the days for which data was available and so it was not clear if it was done due to a concern about the performance of train crew. This means that it is not possible to say if the data analysed was representative of Tangmere's operations as a whole. However, when the results of the data analysis are considered in the context of witness evidence and the events of 7 March 2015, it suggests strongly that the use of the AWS isolating cock to by-pass AWS brake demands was a frequent occurrence on Tangmere and that it had almost certainly become an accepted practice among some train crew operating the locomotive.

129 The use of the AWS isolating cock to by-pass AWS brake demands had probably become accepted because AWS brake demands were a reasonably common occurrence on Tangmere (paragraphs 42, 44, 47 and 124) and because train crews were anxious to avoid the delays which these brake demands could potentially incur (paragraph 119). Witnesses familiar with the operation of the locomotive stated that the reason AWS brake demands occurred on Tangmere in particular was due to the poor audibility of the AWS warning horn (paragraph 114). This is discussed in more detail in paragraph 141.

130 One witness with extensive experience of operating steam locomotives stated that, in his experience, the practice of by-passing AWS brake demands extended to other locomotives operated by West Coast Railways and to other mainline operators of steam locomotives. Although other witnesses suggested that the practice was a particular issue on Tangmere (due to the way that its AWS system was configured) the incident near to Doncaster station in which a fireman working for West Coast Railways by-passed a TPWS brake demand on locomotive 45231 (paragraph 250) suggests that the use of informal practices to by-pass AWS and TPWS brake demands may have extended to West Coast Railways train crews that were operating other locomotives.

131 During its investigation into this SPAD, the RAIB did not find any further evidence (such as reports of specific incidents) that supported the suggestion that train crews employed by other mainline operators of steam locomotives had adopted similar informal practices to by-pass AWS and TPWS brake demands. Although such practices might be detected by techniques such as the large scale analysis of available OTDR data, this was considered by the RAIB to be beyond the scope of its investigation.

Sealing the AWS isolating cock as a preventative measure

132 The vehicle maintenance instruction for Tangmere and the Rule Book both required that the AWS isolating cock was sealed and that the seal be checked before the locomotive entered passenger service (paragraph 21). The fitness-to-run examiner stated that he had applied a numbered red plastic seal to the AWS isolating cock (paragraph 39) and there was uncorroborated witness evidence that he found two broken numbered red plastic seals in the cab during an examination of the locomotive which took place on the night of 7 March 2015. The fitness-to-run examiner took this to indicate that the AWS isolating cock had been opened at some point during the day. However, witness evidence also indicated that the numbers on the seals were not recorded when they were applied. This means it is not possible to say whether or not the seals which the fitness-to-run examiner stated that he found in the cab related to the use of the isolating cock on the day of the incident.

133 Witness evidence from the fireman of train 1Z21 was that the AWS isolating cock was not sealed when he opened it, once the train was in the depot at Bristol (paragraph 43). Although this appears to be inconsistent with the evidence of the fitness-to-run examiner, it is possible that the isolating cock had been opened following the fitness-to-run examination but before the fireman opened it, eg to allow the locomotive to move on the depot with its battery isolated. This might not have been recorded by the OTDR, either because the battery was isolated (which would also turn off the OTDR), or because the OTDR channel which monitors the use of the AWS isolating cock was not functioning (paragraph 43) and the use of the cock was not indicated by other events such as AWS and TPWS brake demands.

134 The absence of a seal on the AWS isolating cock should, however, have been noticed by the driver of train 1Z21. He was required by the Rule Book to check the seal before the train entered passenger service at Southall (paragraph 21), but did not do so because this was not something that he normally checked (paragraph 43). It should also have been checked by the driver of train 1Z67 when the train entered into passenger service at Bristol Temple Meads station. This driver of 1Z67 stated that, in his experience, the isolating cock was never sealed; it is therefore unlikely that the absence of a seal would have struck him as being noteworthy on this occasion.

135 Witness evidence from most of the other train crew familiar with Tangmere was also that they had never seen a seal applied to the AWS isolating cock. One witness familiar with the locomotive suggested that, although seals had been applied in the past, they were frequently broken because the isolating cock needed to be used when Tangmere was to be hauled by another traction unit (paragraph 20).

136 The balance of the preceding evidence suggests that, while individual fitness-to-run examiners may have sealed the AWS isolating cock, these seals were removed as a matter of routine and their removal was therefore not investigated. Had seals been applied to the AWS isolating cock in a way that meant that their removal was traceable, and had West Coast Railways investigated the reasons why a particular seal had been removed, then it is possible that at least some uses of the isolating cock to by-pass AWS brake demands would have been detected and could have been addressed. This might have prevented the inappropriate use of the isolating cock from becoming accepted practice amongst some train crew operating Tangmere.

Use of OTDR to monitor driver actions

137 Issue 1 of Railway Group Standard GM/RT 2472[20], which was in force at the time of the incident, requires an OTDR to be fitted to all trains operating on the mainline railway. The standard requires OTDR data to *'…permit frequent and systematic safety monitoring as a means of preventing incidents and accidents*'. GM/RT 2472 is supported by good practice guidance[21] issued by the Association of Train Operating Companies (ATOC). This states that operators should consider making provisions within their competency management arrangements to use OTDR data to monitor train crew performance and that, as a minimum, there should be at least one OTDR download analysed within each driver's assessment cycle[22]. The analysis should then be used to provide feedback to drivers on their driving performance and operation of train systems.

138 West Coast Railways managers stated that the company did not routinely use OTDR data to monitor driver performance and that it was used only as part of investigating incidents or accidents. West Coast Railways management procedures suggested that use of OTDR data for routine monitoring was complicated by the need for reviewers to be able to determine locations and the operating context. Witness evidence also suggested that the company had only limited facilities for downloading and analysing OTDR data and it is likely that both of these reasons combined led to the absence of routine OTDR data analysis.

139 Although the OTDR channel which monitors the use of the AWS isolating cock was not functioning (paragraphs 43 and 231), analysis undertaken by the RAIB showed that it was still possible to use OTDR data to find occasions when the isolating cock had been used to by-pass AWS brake demands (paragraph 125). Had West Coast Railways routinely used OTDR data to monitor driver performance, it is likely that at least some of the uses of the AWS isolating cock to by-pass AWS brake demands would have been detected by the company and so could have been addressed. This may also have prevented it from becoming accepted practice amongst some train crew operating Tangmere.

[20] GM/RT 2472 'Data Recorders on Trains – Design Requirements', Issue 1, June 2002.

[21] ATOC/GN001 'Use of Data Recorders', Issue 4, August 2012.

[22] The guidance states that this monitoring primarily relates to drivers but may also consider other train crew.

140 Using the AWS isolating cock to by-pass AWS brake demands was a clear contravention of the relevant rules (paragraph 16). One of the original goals of appointing traction inspectors was to enforce footplate and safety discipline (paragraph 77). Assuming that the traction inspectors were effective at enforcing safety discipline, it is probably the case that continuing the practice of appointing a traction inspector to every steam movement would also have prevented the use of the isolating cock to by-pass brake demands from having become an accepted practice. This is supported by witness evidence, which suggested that it was unlikely that train crew would have used the isolating cock inappropriately, had a traction inspector been present.

Identification of underlying factors

The AWS system on Tangmere

141 **The way that the AWS system on Tangmere was designed and installed meant that AWS warning horns were not always audible to drivers and that the AWS system did not meet the requirements of the relevant standards. In addition, the AWS isolating cock was in a position which was accessible to train crew when the train was moving. Despite this, the AWS system was certified as being compliant to the relevant standards. This permitted the locomotive to enter and remain in service with a non-compliant AWS system.**

142 As part of its restoration, Tangmere was fitted with AWS and TPWS equipment by Riley and Son between 2001 and 2004 (paragraph 14). The manager responsible for the restoration stated that exact details of how the work was carried out were not known because the relevant records were transferred to the new owner when Tangmere was sold (paragraph 25). Neither CRRES, the other companies involved in the restoration, nor the new owner were able to provide a full copy of the relevant records, although the RAIB was able to obtain some documents from the companies and individuals involved. These included Conformance Certification Body (CCB) and Vehicle Acceptance Body (VAB) records from Resco (paragraph 28).

143 At the time that AWS and TPWS were installed on Tangmere, the requirements for AWS systems were specified in Railway Group Standard GE/RT 8035[23] with the requirement for the acceptance of vehicles by CCBs and VABs being specified in Railway Group Standard GM/RT 2000[24]. Additional requirements relating to the acceptance of steam locomotives were specified in Railway Group Standard GM/RT 2003[25].

[23] Railway Group Standard GE/RT 8035 'Automatic Warning System', Issue 1, October 2001.

[24] Railway Group Standard GM/RT 2000 'Engineering Acceptance of Rail Vehicles', Issue 2, October 2000.

[25] Railway Group Standard GM/RT 2003 'Certification Requirements for Registration of Steam Locomotives', Issue 1, December 1996.

The design and certification of the AWS system

144 Evidence was not consistent as to who was responsible for the design of the AWS and TPWS systems. Managers at Riley and Son stated that the design had been undertaken by Resco. However, a witness who worked for Resco on this project stated that Resco's involvement was restricted only to its role as the CCB and VAB. There was also witness evidence that, because the installation of AWS and TPWS on Tangmere was closely based on that fitted to other locomotives, detailed design documents were not required or produced.

145 Riley and Son stated that they selected National Railway Supplies (NRS) to supply the TPWS and AWS equipment for all of the locomotives which they owned. The equipment was tested using a steam locomotive, initially during operations on a heritage railway and then during mainline movements. Riley and Son stated that it became apparent during this testing that the AWS warning horn generated by NRS' electronic audible warning indicator could not always be heard by drivers over the ambient noise in the cab. For this reason, a trial audible warning indicator with a louder tone was produced by NRS and an orange flashing light was also installed and connected to the warning horn (paragraph 14). This arrangement was subsequently adopted for use in other steam locomotives, including Tangmere.

146 The installation of TPWS and AWS equipment onto Tangmere was completed in January 2003. Photographs within Resco's design scrutiny records show that the AWS audible warning indicator unit was installed just behind the driving position (figure 15). Witness evidence was that this position was chosen as it was thought to be as close to the driver as possible. The position of the orange flashing light was not discussed in the design scrutiny records, although there is no evidence that it was ever installed in any position other than where it was located when the incident occurred (paragraph 14).

147 The technical specifications for the AWS audible warning indicator state that it was required to produce warnings with a sound level of between 90 and 95 dB(A). Witness evidence was that these units were generally produced by manufacturers to meet the requirements of GE/RT 8035 (which mandated an upper limit of 95 dB(A) (paragraph 153)) and this suggests that it was unlikely that a unit of this kind could have been purchased which produced louder warnings. Witness evidence was also that it was not possible to modify the NRS units to further increase their volume, due to technical limitations.

148 The RAIB undertook measurements of the ambient noise in the cab of another steam locomotive operating on the mainline. These measurements showed that the ambient noise in the cab with the steam shut off was between 83 and 85 dB(A) increasing to between 89 and 91 dB(A) when accelerating and to between 90 and 91 dB(A) when the injectors were in use. West Coast Railways undertook measurements on Tangmere which returned broadly similar results.

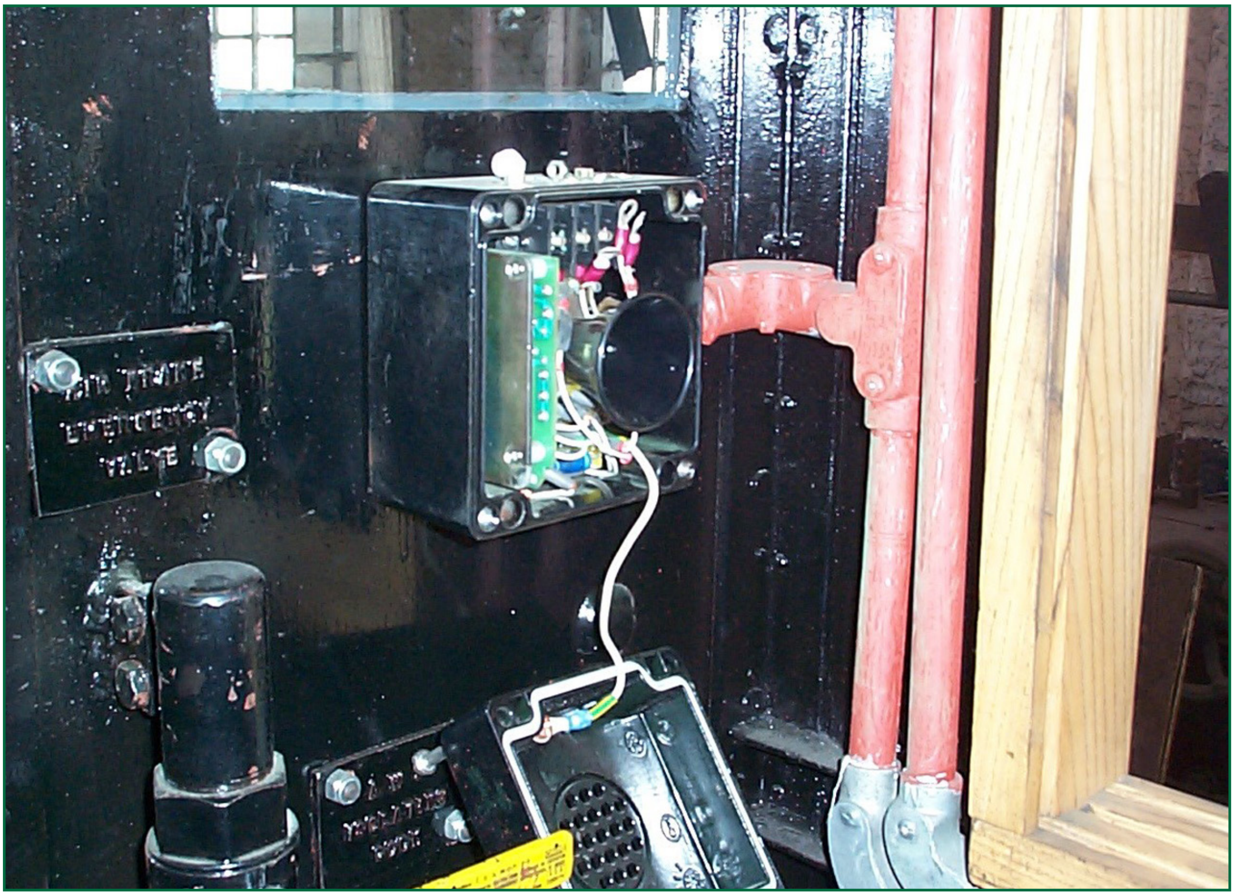

Figure 15: The AWS audible warning indicator unit fitted to Tangmere during its restoration (photograph courtesy of Resco Railways)

149 At the time that Tangmere's AWS system was installed, there was no requirement in GE/RT 8035 for the sound level of AWS warnings to be above ambient noise levels by a specified amount. However, later standards require warnings to have a sound level of between 6 dB(A)[26] and 10 dB(A)[27] above the expected level of ambient noise and RSSB's Good Practice 'Guide for the design of alarms and alerts'[28] states that audible alarms should generally be at least 15 to 25 dB(A) above ambient, in order to ensure that they are not missed.

150 Adopting even the lowest of this range of audibility requirements suggests that the warnings which were produced by the AWS audible warning indicator fitted to Tangmere would have been at risk of being missed in noise conditions which were a routine part of steam locomotive operations.

151 Resco's design scrutiny records stated that the electronic unit replaced an existing vacuum-operated AWS warning horn which was fitted to Tangmere as part of the earlier British Rail AWS system (appendix C). However, the manager responsible for the restoration at Riley and Son stated that Tangmere had no AWS equipment fitted when the restoration started and that a vacuum-operated AWS warning horn would not have been subsequently fitted because it was a scarce and high-value item.

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[26] 'Technical specification for interoperability relating to locomotives and passenger rolling stock' (LOC& PAS TSI).

[27] Railway Group Standard GE/RT 8075 'AWS and TPWS Interface Requirements', Issue 2, March 2015.

[28] J. Edworthy, E. Hellier, J. Noyes, K. Aldrich, A. Naweed, B. Gall, R. Metcalfe 'Good Practice Guide for the design of alarms and alerts', RSSB, 2008.

152 Witness evidence also suggests that an electronic unit was used in order to ensure that the system installed on Tangmere met the relevant standards as closely as possible. Measurements taken by the RAIB of the sound levels produced by an older pattern of air-operated AWS warning horn show that this would have breached the 95 dBA limit specified in GE/RT 8035 and it is likely that a vacuum-operated AWS horn would have done the same. Given the desire that the AWS system on Tangmere comply as closely as possible with the relevant standards, it seems likely that an electronic audible warning indicator would have been fitted on Tangmere as part of the restoration, regardless of the status of any pre-existing AWS equipment.

153 GE/RT 8035 stated that:

> '*Each driving cab shall be fitted with an AWS audible indicator that is capable of providing a 'warning' indication... These… indications shall…Have a sound level of 90-95 dBA at a distance of one metre from the front of the equipment, measured as installed in the driving cab…* [and] *be audible from all applicable driving positions and in all driving conditions…*'

154 As with all steam locomotives operating on the mainline, Tangmere is subject to a *derogation* from a substantial number of railway group standards, due to its status as a heritage vehicle. However, RSSB records confirmed that Tangmere is not the subject of a derogation or non-compliance authority for this particular requirement of GE/RT 8035.

155 Resco's design scrutiny of the installation of TPWS and AWS on Tangmere was completed in early February 2003. A commentary document written by Resco's design scrutineer stated that the AWS warnings generated by the audible warning indicator met the sound level requirements in GE/RT 8035 but that they were '… *not considered sufficiently loud to be audible under certain driving conditions'* and that '*… therefore a visual indicator light has been fitted that will flash when the horn sounds*'. Despite this apparent acknowledgement that the AWS warnings were not sufficiently audible, the commentary document shows that the scrutineer found that the AWS system complied with the audibility requirements of GE/RT 8035.

156 The design scrutineer responsible for finding the system compliant stated that, at the time the scrutiny was undertaken, there was only limited experience of how the NRS AWS system performed in operational conditions on steam locomotives and that Tangmere's AWS system had not then been tested with the locomotive in steam. This had meant that there was insufficient evidence for him to make a finding of non-compliance regarding audibility and that the remarks he had made in the commentary document had only represented his opinion.

157 This statement suggests that the AWS warnings on Tangmere were found to comply with the audibility requirements of GE/RT 8035 without there being any clear evidence to show that they were compliant. The finding that the system was compliant would also appear to be inconsistent with the available witness evidence, the design scrutiny records and statements made by managers at Riley and Son (paragraph 145), all of which showed that there was an existing awareness of the issues with AWS warning audibility and that the orange flashing light had been fitted to address this.

158 The design scrutineer stated that he also would have expected any issues with AWS warning audibility to have been reported to Resco as part of the *product acceptance* trial of a number of TPWS and AWS components fitted to Tangmere. These trial components, which included the louder AWS electronic audible warning indicator developed by NRS (paragraph 145), were being used under a certificate of authority for product trial. This certificate allowed the use of the components provided certain conditions were met and was re-issued periodically in order to allow them to be fitted to additional vehicles and to extend the duration of the trial.

159 A copy of the certificate of authority for product trial which was in force when the TPWS and AWS equipment was fitted to Tangmere was not held by Network Rail and did not form part of the records recovered by the RAIB (paragraph 142). However, copies of later issues of the certificate were available and these stated that the conditions for the trial were as follows:

- assurance was to be provided to the VAB that the installation and location of indicators provided clear visual and audible information to train crew;
- a *driver standards manager* sufficiently familiar with the route was to accompany the first operation of any vehicle fitted with the equipment in order to monitor the operation of TPWS and AWS equipment; and
- a traction inspector was to accompany steam locomotives throughout the period of the trial in order to monitor the operation of TPWS and AWS equipment.

160 Although the design scrutiny records recovered by the RAIB made reference to the certificate of authority for product trial, there is no evidence that these conditions were taken into account by the design scrutineer when he confirmed compliance to the audibility requirements of GE/RT 8035. In addition, while the condition regarding the presence of a traction inspector was included on later Certificates of Conformance for Vehicle Design and Certificates of Engineering Acceptance there was no requirement on these certificates for issues of audibility to be reported to the VAB or CCB and the condition relating to the traction inspector was removed once the components received product acceptance from Network Rail in 2004.

The audibility of the AWS warning horn in service

161 There was witness evidence that train crews operating Tangmere sometimes found it difficult to distinguish the AWS warning horn above the relatively high level of ambient noise present in the cab (paragraph 114) and that this issue was long-standing and had been reported by train crews to operations managers. Because of these reports, CRRES moved the AWS audible warning unit to a position closer to the driver in 2013. This was its position at the time of the incident (figure 8). Although this change may have made the AWS warning horns more audible to drivers, witness evidence and the fact that drivers continued to experience AWS brake demands after 2013 (paragraphs 42, 44, 47 and 124) suggests that the change was not effective at addressing the underlying audibility issue.

162 West Coast Railways' management procedures require all modifications made to vehicles operated by the company to be subject to a level of scrutiny and acceptance which is commensurate with the assessed risk. The relevant procedure states that it will be West Coast Railways' policy to use the process outlines in GM/RT 2000 (issue 3 of which was in force when the procedure was issued). This requires any engineering change being made to a vehicle in an area covered by a mandated standard (such as AWS) to be subject to design scrutiny and engineering acceptance. Witness evidence was that the change was not subject to either process.

163 A comparison of figures 8 and 15 suggests that the audible warning indicator fitted during the 2001 restoration had also been changed for another design of unit at some point, although there are no records to suggest when this might have occurred or if the change was subject to scrutiny or acceptance. Managers at West Coast Railways stated that they thought that the audible warning indicator which replaced that originally fitted was a standard AWS component which they understood had a sound output level of 94 dBA. This suggests that its performance was probably comparable with the warning indicator originally installed during the restoration.

The position of the AWS isolating cock

164 The events of 7 March 2015 demonstrated that the AWS isolating cock was easily accessible to train crew while the train was moving (paragraph 48). This may have contributed to it becoming accepted practice to use the isolating cock to by-pass AWS brake demands (paragraph 129). Resco design scrutiny records state the AWS isolating cock was installed in this position for the sake of standardisation with other similar locomotives, such as 34027 'Taw Valley'.

165 GE/RT 8035 stated that:

> *'…Each vehicle shall be fitted with an AWS isolation device to enable the trainborne AWS equipment to be isolated. This shall not be located where the driver can operate it from a driving position...'*.

This requirement appears to be a preventative measure against the potential misuse of AWS isolating devices by drivers.

166 Although the position of the AWS isolating cock on Tangmere is close to the driver's seat, its location near to the cab floor plates means that the driver would need to move from the driving position to open it. However the events of 7 March 2015 demonstrated that a second person, such as the fireman, could quickly and easily access the isolating cock while the train was moving (paragraph 48). This was not accounted for in GE/RT 8035, which probably did not consider the possibility of there being a misuse of AWS isolating devices which would involve multiple members of train crew.

167 In its role as the CCB, Resco considered if the position of the AWS isolating cock was compliant with GE/RT 8035. The design scrutiny records note that the position of the cock is to the rear of the driving position and go on to state that '*All steam locomotives normally operate with a "footplate inspector" on board, the cock is fitted with a wire seal*'. It appears that the position of the cock was found to conform to the requirements of the standard on this basis. However by 7 March 2015 West Coast Railways no longer ran steam movements with a traction inspector (paragraph 76) and the AWS isolating cock was not being effectively sealed (paragraph 132).

The design and implementation of the TSR

168 **The TSR in force on the approach to Wootton Bassett Junction was based on an earlier emergency speed restriction. However, the design of this emergency speed restriction was based on incorrect information. This ultimately resulted in the warning board for the TSR being placed between the fixed AWS magnet for signal SN43 and the signal itself, even though this was not permitted by the relevant standards. Opportunities to correct this error during implementation of the TSR and ESR were also missed.**

169 The 85 mph TSR on the up main was originally imposed in early January 2015 as an *emergency speed restriction* (ESR) by a manager working for Network Rail's Swindon Maintenance Delivery Unit (MDU) following reports of poor track quality. The design used for the ESR had originally been provided in November 2013 for an ESR relating to a previous track problem at the same location.

170 The 2013 ESR design was undertaken on behalf of Swindon MDU by URS (now Aecom) who have a contract to design all of the speed restrictions for Network Rail's Western route. Managers at Aecom stated that the design had been prepared following a verbal instruction from a manager at Swindon MDU and that they had used the *sectional appendix*, Network Rail signalling diagrams and relevant rules and standards to prepare it. Network Rail managers stated that Swindon MDU does not have staff qualified to design speed restrictions, or to check designs prepared for them by third parties.

171 Managers at Aecom stated that the initial intent of the 2013 ESR design was to place all of the warning equipment needed between signals SN43 and SN45. However, an ESR requires two portable AWS magnets (one for the warning board, as with a TSR, and one for the *emergency indicator*, which is required by an ESR but not by a TSR). The design also had to ensure that there was at least four seconds of running time between the AWS magnets (paragraph 179) which the designers assumed would equate to a distance of 12 *chains* (241 metres). The combination of these requirements meant that the portable AWS magnet required for the emergency indicator would have had to have been positioned between the fixed AWS magnet for SN43 and the signal. As this was not permitted by the relevant rules and standards[29], the whole design was moved upwards in mileage (ie towards Chippenham) so that the warning equipment would be installed on the approach to signal SN43. The intention was that the warning board would now be positioned at the fixed AWS magnet for SN43 and therefore be compliant to the relevant rules.

[29] Railway Group Standards GE/RT 8000 Rule Book, Module SP 'Speeds' and GK/RT 0075 'AWS and TPWS Interface Requirements', Issue 1, September 2013.

172 Aecom stated that the position of signal SN43 was given on signalling diagrams as being 83 miles 54 chains. As there was no annotation on the diagrams to suggest otherwise, the fixed AWS magnet was assumed to be at the standard distance of 180 metres on approach to the signal[30]. Aecom tried to confirm this by scaling off the signalling diagram; this suggested that the fixed AWS magnet was positioned somewhere between 180 and 200 metres from the signal. Aecom used the higher of the two figures in the design and this should have meant the warning board was placed at the position of the fixed AWS magnet, around 200 metres on approach to SN43.

173 Analysis of OTDR data and video images shows that signal SN43 is actually situated around 12 metres closer to the junction than was assumed in the design. The analysis also showed that the fixed AWS magnet for SN43 is installed at a non-standard distance of almost 280 metres on the approach to the signal. This meant that the ESR design inadvertently positioned the warning board around 212 metres on approach to the signal and in a position where it would be in-between the fixed AWS magnet and SN43 (figure 16). Positioning the warning board between the fixed AWS magnet and the signal meant that the design did not comply with the relevant rules and standards (paragraph 85).

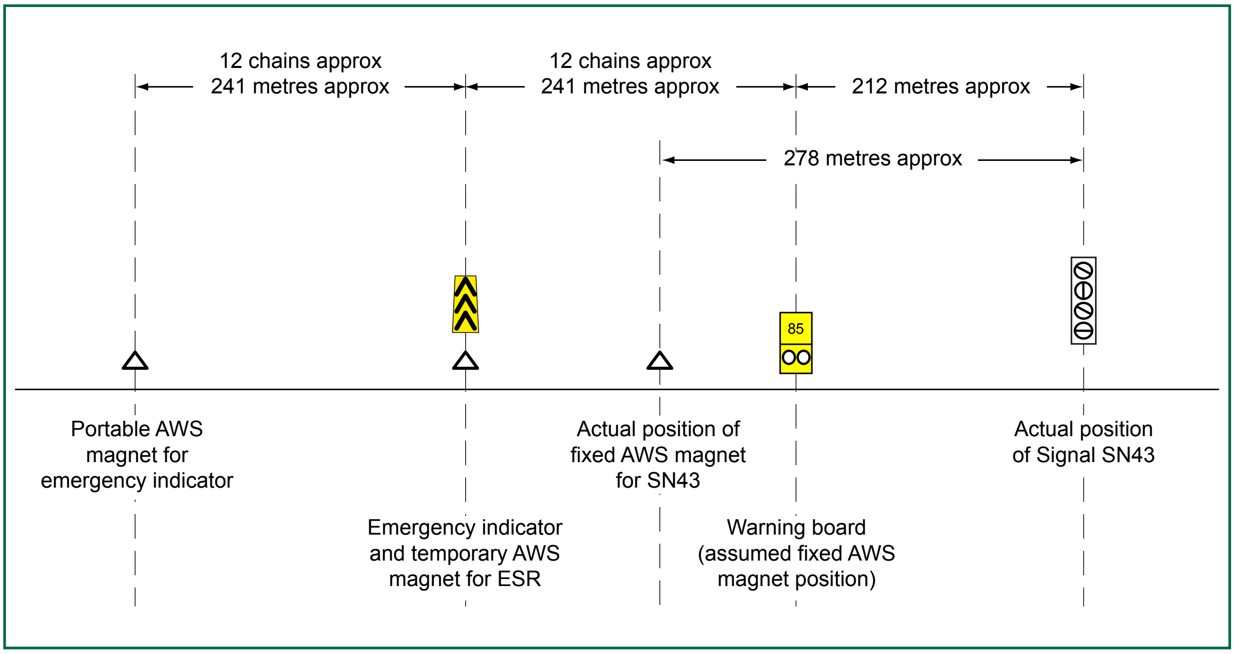

Figure 16: ESR arrangements

174 Network Rail were unable to confirm why the fixed AWS magnet for SN43 was at a non-standard distance. British Rail signalling alteration documents showed that it had been installed at this position in 1978, but did not say why a longer distance was needed and the relevant information was not contained in any of the other available records.

[30] AWS magnets are normally fitted around 180 metres on the approach to any colour light signal which can display a restrictive aspect and to semaphore distant signals. Depending on the maximum permitted line speed and the date that the AWS equipment was initially installed, this distance can be extended up to 230 metres.

175 A second option permitted by the rules was for the ESR designers to have placed the warning board at signal SN43 itself. The AWS equipment for the signal could then have been disconnected to ensure that it always gave a warning to approaching trains, thus removing the need to install a portable magnet. Managers at Aecom stated that this option was not used as Network Rail discouraged it, because signalling engineers would be required to attend and also because Network Rail preferred, if possible, not to disturb AWS track equipment.

176 The 2013 ESR design was followed shortly afterwards with a design for a TSR, which Aecom sent to Network Rail. This placed the warning board and the portable AWS magnet for the TSR between signals SN43 and SN45 and complied with the relevant rules.

177 When an ESR was required again in January 2015, track engineering staff working for Swindon MDU re-used the 2013 ESR design without making any changes. Analysis of OTDR data and video images suggest that when the warning board and portable AWS magnet were installed in January 2015 as part of the ESR, they were positioned close to the position specified in the 2013 ESR design. However track engineering staff placing the warning board were unable to see where it was in relation to the fixed AWS magnet for SN43 because it was dark when they installed it. This meant that they were unaware that the warning board had been placed in a non-compliant position.

178 The ESR was converted to a TSR on 17 January 2015, when it was published in the WON. However, although there was a compliant TSR design available, Network Rail managers at Swindon MDU stated that staff were unaware of this and that the ESR had been converted to a TSR by removing the emergency indicator and its associated portable AWS magnet. No other changes were made and this meant that an opportunity to correct the non-compliant position of the warning board was missed.

The position of the AWS magnets

179 The Rule Book and other railway group standards relating to TSRs require there to be at least 4 seconds of running time at the maximum permitted line speed between portable AWS magnets and other fixed AWS magnets. For the up main line on approach to Wootton Bassett (which had a maximum permitted line speed of 125 mph (201 km/h)), this should have meant that the portable AWS magnet for the TSR was situated at least 223 metres from the fixed AWS magnet for signal SN43.

180 This general requirement for there to be at least 4 seconds of spacing between AWS magnets, combined with the 2.7 seconds that drivers of Tangmere have to respond to AWS warnings (paragraph 16) should have meant that there should always be at least 1.3 seconds between a driver on this locomotive acknowledging one AWS warning and the start of the next one.

181 The design of the speed restriction placed the AWS portable magnet for the TSR around 170 metres on approach to the AWS fixed magnet for SN43 (figure 5). This was approximately 50 metres less than the minimum spacing required because the TSR design had assumed the wrong position for the fixed AWS magnet (paragraph 172). This shorter distance reduced the running time at maximum line speed between the two AWS magnets to just over 3 seconds.

182 On 7 March 2015, Tangmere approached Wootton Bassett Junction at 59 mph (95 km/h), just under half of the maximum permitted line speed (paragraph 47). This lower speed meant that there was around 6.5 seconds of running time between the two AWS magnets for Tangmere. There should have therefore been at least 3.8 seconds between acknowledging one warning and the next starting (ie allowing for the 2.7 second response time). OTDR data showed, however, that only around 2.5 seconds separated the ending of the first warning and the starting of the second on 7 March 2015. This was because the driver did not acknowledge the first AWS warning within the permitted response period (paragraph 47). Had the two AWS magnets been at the correct minimum spacing then this would have increased the time between the two AWS warnings received by the driver to around 4.5 seconds, even allowing for the driver's late response to the first warning.

183 The signal sighting committee convened following the incident (paragraph 75) considered that this reduced running time between the two magnets, combined with the incorrect position of the warning board (paragraph 85) may have distracted the driver on his approach to signal SN43. However, although the interval between the AWS warnings was shorter than it would have been had the minimum spacing been observed, the 2.5 seconds the driver received was still almost double the 1.3 second minimum interval required for locomotives such as Tangmere by the relevant rules and standards. For this reason the reduced distance between the two AWS magnets and the consequent reduced interval between the AWS warnings is not considered by the RAIB to be a factor in the incident.

The safety culture at West Coast Railways

184 **West Coast Railways had a weak safety culture when the incident occurred. This affected how its staff complied with the requirements of the Rule Book, relevant railway group standards and the company's safety management system.**

185 Safety culture can be said to be '*…the way safety is perceived, valued and prioritised in an organisation. It reflects the real commitment to safety at all levels in the organisation*'[31]. Safety culture is a function of the awareness of employees and their understanding, attitudes, perceptions and beliefs in relation to safety. Organisations with a strong or positive safety culture are '*…characterised by communications founded on mutual trust, by shared perceptions of the importance of safety, and by confidence in the efficacy of preventative measures*'[32].

186 In broad terms, having a strong safety culture will help to ensure that the arrangements in a safety management system are observed and that the system itself is developed and improved. An organisation with a weak or negative safety culture is likely to see the inverse effect and this may manifest itself in behaviour such as adopting informal practices, cutting corners, or making unsafe decisions or judgements.

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[31] 'Safety Culture in Air Traffic Management A White Paper', European Organisation for the Safety of Air Navigation, December 2008 and Safety Culture in ATM – An overview, European Organisation for the Safety of Air Navigation, December 2008

[32] M. Fleming, 'Safety Culture Maturity Model, Offshore Technology Report', The Health and Safety Executive, 2000.

187 The RAIB's investigation has found that staff working for West Coast Railways did not effectively implement the requirements of the Rule Book, relevant railway group standards and the company's safety management system on a number of occasions. These included:

- two members of the support crew were present in the cab of Tangmere when the incident occurred, although only one was permitted (paragraph 61);
- the driver of 1Z67 was not tested for drugs and alcohol immediately following the incident (paragraph 100);
- the driver could not remember reading the WON on 7 March 2015 (paragraph 112);
- it had probably become an accepted practice for some train crew to use the AWS isolating cock to by-pass AWS brake demands (paragraph 128);
- the drivers of trains 1Z21 and 1Z67 did not check that a seal was applied to the AWS isolating cock before entering their trains into passenger service (paragraph 129);
- AWS isolating device seals were being removed and their removal was not being investigated (paragraph 136);
- AWS warnings were not audible in the cab on Tangmere and this was not effectively addressed (paragraph 161);
- the change to the position of the AWS audible warning indicator on Tangmere was not subject to the required scrutiny or approval (paragraph 162); and
- OTDR equipment on locomotives being operated by the company was not being maintained in accordance with the requirements of GM/RT 2472 issue 1 (discussed as an observation, paragraph 231).

The number of occasions when the requirements of relevant rules, standards and the safety management system were not observed and the gravity of some of the non-compliances found strongly suggest that West Coast Railways had a weak safety culture when the incident at Wootton Bassett Junction occurred.

188 A 2014 internal audit undertaken by West Coast Railways stated that the company employed just over 100 train crew, of which around half were qualified to work on steam movements. It also employed six traction inspectors and five further staff who were categorised as operations or train crew managers, many of whom could also act as traction inspectors and continued to work as train crew. Witness evidence was that almost all of the train crew employed by West Coast Railways worked for them either part-time or on the basis of a zero-hours contract.

189 Although there was evidence that West Coast Railways train crew attended annual safety briefings and were also subjected to practical assessments (paragraph 31) the flexible working patterns used by train crew, coupled with the absence of adequate arrangements to ensure that they were subject to routine fitness-for-duty checks (paragraph 224), meant that train crew only had face-to-face contact with their managers during assessments or if the manager concerned happened to form part of a train's crew with them. The relatively infrequent nature of face-to-face contact meant that the opportunities available for managers to monitor staff and to reinforce safety discipline were reduced and this may have weakened the safety culture within the company.

190 Conclusions regarding West Coast Railways' safety culture can also be drawn from an earlier incident. On 12 July 2014, a West Coast Railways steam charter train was involved in a lineside fire on the approach to Bell Busk on Network Rail's London North Eastern route. As a consequence of this incident, Network Rail suspended West Coast Railways steam services on this route, on the grounds that the operator had breached the safety obligations in the track access contract which existed between the two companies. Network Rail stated that, as a result of this incident and a subsequent investigation, it had general concerns about West Coast Railways' safety management system and how it was applied. West Coast Railways disputed this decision to suspend access, which was subsequently referred to the *access disputes committee* for adjudication.

191 In October 2014, the adjudicator considering the dispute determined[33] that Network Rail had been justified in suspending West Coast Railways' operation of steam services on the route. The adjudicator also found that Network Rail had reason to be concerned about the way that West Coast Railways' safety management system had been implemented and that the Chairman of West Coast Railways had issued an instruction to his staff which effectively breached the requirement in The Railways and Other Guided Transport Systems (Safety) Regulations 2006[34] (ROGS) for *transport operators* to co-operate with each other regarding the safe operation of the railway. If negative behaviours relating to safety extended to the leadership of the West Coast Railways organisation, as this suggests they had done, then this was likely to have been particularly damaging to the development of a strong safety culture within the company.

West Coast Railways safety management system

192 The relationship between safety culture and the safety management system is one of interdependency ie while a strong safety culture will reinforce a safety management system, the lack of a well-developed safety management system in an organisation is likely to inhibit the growth of a strong safety culture.

193 Due to its status as a *transport undertaking* West Coast Railways is required by ROGS to have a safety management system which complies with the requirements of the regulations. A safety management system in this context refers to the organisation and arrangements made by a company to ensure that it is safely managing its activities (eg that it is observing the appropriate safety rules and adequately controlling any risks arising from its operations). As transport undertakings, train operators are required to submit general details of their safety management system to the safety authority (in this case, the Office of Rail and Road (ORR)) as part of their application for a *safety certificate*, which they are required to hold before they can operate on the mainline railway. Transport undertakings are required to monitor the effectiveness of their own safety management systems during operations.

[33] The full text of the adjudicator's determination is available from http://www.accessdisputesrail.org/New%20ADC%20Web/Access%20Dispute%20Adjudications/ADA20%20Documents/ADA20%20determination.pdf.

[34] The Railways and Other Guided Transport Systems (Safety) Regulations 2006 as amended by the Railways and Other Guided Transport Systems (Safety) (Amendment) Regulations 2011 and the Railways and Other Guided Transport Systems (Miscellaneous Amendments) Regulations 2013.

194 As part of its investigation, the RAIB examined a number of the policies, management procedures, work instructions and risk assessments which formed West Coast Railways' safety management system. As a result of this examination the RAIB found that West Coast Railways' safety management system did not incorporate adequate arrangements in relation to:

- the identification of signals and lineside signs which may be difficult to see from a steam locomotive's cab, as is required by the relevant railway group standard (paragraph 74);
- the routine use of OTDR data for the purposes of systematic safety monitoring or to monitor driver performance, in line with the provisions of the respective railway group standard and industry guidance (paragraph 138);
- the incorporation of industry best practice regarding the acquisition and retention of route knowledge by drivers (discussed as an observation, paragraph 211); and
- the routine checking of train crew to ensure that they had the correct equipment and were fit for duty (discussed as an observation, paragraph 224).

195 As part of his determination, the adjudicator considering the suspension which followed the July 2014 lineside fire required West Coast Railways to make changes to its safety management system. In order to provide advice and guidance as to the changes required, a senior safety manager from Network Rail headquarters reviewed sample documents from West Coast Railways' safety management system in conjunction with managers at the company. This review, which was completed in January 2015, identified that improvements could be made in several areas, including the use of OTDR data to monitor driver performance. The senior manager from Network Rail involved in the review concluded that, although there were issues with West Coast Railways' safety management system, they were not serious enough to warrant again suspending track access.

196 The RAIB's investigation has found that the improvements identified during this review had not been actioned prior to the incident (paragraphs 138 and 194). This was probably because there were only a few months between the review ending and the incident occurring and this was insufficient time for the changes to be implemented. However, the need for the involvement of an external party to identify that these changes were required suggests that West Coast Railways' safety management system was not being developed proactively by the company's managers prior to the incident. This lack of a proactive approach may have been a further factor that led to the safety culture within the company becoming weakened. Further evidence indicating that the company did not have a proactive approach to its safety management system is discussed in paragraph 200.

197 Following the incident, the ORR notified West Coast Railways that it was considering using powers under ROGS to revoke its safety certificate. Following a consultation period, one of the ORR's conclusions was that West Coast Railways had an inadequate appreciation of the need for an appropriate safety culture. This is discussed further in paragraph 276.

The role of the safety authority prior to the incident

198 The ORR undertook an inspection of West Coast Railways between July 2011 and March 2012. This inspection focused on how the parts of the company's safety management system relating to driver management complied with the requirements of ROGS. As part of the inspection the ORR undertook interviews and meetings with West Coast Railways staff, reviewed relevant documents and data and also attended one of the company's annual safety briefings.

199 The findings of the inspection were evaluated using the ORR's Railway Management Maturity Model (RM3). RM3 assessments compare an organisation's management systems against set criteria. The ORR regard an RM3 assessment as providing an indication of an organisation's progress towards excellence in safety, with the level of progress achieved being expressed against a five point scale.

200 The ORR's report of this inspection was provided to the RAIB. This report stated that, at the start of the inspection period, the ORR found that the sections of the safety management system which related to driver management had not been reviewed by the company or updated to reflect how operations were being carried out. These parts of the safety management system were assessed by the ORR as being at 'Level 1' against the RM3 criteria, which signified that they were '*ad hoc and un-coordinated'*. As a result of the findings of the inspection, the ORR issued an *improvement notice* to West Coast Railways, which required it to remedy the issues which had been identified.

201 The inspection report noted that the improvement notice had been complied with during the inspection period and that West Coast Railways had gone on to implement a wider review of its safety management system during 2012. Because improvements had been made in order to comply with the notice, the part of the safety management system relating to driver management was reassessed against the RM3 criteria. This second evaluation found that the relevant parts of the system were now mainly operating at 'Level 2' which signified that '...*Local groups are managed to ensure repeatable performance, but groups perform similar tasks differently'*. It also found that the system had reached 'Level 3' in some areas relating to driver management, signifying that '*…Good practice has been synthesised into standard processes*'. The inspection report made two recommendations for further action, neither of which were of direct relevance to this investigation.

202 In 2013 West Coast Railways submitted an application to the ORR to renew its safety certificate. The renewal of a safety certificate follows a five-year cycle and there is a standard process used by the ORR to assess applications against the requirements of ROGS. This process requires the main part of the assessment to focus on the management system and structures which support the safety management system, although assessments can also include consideration of selected risk control measures and procedures. Managers at the ORR stated that, in practice, assessments relating to safety certificate renewals tend to focus on changes made to a company's safety management system since the last certification. Managers at the ORR stated that, in addition to evaluating systems and structures, assessments will consider the results of any inspections or enforcement action taken during the previous five years as well as any incidents which had occurred which involved the company being evaluated.

203 The ORR's assessment of West Coast Railways' application to renew its safety certificate was provided to the RAIB. The ORR's lead assessor stated in this assessment that, since the previous renewal, West Coast Railways had improved the connection between its safety management system and its day-to-day operations. The lead assessor stated that no weaknesses were found in West Coast Railways' safety management system during the assessment and also noted that elements of the system had been tested by inspection activity and by the ORR's investigation into the derailment of a West Coast Railways locomotive at Ordsall Lane junction in January 2013 (RAIB report 07/2014).

204 Managers at the ORR stated that the lead assessor would have been aware of the improvement notice issued to West Coast Railways in 2011 regarding the management of drivers. The ORR also stated that, while the assessment had included an opportunity for interested parties, such as trade unions, Network Rail and any other operators affected by the application to raise any concerns which they may have had, no such concerns had been raised.

205 At the end of the assessment, the lead assessor recommended that West Coast Railways' safety certificate be renewed. This recommendation was endorsed by an ORR assessment manager. The assessment record was also reviewed by an 'assuror', who confirmed that the assessment process had conformed to the relevant ORR procedures. West Coast Railways' safety certificate was subsequently re-issued in September 2013; the lead assessor identified three points which would require follow up inspection by the ORR after the certificate was issued, none of which were of direct relevance to this investigation.

206 As part of its planned inspection activities, the ORR started a further inspection of West Coast Railways in July 2014. This inspection was still ongoing when the SPAD occurred at Wootton Bassett Junction on 7 March 2015. Because the ORR was undertaking a broader examination of how drivers were managed in the freight and charter sectors and because an improvement notice concerning driver management had previously been issued to the company, the ORR used this inspection to again review the parts of the company's safety management system which related to driver management.

207 The 2014 inspection was terminated when the SPAD occurred on 7 March 2015 and this meant that the associated inspection report was not fully completed. The ORR manager responsible for the 2014 inspection stated that, prior to its termination, the inspection found that the safety management system as it related to driver management was adequate, although newly created and still at an early stage of implementation. The inspection did, however, raise concerns about the way that West Coast Railways was proposing to manage the route knowledge of drivers. The manager stated that, as a result of the ORR raising these concerns, West Coast Railways agreed that it would work with an independent consultant in order to improve the relevant policies and procedures and that this work was still ongoing when the inspection was terminated.

208 The incident involving the lineside fire at Bell Busk (paragraph 190) also occurred during the 2014 inspection period. Managers at the ORR stated that they were aware of the incident, the suspension of steam operations which followed and the adjudicator's determination (paragraph 191). The ORR stated that it had also been kept fully informed by both West Coast Railways and Network Rail of the review undertaken following the publication of the determination (paragraph 195) and that the ORR manager responsible for the inspection had met West Coast Railways in February 2015 in order to discuss how the findings of the review were being implemented. This ORR manager stated that he was satisfied as a result of this meeting that the company was making progress towards addressing the issues identified.

209 The preceding paragraphs show that the parts of West Coast Railways' safety management system which relate to driver management were subject to inspection by the ORR on two separate occasions in the years preceding the SPAD and that the safety management system as a whole was assessed by the ORR in 2013. Although there was evidence that the inspections resulted in at least some weaknesses in the safety management system being recognised and in action being taken, neither the inspections nor the assessment identified all of the inadequacies in the structure and implementation of the safety management system which have subsequently been revealed by this investigation (paragraphs 187 and 194).

210 However, it is important to note that, in the absence of specific relevant incidents or reports from other interested parties, it is probably the case that deficiencies of the type identified by the RAIB's investigation would only have been uncovered if the contents and implementation of the specific policy, procedure or instruction had been subject to a detailed review during the inspections and assessment. The main objective of the assessment process is to determine whether a safety management system demonstrates a company's organisational capability to operate safely and planned inspections are intended to allow safety authorities to address outstanding points from assessments and to examine industry-wide or strategic topics (such as driver management). Neither mechanism is intended to allow an examination of every aspect of how a transport operator is implementing its safety management system. This should instead be the subject of monitoring by the system's internal audit mechanism, which should allow the transport operator to identify any issues arising and to take corrective action where required.

Observations

The management of the driver's route knowledge

211 **Although the driver's route knowledge of Wootton Bassett Junction was probably adequate on the day of the SPAD, West Coast Railways did not incorporate industry best practice into its procedures relating to the acquisition and retention of route knowledge by train crew.**

212 Main line signalling in Great Britain is based on the principle of route signalling, in which the signalling system provides the train driver with an indication of the route that a train is to take, and drivers use their knowledge of the route to drive trains at the appropriate speed.

213 The operational safety files for the driver of train 1Z67 showed that he first signed a West Coast Railways route and traction knowledge card to show that he was competent to work trains over Wootton Bassett Junction in March 2014. The driver stated that he signed his route card on this date because he had driven over the junction a number of times in the preceding months as part of his initial training with Colas Rail (paragraph 30). This was confirmed by his safety files, which showed that he first drove the route in December 2013 and that he had subsequently driven trains over the junction on several occasions in the intervening period, while under the supervision of a Colas Rail instructor.

214 West Coast Railways procedures do not require its drivers to have passed over a route on a minimum number of occasions under route learning conditions before their knowledge of the route is assessed (paragraph 222). The relevant work instruction instead required drivers to be assessed on their route knowledge once they felt that they had undergone sufficient training. This assessment could take the form of verbal questioning by an assessor, the use of a written questionnaire or a practical assessment. Once a driver had signed for a particular route, the retention of route knowledge was subsequently dictated by the professional judgement of the driver and their operations manager. The driver’s operational safety files show that West Coast Railways had not undertaken an assessment of his route knowledge of the junction before he signed the route card in March 2014.

215 Records showed that, after he had signed his West Coast Railways route card, the driver undertook further training journeys over Wootton Bassett Junction with Colas Rail. Records also showed that the driver’s route knowledge of the junction was subject to a practical assessment by Colas Rail in June 2014 and that the assessor found that the driver had acquired the level of route knowledge required to work trains over the route. A copy of this assessment was subsequently provided to West Coast Railways by the driver. Although the assessment took place three months after the driver had signed his West Coast Railways route card, managers at West Coast Railways stated that he was not assigned to work trains over the route during this period because they were aware that this route knowledge assessment remained outstanding.

216 West Coast Railways does not keep a central record of when a driver has driven over a given route. Witness evidence was that drivers are instead asked to keep a personal log of the journeys they had undertaken. The driver of train 1Z67 stated that he had kept a personal record of this type but that he was unable to find it following the incident. This means that it is not possible to say exactly how many times he drove over the route for West Coast Railways or when he did so. The driver stated that he thought that, taking into account his work for both companies, he had probably driven over Wootton Bassett Junction a total of around 12 times during 2014. In addition to the journeys undertaken in 2014, Colas Rail’s records show that the driver also worked a train over the junction in January 2015, although this was in the opposite direction to that taken by train 1Z67 on 7 March 2015.

217 While there may have been an irregularity in the way the driver signed his route card for West Coast Railways, he had (if his recollection is correct) passed over the junction at Wootton Bassett on at least a dozen occasions prior to the SPAD on 7 March 2015. He had also been formally assessed less than a year before the SPAD occurred and found to hold adequate route knowledge of the junction. The driver was also extremely experienced (paragraph 29) and was satisfied with his own knowledge of the junction on the day of the incident (paragraph 89). This evidence combined shows that the driver probably had acquired an adequate level of route knowledge of the junction by the time that the SPAD occurred.

West Coast Railways' compliance with RIS-3702

218 Best practice for train operators on the training, development, monitoring and assessment of train crew on route knowledge and route risks is described in *Rail Industry Standard* RIS-3702[35]. Railway companies can choose to adopt the best practice or arrangements proposed by a rail industry standard or they can develop another approach if they prefer. The ORR has stated to the RAIB that it treats RIS-3702 in the same manner as it would an *approved code of practice*. This means that train operators not adopting the provisions of the standard are expected by the ORR to have made arrangements which are equally as effective.

219 RIS-3702 proposes that train operators identify the elements of route knowledge essential for safe operation, as well as anything which could affect the ability of train crew to learn and retain route knowledge. This includes the routes being operated over and the individual characteristics of train crew such as their previous experience and working patterns. The standard suggests that train operators develop detailed route risk assessments in order to identify and manage anything which could increase safety risk on a particular route. It also discusses how train operators should share information, organise route learning and assess route knowledge competency.

220 The West Coast Railways work instruction in force at the time of the incident which related to the acquisition and retention of route knowledge incorporated some of the requirements of RIS-3702. It required, for example, that drivers be assessed on their route knowledge after an initial period of route learning. It also required that drivers be given supporting information (such as the sectional appendix, local instructions and route learning DVDs). West Coast Railways was able to provide evidence that these items were available at its Carnforth offices and that it maintained route maps at this office which incorporated details of route risks and which were updated using information from other parts of the rail industry. An inspection undertaken by the ORR in August 2015 of West Coast Railways' Rugby offices found, however, that while route learning materials were available at this location, there was no mechanism to update route maps (paragraph 275).

[35] RIS-3702-TOM 'Rail Industry Standard for Management of Route Knowledge for Drivers, Train Managers, Guards and Driver' Managers, Issue 2, December 2014.

221 The West Coast Railways work instruction relating to route knowledge did not include some of the best practice contained in RIS-3702 which is commonly implemented by other train operators. The absent features included there being no specified minimum number of occasions that a driver must have passed over a route in order to have learned it, no route learning plans for individual drivers and no specified minimum interval which drivers needed to work over routes in order to retain their route knowledge (the 'route retention frequency'). Route learning and retention instead relied on the professional judgment of drivers and managers as to when route knowledge refreshment and re-assessment was required. The work instruction also did not make use of route risk assessments. The use of these assessments was discussed by West Coast Railways in a 2012 risk assessment, which stated that they had been discontinued and replaced in 2006 by route maps because the validity and origins of the existing risk assessments were not clear and the resources to apply and validate them posed difficulties.

222 When considered within the context of this incident, this approach meant that West Coast Railways did not require drivers to have passed over Wootton Bassett Junction a minimum number of times as part of route learning before being assessed on their knowledge of it (paragraph 214). The company also did not require drivers to have worked a train over the junction at a minimum interval in order to retain their route knowledge of it. This can be contrasted with the approach adopted by Colas Rail, who undertook a formal assessment of the route including Wootton Bassett Junction and determined it as being 'medium risk'. This meant that Colas Rail required drivers to have passed over the route at least ten times (over five days) before they could be assessed for their competency to drive over it and that the route needed to be worked by a driver at least once every eight months in order for them to retain their route knowledge.

223 Following the incident, the ORR examined West Coast Railways' arrangements for managing route knowledge and concluded that they lacked robustness in some key respects. This is discussed further in paragraph 276.

West Coast Railways' checking of train crew fitness for duty

224 **West Coast Railways did not make adequate arrangements to routinely check that train crew had the correct equipment and were fit for duty**.

225 The Rule Book requires drivers to carry certain equipment and for them to have read the WON (paragraph 86) and other relevant publications before reporting for duty. Drivers are also required by law and the relevant railway group standard not to report for duty if they are subject to the effects of alcohol or drugs or if they are taking prescription medication, which has not been previously approved by their employer. ROGS also requires transport undertakings to ensure, so far as is reasonably practicable, that their staff are not subject to a level of fatigue which could affect safety.

226 Train operators meet these requirements in a number of different ways. They may, for example, require train crew to book on and off duty in the presence of a competent person (such as a supervisor or manager) who can ensure that the driver has their equipment, has read their notices and appears to be fit for duty. This competent person can also, if needed, brief the driver on any emergency or special circumstances which may affect them. Train operators may alternatively allow drivers to book on and off duty at remote locations either by reporting to a competent person at the location or by telephoning a competent person at the operator's control room. Some train operators also allow drivers to report to automated response services, with checks being conducted randomly on a sample of those drivers reporting in.

227 Prior to the incident of 7 March 2015, West Coast Railways did not require its train crew to book on or off duty. Its procedure instead stated that train crew should be checked for equipment and their fitness for duty four times per year, although the procedure did not specify when or how this was to be done. The practice of not booking on or off duty had been the subject of a risk assessment undertaken by the company in 2012. This assessment stated that train crew had previously been required to book on at a supervised location or by telephone but that this had been discontinued and the company was using alternative measures to achieve the same objectives. These included posting or emailing relevant documents directly to train crew at home, monitoring hours worked and by undertaking routine practical assessments and medical examinations. The company also issued drivers with a mobile phone so that they could be updated at short notice regarding urgent operational information.

228 The risk assessment found that the measures adopted by the company were '…*effective and appropriate*…' and that '…*they were performing well in practice*…'. A discussion in the assessment about the safety implications of not booking on and off duty found that there was no history of fitness for duty issues within the company and that the 'hand-picked' nature of their train crew, along with periodic checks by traction inspectors should mitigate any future risks. The assessment also noted that most West Coast Railways trains had multiple crew members, which would also help to control any risks around train crew reporting while unfit for duty.

229 Evidence from operational safety files was that the hours worked by at least some drivers (ie those working for two train operators) were recorded at the end of each month. There was also evidence in the files that train crew were subjected to medical examination (including screening for drugs and alcohol) and that periodic practical assessments (paragraph 31) included checks on equipment and documents. Managers at West Coast Railways also stated to the RAIB that they were in frequent contact with their drivers by telephone and that staff were subject to '*announced and unannounced, formal and unobtrusive, monitoring*' by operations managers.

230 However, despite these statements, witness evidence was that train crew working for West Coast Railways were not contacted to ensure that they had received relevant publications, such as the WON. There was also no evidence which showed that the company had met its own requirements to check each member of train crew at least four times per year or how it had intended to do so.

The maintenance of OTDR equipment

231 **West Coast Railways did not ensure that OTDR equipment on locomotives which it operated was being maintained and repaired in accordance with the requirements of GM/RT 2472 issue 1**.

232 Examination of OTDR data relating to the incident on 7 March 2015 showed that the OTDR channels monitoring the vacuum braking system, the use of the AWS isolating cock (paragraph 43) and the steam chest pressure (which would indicate the position of the *regulator*) were not functioning on the day of the incident. Examination of the available OTDR data from other days showed that these channels had not been functioning since at least 26 April 2014 (paragraph 124).

233 The OTDR system on a traction unit consists of a number of components, including a recorder unit and the wiring, switches and transducers which generate and carry the signals being monitored. West Coast Railways examined the OTDR system on Tangmere following the incident of 7 March 2015 and reported that the loss of the vacuum braking channel was due to a broken pin in a plug and that the lack of a steam chest pressure reading had been due to a defective transducer. West Coast Railways also confirmed that the channel which monitored the use of the AWS isolating cock was also not working due to a defective plug. Information from the manufacturer of the recorder unit confirmed that, as is generally the case, none of these dormant channels would have caused the OTDR health indicator located in the locomotive's cab to have indicated a fault condition.

234 Issue 1 of Railway Group Standard GM/RT 2472 required train operators to have a documented maintenance, testing and repair system in place for OTDR equipment. This was required to ensure, as far as was reasonably practicable, that the OTDR was functioning correctly when a train was in service and that faults during train operation are identified and rectified as soon as possible. Managers at West Coast Railways stated that the company did not own any traction units and so was not directly responsible for the maintenance of OTDR equipment. The company instead required suppliers of traction units to ensure that the appropriate maintenance had been carried out before they were offered for service.

235 In the case of Tangmere, the responsibility for vehicle maintenance belonged to CRRES (paragraph 24). CRRES issued a vehicle maintenance instruction for the locomotive which requires a visual check to be made of OTDR equipment during fitness-to-run examinations. This check is intended to ensure that the recorder and visible wiring is secure and intact and that the health indicator is not showing a fault. The maintenance instruction also requires an annual test of the OTDR equipment. This includes a more detailed visual examination and the analysis of downloaded data to ensure that certain channels are functioning and are correctly calibrated. The channels to be checked included those monitoring the vacuum braking system and the steam chest pressure.

236 The last time that the OTDR system on Tangmere was subject to the annual test prior to the incident was on 22 April 2014, as part of a broader maintenance examination undertaken by CRRES. Records from the maintenance examination indicated that the testing was completed correctly; however the detailed records which should have shown how the vacuum braking system and the steam chest pressure channels were checked for function and calibration could not be located by CRRES. West Coast Railways managers stated that a steam locomotive is quite an aggressive environment in which to operate electronic equipment due to the presence of steam, water and coal dust. However, while this may well be the case, OTDR data showed that both of these channels were not functional only four days after they were meant to have been subjected to detailed testing. This suggests that the maintenance examination undertaken on the OTDR on 22 April 2014 was not effective. It also shows that significant faults had existed with the equipment for almost 11 months, without them having been identified and rectified.

237 This is the third occasion on which the RAIB has obtained OTDR data from West Coast Railways and where analysis has subsequently shown that the equipment was faulty. On 29 June 2013, a member of the public was injured by a lump of coal which had fallen from the tender of a passing West Coast Railways operated steam locomotive as it was being hauled through a station by a diesel locomotive. As part of its preliminary examination of this incident, the RAIB requested that OTDR data from the locomotive be downloaded. Subsequent analysis of the data showed that the channel which measured the locomotive's speed was not functioning when the incident occurred. The RAIB did not subsequently investigate this incident but wrote to West Coast Railways to remind it of the requirements of GM/RT 2472 with respect to OTDR maintenance.

238 The RAIB's report into a locomotive failure near Winchfield on 23 November 2013 (RAIB report 13/2014[36]) found that, during this incident, Tangmere's OTDR had not recorded the locomotive's movements due to the poor condition of the recorder unit's internal battery. During the Winchfield investigation, West Coast Railways reported that it had modified its maintenance processes to address this issue. Managers at the company have since confirmed to the RAIB that all recorder units fitted to traction units operated by the company were subsequently returned to the manufacturer for overhaul.

239 The significant nature of the faults which existed on the OTDR equipment fitted to Tangmere on 7 March 2015, the length of time which they had existed for without being rectified and the previous occasions when OTDR equipment was found to be faulty show that West Coast Railways was not effectively discharging its responsibilities as a train operator under Railway Group Standard GM/RT 2472 issue 1 to ensure that OTDR equipment was functioning correctly in service and that faults with it were identified and rectified as soon as possible.

[36] Copies of RAIB reports be found on RAIB's website www.gov.uk/raib.

The control of overrun risk at signal SN45

240 **The current arrangements for assessing overrun risk on Network Rail managed infrastructure do not account for the movement of steam locomotives or preserved vehicles.**

241 The operation of steam locomotives and preserved vehicles on the mainline railway has the potential to increase the risk from signal overruns. This is because vehicles of this nature have characteristics (such as reduced forward visibility, higher levels of ambient noise or other possible distractions) which may increase the likelihood of an overrun occurring when compared to modern trains. They may also be fitted with braking systems which, while complying with current standards, do not achieve modern standards of performance. This means that the magnitude of an overrun may be greater when compared to modern trains (paragraph 97). The use of vehicles not designed to modern standards of crashworthiness (such as Mark 1 coaches, paragraph 12) and the presence of a pressurised boiler on the locomotive may also mean that the consequences of a collision resulting from an overrun are potentially worse.

242 The risks of steam locomotives over-running signals are controlled by the railway industry in a number of ways, including:

- the requirements of the Rule Book and standards such as GE/RT 3440, which lays down minimum requirements for crewing and requires operators to assess difficulties in sighting signals and lineside signs (paragraph 71);
- the control of derogations from railway group standards for individual vehicles (paragraph 153);
- the safety management systems of train operators using steam traction on Network Rail managed infrastructure (paragraph 192); and
- the evaluation and assessment of the overrun risk at individual signals by the infrastructure manager (ie Network Rail).

The assessment of overrun risk at individual signals

243 Best practice for evaluating and assessing the risk of overruns at individual signals is described in Rail Industry Standard RIS-0386-CCS[37]. Network Rail satisfies the guidance in this standard by using an evaluation methodology which is based on the *Signal Overrun Risk Assessment Tool* (SORAT). SORAT uses specialist software to assess overrun risk based on factors such as the speed of approach to the signal, the number and type of trains and their passenger loadings, the arrangement of the infrastructure and the potential for conflict between trains. SORAT assessments are intended to reflect the braking and crashworthiness characteristics of the trains which approach a signal and the effectiveness of systems such as TPWS in reducing risk.

[37] RIS-0386-CCS ‘Rail Industry Standard on Signal Overrun Risk Evaluation and Assessment’, Issue 1, December 2014.

244 Both RIS-0386-CCS and SORAT have been introduced comparatively recently and this meant that signal SN45 had not been subject to a SORAT assessment prior to the SPAD of 7 March 2015. SN45 had, however, been assessed in 2009 using an earlier evaluation technique, known as the Signal Assessment Tool (SAT). Records of the 2009 SAT assessment show that the overrun risk at the signal was found to be acceptable, once the ATP equipment fitted to the Class 43 High Speed Trains which operate over the junction was taken into account.

245 Following the SPAD on 7 March 2015, Network Rail undertook a SORAT assessment of signal SN45. This assessment was based on the *working timetable* and assumed that trains approaching the signal would include Class 43 High Speed Trains equipped with ATP, two classes of diesel multiple units and three different types of freight service. The SORAT assessment predicted that the TPWS equipment at signal SN45 would reduce the risk at the signal by 89% and the signal was categorised as having a score of 'H3'. This represents a medium relative risk due to overrun, although one which Network Rail's draft standard on SORAT states has been demonstrated as being reduced as far as is reasonably practicable.

246 When TPWS was installed on the mainline railway there was no expectation that it would completely remove the risk from SPADs. The 2001 joint enquiry into train protection systems[38] concluded that TPWS was expected to reduce the occurrence of SPADs by around two-thirds, with further reductions possible depending on the extent of the equipment's use and the adoption of enhancements such as TPWS+. RSSB's 'Learning from Operational Experience Annual Report' for 2014/15 noted that SPADs had reduced from over 500 per year in the late 1990s to fewer than 300 a year in 2014/15 and that the combined effect of TPWS, the professionalism of drivers and the development of driving policies and practices meant that only one SPAD occurs for around every 50,000 danger signals approached. The report also shows that the risk presented by SPADs had almost halved between 2003 and 2006[39] and that the risk in 2014 had reduced to around three-quarters of that calculated for 2006.

247 The 2001 joint enquiry noted that the effectiveness of TPWS was adversely affected by a number of factors, including its operation with trains which achieved a mean retardation of less than 12%g during emergency brake application (considered by the inquiry to be typical of the braking characteristics of modern trains). After TPWS was introduced, RSSB continued to monitor the effectiveness of it with respect to trains with these lower braking rates. The need for assessments of the risk of overruns to correctly take into account the braking performance of trains which will pass a signal was also the subject of a previous recommendation made by the RAIB's investigation into a signal passed at danger and subsequent near miss at Didcot North junction on 22 August 2007. In January 2015, RSSB's board noted that Network Rail was now using SORAT to assess how trains with these braking characteristics would affect the risk associated with new signalling schemes.

[38] Professor John Uff QC FREng, The Rt Hon Lord Cullen PC 'The Southall and Ladbroke Grove Joint Inquiry into Train Protection Systems', The Health and Safety Executive, 2001.

[39] The RSSB report uses the SPAD risk in September 2006 as the benchmark against which other years are measured.

248 Although the SORAT assessment undertaken of signal SN45 following the SPAD confirmed that trains with lower braking rates and a variety of crashworthiness characteristics are already accounted for within SORAT assessments, there is no evidence in this assessment, or from Network Rail's draft standard, that SORAT currently accounts for the characteristics of steam locomotives and preserved vehicles which may potentially increase the risk from overruns. As SORAT is the basis of all new assessments of overrun risk at individual signals, this means that the current arrangements for assessing the overrun risk at individual signals do not account for the movements of steam locomotives or preserved vehicles.

The absence of a system-wide risk assessment

249 Although each of the separate mechanisms used by the rail industry to control overrun risk (paragraphs 242 and 243) may include the assessment and mitigation of specific risks relating to the operation of steam locomotives or preserved vehicles, the RAIB has not been able to find any evidence that the rail industry has considered these risks within a single, system-wide assessment of risk. The RAIB considers that an assessment of this type could potentially identify weaknesses in existing risk controls and help to ensure that the risks of operating steam locomotives or preserved vehicles on the mainline railway are reduced so far as is reasonably practicable.

Occurrences of a similar character

Incident at Hexthorpe Goods chord

250 On 2 October 2015 train reporting number 5Z15, an empty coaching stock movement consisting of steam locomotive 45231 and its support coach, was making a slow speed propelling movement towards a caution signal situated on the Up and Down Hexthorpe Goods chord, near to Doncaster station. As the support coach passed the signal, the signalling system detected its presence and the signal changed to display a danger aspect. The TSS at the signal also became energised.

251 When making a propelling movement of this nature, train crews operating steam locomotives normally operate the TPWS temporary isolation switch in order to avoid spurious TPWS brake demands (paragraph 22). On this occasion, however, the driver had forgotten to operate the TPWS temporary isolation switch and this resulted in a TPWS brake demand being generated as the locomotive passed the TSS. The driver was aware that a TPWS brake demand had occurred and so shut the regulator and applied the brakes[40]. He then contacted the signaller using his GSM-R radio, as required by the Rule Book.

[40] West Coast Railways requires its drivers to fully apply their brakes following AWS or TPWS brake demands in order to avoid any chance of the train moving once the brake demand has expired and while the driver is potentially occupied with reporting to the signaller.

252 The GSM-R radio is located on the front of the tender on this locomotive and the driver stated that he therefore had his back to his driving controls while speaking with the signaller. He stated that while he was making his report, and without his permission or knowledge, the fireman crossed the cab and operated the switch which electrically isolates the AWS and TPWS systems. The fireman cycled this switch to the off position and then back to the on position. For the type of TPWS equipment fitted to this locomotive, this had the effect of resetting the combined AWS/TPWS control unit.

253 Having been reset, the combined control unit entered a self-testing phase; once this had been completed (by the fireman acknowledging an AWS warning) the TPWS brake demand ceased. The fireman then manually released the brakes and opened the regulator. The driver stated that at this point he became aware that the train was moving and that he immediately brought the train to a stand. He then finished speaking with the signaller and, having received permission to continue, completed the movement.

254 The driver reported the incident to West Coast Railways control at the end of his shift. A local investigation undertaken by West Coast Railways confirmed the driver’s report and found that it had taken around 40 seconds from the start of the TPWS brake demand to the brakes being released. The fireman stated that he was aware that he should not have attempted to by-pass the TPWS brake demand and that he had done so in order to save time.

Summary of conclusions

Immediate cause

255 Train 1Z67 approached signal SN45 at too high a speed to stop before passing the signal at danger and coming to a stand across Wootton Bassett Junction (**paragraph 62**).

Causal factors

256 The driver of train 1Z67 had not taken account of the caution aspect at signal SN43 and reduced the train's speed appropriately as it approached signal SN45 (paragraph 63a). This was due to a combination of the following factors:

a. The driver did not see signal SN43 as train 1Z67 passed it (**paragraph 67, Recommendation 1**).

b. The AWS warning relating to signal SN43 did not alert the driver that he had passed signal SN43 and that the signal was displaying a caution aspect. This was in part due to the way a temporary speed restriction on approach to the signal had been implemented (**paragraphs 80 and 276, Recommendations 1 and 5**).

c. The driver did not realise that he had missed signal SN43 even though it was an important feature of the route on the approach to Wootton Bassett Junction (**paragraph 89, no recommendation**).

257 The TPWS system on board Tangmere was unable to reduce the speed of train 1Z67 so as to prevent it from over-running the signal and the up Badminton line. This was because TPWS brake demands had been rendered ineffective by the train crew's earlier use of the AWS isolating cock, in contravention of the relevant rules (paragraph 102). The isolating cock was opened due to a combination of the following factors:

a. The driver had not acknowledged the AWS warning associated with the TSR within the required period and this caused an AWS brake demand (**paragraphs 110 and 276, Recommendations 1 and 2**).

b. The driver did not want the train to come to stand as a result of the AWS brake demand (**paragraph 118, Recommendations 1 and 2**).

c. The driver and fireman had a low perception of the risk of using the AWS isolating cock to by-pass the AWS brake demand (**paragraphs 121, 266, 268, 269 and 276, Learning point 1**, **Recommendations 1 and 2**).

Underlying factors

258 The way that the AWS system on Tangmere was designed and installed meant that AWS warning horns were not always audible to drivers. This meant that the AWS system did not meet the requirements of the relevant standards. In addition, the AWS isolating cock was in a position which was accessible to train crew when the train was moving. Despite this, the AWS system was certified as being compliant with the relevant standards and the locomotive was permitted to enter into service (**paragraphs 141 and 276, Recommendation 1**).

259 The TSR in force on the approach to Wootton Bassett Junction was based on an earlier emergency speed restriction. However, the design of this emergency speed restriction was based on incorrect information. This ultimately resulted in the warning board for the TSR being placed between the fixed AWS magnet for signal SN43 and the signal itself, even though this was not permitted by the relevant standards. Opportunities to correct this error during implementation of the ESR and TSR were also missed (**paragraph 168, Recommendation 5**).

260 West Coast Railways had a weak safety culture. This affected how its staff complied with the requirements of the Rule Book, relevant railway group standards and the company's safety management system (**paragraphs 184 and 270, Recommendation 2**).

Additional observations

261 Although the driver's route knowledge of Wootton Bassett Junction was probably adequate on the day of the SPAD, West Coast Railways did not incorporate industry best practice into its procedures relating to the acquisition and retention of route knowledge by train crew (**paragraph 211, Recommendation 3**).

262 West Coast Railways did not make adequate arrangements to routinely check that train crew had the correct equipment and were fit for duty (**paragraphs 224 and 269, no recommendation**).

263 West Coast Railways did not ensure that OTDR equipment on locomotives which it operated was being maintained in accordance with the requirements of GM/RT 2472 issue 1 (**paragraph 231, Recommendation 4**).

264 The current arrangements for assessing overrun risk on Network Rail managed infrastructure do not account for the movement of steam locomotives or preserved vehicles (**paragraph 240**, **Recommendation 1**).

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

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

Network Rail's suspension of track access

265 Network Rail suspended West Coast Railways' track access agreement across all of its routes on 1 April 2015. Network Rail stated that it had taken this action because it believed that the operations of West Coast Railways were a threat to the safe operation of the railway. Network Rail also stated that West Coast Railways' response to the SPAD of 7 March 2015 had showed that, in its opinion, the company's controls, communication and commitment were inadequate. Network Rail required West Coast Railways to address a number of issues before its track access would be restored. On 7 May 2015 Network Rail wrote to West Coast Railways and informed it that its track access was to be restored on the basis that the operator had addressed the issues identified in the suspension notice.

266 West Coast Railways reported to the RAIB that it had undertaken a number of actions following the SPAD and its subsequent suspension by Network Rail. This included the introduction of a new work instruction which requires OTDR data downloads to be used as part of the routine monitoring of driver performance. This work instruction requires there to be a minimum of one download analysed per year for each driver working for the company and also for OTDR data to be downloaded following any incidents or accidents. The work instruction also requires data to be used to assist the owners and maintainers of traction units to ensure that OTDR equipment is maintained.

267 West Coast Railways also reported to the RAIB that it had purchased extra OTDR download and analysis equipment and that (as at October 2015) all except six drivers had had data from at least one OTDR download analysed as part of an exercise to establish a base of data. Managers at West Coast Railways stated that they thought that this was an effective way of monitoring the isolation of safety systems such as AWS and that the ongoing analysis had already identified occasions where drivers had been late to acknowledge AWS warnings. Operations managers had been able to cross-check these occurrences with the relevant railway control logs and so confirm that drivers were reporting AWS brake demands in accordance with the Rule Book.

268 West Coast Railways further stated to the RAIB that it had updated its arrangements for fitness-to-run examinations and that the numbers on isolating device seals are being recorded and cross-checked on successive examinations in order to ensure that seals are not being removed inappropriately. The relevant work instruction also requires the removal of any seal for operational reasons to be immediately reported to West Coast Railways control so that the circumstances can be recorded.

269 West Coast Railways provided evidence to the RAIB that it had created a new work instruction which requires train crew to ring West Coast Railways control when booking on duty. The duty controller is required to ask a series of questions to establish that the person calling is carrying the correct equipment and is fit for duty and is also required to brief them on any relevant urgent operational information. Managers at West Coast Railways stated that train crew are also now required to confirm receipt of documents, such as the WON, which are posted to their homes.

270 West Coast Railways reported to the RAIB that it had also reviewed its safety governance. As a result it had recruited a non-executive director, an externally recruited board-level General Manager (responsible for operations, safety and standards) and a Safety Manager. West Coast Railways stated that it had also joined RSSB.

Actions taken by the ORR

271 Concurrent with Network Rail's suspension, the ORR notified West Coast Railways on 17 April 2015, that it was considering using its powers under ROGS to revoke West Coast Railways' safety certificate. This triggered a formal consultation period, during which West Coast Railways and other affected parties could make representations.

272 At the end of this consultation period the ORR stated that, owing to the steps already taken by West Coast Railways and the results of its site visits, the ORR was satisfied that there was no significant risk requiring the revocation of the company's safety certificate. However, because there were still some outstanding matters and because the changes made had not yet become fully embedded, the ORR concluded the consultation by issuing an improvement notice to West Coast Railways. This notice, issued on 20 May 2015, required West Coast Railways to further review its safety management system in order to ensure that it was robust and that it included relevant policies, competence management arrangements, management procedures and risk controls.

273 As a result of the incident on 2 October 2015 at Hexthorpe Goods chord where a TPWS brake demand was interfered with by the fireman of train reporting number 5Z15 (paragraph 250), the ORR issued a *prohibition notice* to West Coast Railways on 24 November 2015. This notice prohibited West Coast Railways from operating further steam movements until locomotives were fitted with an effective means of preventing interference with the correct operation of AWS and TPWS.

274 On 9 December 2015, the ORR again notified West Coast Railways that it was considering using powers under ROGS to revoke its safety certificate because of serious concerns that the company was no longer satisfying its conditions. Following a period of consultation, the ORR wrote to West Coast Railways on 17 February 2016[41] to inform it that its safety certificate was not being revoked. West Coast Railways was, however, issued with a prohibition notice by the ORR on the same date which prevented it from operating any further trains on the mainline network with effect from 18 February 2016. The ORR stated that this notice would remain in force until such time as West Coast Railways could satisfy the ORR that its governance and actions were fit for the scale of its operations.

[41] The full text of the ORR's decision letter is available from http://orr.gov.uk/__data/assets/pdf_file/0004/20848/2016-02-17-decision-letter-to-west-coast-railway.pdf.

275 The ORR stated in its decision letter of 17 February 2016 that there were a number of issues which had raised concerns, including the following matters which are of particular relevance to this investigation:

- A driver management inspection at Rugby in August 2015 found that, while route learning materials were available, there was no mechanism to update route maps and that route risk assessments were not available for inspection. In addition, the ORR found that route knowledge refresher training depended on drivers making a request for it and that there was no system for monitoring when it might be required. The ORR considered that this meant that it was not being robustly managed.
- The newly recruited board-level General Manager had resigned and not been replaced.
- The ORR's opinion was that West Coast Railways was not effectively managing safety at the most senior levels of its organisation and that staff taking safety-related decisions were having their actions negatively interfered with by board members, in particular the Chairman. In addition, the ORR was concerned that the Chairman was taking decisions contrary to the advice of other staff and the requirements of West Coast Railways safety management system.

276 The ORR concluded in this decision letter that West Coast Railways apparently did not understand the importance of route risk assessments and identifying appropriate route retention frequencies. The ORR also determined that West Coast Railways did not have sufficient management and supervision of its train crews and that the company had an inadequate appreciation of the need for an appropriate safety culture from the board down. The ORR found that the West Coast Railways arrangements for governance, management and supervision did not accord with industry best practice and were not those expected of an operator undertaking safety critical operations on the mainline railway.

277 On 22 March 2016, West Coast Railway wrote to the ORR[42] stating that it committed to implementing the following actions;

- Undertaking a strategic review with the intent of reducing business complexity.
- Restructuring the board and management team to include a subcommittee with an independent chairman drawn from the UK rail industry, whose sole focus will be safety.
- Appointing an independent safety consultancy to review the company's management arrangements, to conduct safety culture surveys and to undertake gap analysis.
- Allowing the managing director to pursue safety and training improvements independently, under a dispensation from the board.
- Directing more resources into the development of route risk assessments.
- Placing traction inspectors on all steam charters except for regular operations where a risk assessment had demonstrated that this is not necessary.

[42] The full text of West Coast Railways letter is available from http://orr.gov.uk/news-and-media/news-and-announcements/2016/orr-lifts-prohibition-notice-on-west-coast-railways.

- Drawing the steam drivers used by the company from a pool of 29, all of whom have been re-assessed.
- Prohibiting the use of trains which mix vacuum and air braked rolling stock.
- Trialling the use of CCTV in the cabs of steam locomotives.

278 As a result of these commitments, the ORR lifted the prohibition notice applying to West Coast Railways on 28 March 2016.

Prosecutions

279 Both the driver of train 1Z67 and West Coast Railways have been charged by the ORR with offences under the Health and Safety at Work Act 1974. All of the charges relate to the SPAD on approach to Wootton Bassett Junction on 7 March 2015. At the time of writing (April 2016) the case against both parties is awaiting trial.

Other relevant actions

280 In June 2015 issue 2 of Railway Group Standard GE/RT 8075[43] came into force as part of the ongoing development of the AWS and TPWS systems. This standard requires any new or upgraded AWS or TPWS systems installed onto trains after this date to have AWS audible indications with a sound level of at least 10 dBA above expected ambient noise, subject to a minimum sound level of 65 dBA and a maximum sound level of 95 dBA. Audible indications meeting the requirements of this standard would still be at risk of being missed on steam locomotives during routine operational noise conditions (paragraph 147).

281 GE/RT 8075 also requires AWS and TPWS brake applications not to be affected if power to the combined control unit is cut and restored, as occurred on 2 October 2015 at Hexthorpe Goods chord (paragraph 250).

Previous investigations

282 There have been a number of previous inquiries and investigations that consider issues directly relevant to this investigation. These include;

- the isolation of AWS (The Southall Rail Accident Inquiry Report[44]);
- driver distraction and TPWS design assumptions relating to trains with lower braking rates (Didcot North, RAIB report 23/2008);
- steam locomotive crew distraction (Wood Green Tunnel, RAIB Bulletin 04/2012); and
- the maintenance arrangements of Tangmere and their non-compliance with the principles of West Coast Railways safety management system (Winchfield, RAIB report 13/2004).

[43] Railway Group Standard GE/RT 8075 ‘AWS and TPWS Interface Requirements’, Issue 2, March 2015.

[44] Professor John Uff QC FREng, ‘The Southall Rail Accident Inquiry Report’, The Health and Safety Executive, 2000.

Learning point

283 The RAIB has identified the following key learning point[45]:

1 Allowing safety systems such as AWS and TPWS to function without improper interference is vital to the safe operation of the railway. The importance of this cannot be overstated. By-passing safety systems, or isolating them other than in accordance with the requirements of the Rule Book, can have catastrophic consequences (paragraph 257c).

The risks of running trains with safety systems such as AWS isolated have previously been highlighted by the inquiry into the 1997 accident at Southall, in which 7 people were killed and a further 139 were injured (paragraph 282).

[45] '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.

Recommendations

284 The following recommendations are made[46]:

1 *The intent of this recommendation is that the risk of overrun by trains operated by steam traction on Network Rail managed infrastructure is reduced as far as is reasonably practicable.*

RSSB, working in conjunction with operators of steam traction and Network Rail, and in accordance with normal industry processes, should undertake a review of the current standards, policies, procedures and risk assessment tools intended to assess, prevent and mitigate the risk associated with overruns on Network Rail managed infrastructure.

This review should consider if these arrangements adequately control the risk of overrun associated with the movement of trains formed of steam locomotives and/or preserved vehicles. It should specifically consider:

- the extent to which existing railway group standards and associated guidance adequately mitigate the risk of operating such trains;
- if there are features of steam locomotives and preserved vehicles which may potentially increase the likelihood or magnitude of overruns (such as reduced forward visibility or braking systems not designed to meet modern standards of performance) or which may potentially make the consequences of an overrun worse (such as vehicles not being designed to meet modern standards of crashworthiness);
- the compatibilty of braking performance of steam-hauled trains and/or preserved vehicles with signal spacing on lines where signals are more closely spaced (eg lines where different maximum permitted speeds apply to passenger and freight trains);
- how the train crew of steam locomotives interact with the controls and visual and audible indications of the Automatic Warning System and the Train Protection and Warning System;
- if the minimum crewing level for steam movements specified within GO/RT 3440 Issue 2 remains appropriate; and

continued

[46] 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.

- if steam movements are adequately accounted for within existing tools intended to assess the risk of overruns (such as SORAT).

Companies operating steam locomotives and/or preserved vehicles on Network Rail managed infrastructure and Network Rail should implement any measures identified by this review as being required to adequately control the risk from overrun (paragraphs 256a, 256b, 257a, 257b, 257c, 258 and 280).

2 *The intent of this recommendation is that an external party reviews the implementation of changes to West Coast Railways' safety management system following this incident in order to ensure that they have been effective. The review should also consider the company's safety culture.*

West Coast Railways should make arrangements for a review of its safety management system and safety culture to be undertaken by an external independent party whose suitability has been agreed with the Office of Rail and Road. The review should consider if the changes made following the SPAD of 7 March 2015 have been implemented and if they have improved the capability of West Coast Railways to control risk and the prevailing safety culture within the company. This review should specifically examine;

- governance, policy and leadership;
- control and communication and how this is organised;
- the co-operation and competence of employees;
- the planning and implementation of risk controls and how this is managed; and
- monitoring, review and auditing of compliance to the safety management system and how this is managed.

West Coast Railways should make any changes identified as necessary (paragraphs 257a, 257b, 257c and 260).

continued

3 *The intent of this recommendation is that West Coast Railways implements arrangements for the acquisition and retention of route knowledge by drivers which are in line with industry best practice. It is also intended to ensure that West Coast Railways observes the requirements of mandatory standards with respect to identifying signals and signs which may be difficult to see from steam locomotives.*

West Coast Railways should review the arrangements by which drivers that it employs acquire and retain route knowledge. This review should take into account whether these arrangements meet with the requirements of RIS 3702 Issue 2 'Route Knowledge for Drivers, Train Managers, Guards and Driver Managers'.

West Coast Railways should also consider how proposed routes for steam operations are assessed in order to identify signals and lineside signs which may be difficult to see from a steam locomotive cab and how drivers of West Coast Railways operated steam trains are to be provided with additional competent assistance in sighting any signals or lineside signs falling within this category. This should be done with regard to the requirements of GO/RT 3440 Issue 2 'Steam Locomotive Operation'.

West Coast Railways should make any changes identified as necessary (paragraph 261).

4 *The intent of this recommendation is that West Coast Railways implements arrangements for the maintenance of On Train Data Recorders which ensure that this equipment can meet the requirements of the relevant mandatory standards.*

West Coast Railways should review the arrangements by which On Train Data Recorders fitted to trains that it operates are maintained. This review should specifically ensure that such recorders are maintained in a way which means that they are capable of supporting the key objectives for data recording as laid down in GM/RT 2472 Issue 2 'Requirements for Data Recorders on Trains'. These include:

- the use of systematic safety monitoring as a means of preventing incidents and accidents;
- the identification of driver, train and infrastructure performance in the period leading up to and (if appropriate) immediately after an incident or accident; and
- the recording of information relating to the performance of both the locomotive / traction unit and the person driving.

West Coast Railways should make any changes identified as necessary (paragraph 263).

continued

5 *The intent of this recommendation is to ensure that emergency and temporary speed restrictions are designed and implemented in a way which results in clear and correct information being provided to train drivers.*

Network Rail, in association with any contractors who carry out such work, should review how the design and implementation of emergency and temporary speed restrictions is managed by the Swindon Maintenance Delivery Unit and how this resulted in the errors identified in this report. This review should consider:

- the information, instruction and training given to designers of TSRs;
- the procurement process for designs, including the circulation list for information and designs provided to Network Rail;
- the process for conversion of ESRs to TSRs, including the criteria for deciding whether an ESR design is modified, or if a new design must be used; and
- the process for implementing ESRs and TSRs, including the checking of designs and the action to be taken if conditions on the ground do not match the design.

Network Rail should also determine whether any of the issues identified may apply to other maintenance delivery units and take action as necessary to make any changes required (paragraph 256b)

Appendices

Appendix A - Glossary of abbreviations and acronyms

ATP	Automatic Train Protection
AWS	Automatic Warning System
CCB	Conformance Certification Body
ESR	Emergency Speed Restriction
GSM-R	Global System for Mobile Communications – Railways
MDU	Maintenance Delivery Unit
OSS	Overspeed Sensor System
OTDR	On Train Data Recorder
PSB	Power Signal Box
ROGS	The Railways and Other Guided Transport Systems (Safety) Regulations 2006
SAT	Signal Assessment Tool
SORAT	Signal Overrun Risk Assessment Tool
SPAD	Signal Passed at Danger
TOPS	Total Operations Processing System
TPWS	Train Protection and Warning System
TRUST	Train Running System on TOPS
TSR	Temporary Speed Restriction
TSS	Train Stop System
VAB	Vehicle Acceptance Body
WON	Weekly Operating Notice

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.

Access disputes committee	The body responsible for the operation of the dispute resolution procedures that form part of all access agreements on the national railway network in Great Britain.
Application unit	A component within the air braking system on a traction unit which reacts to the activation of certain safety systems by venting the automatic air braking pipe in order to apply the brakes.
Approved code of practice	Guidance which has a specific legal standing within health and safety law. Failure to follow the guidance in an approved code of practice is not an offence, but a company will need to show that any alternative method adopted to achieve compliance with their legal duties is equally or more effective than that proposed by the guidance.
Automatic air brake pipe	A pipe running the length of a train that controls (and in the single brake pipe configuration also supplies) the air brakes on the rail vehicles forming the train. A reduction in brake pipe air pressure will apply the brakes.
Automatic Train Protection (ATP)	A control system which utilises lineside equipment to transmit permissible speed and signal aspect information to trains. Since the signalling system tells the train how fast it may proceed at any given point, the system is capable of taking control from the driver and applying the brakes automatically should the driver attempt to exceed the safe speed.*
Automatic vacuum train pipe	A pipe running the length of a train that controls (and creates a vacuum in) the vacuum brakes on the rail vehicles forming the train. An increase in pressure in the vacuum train pipe will apply the brakes.
Automatic Warning System (AWS)	A safety system for alerting train drivers about the signal aspect or speed restriction ahead. A horn sounds in the driving cab for a red, single or double yellow signal aspect, or a warning sign for a speed restriction. A bell sounds to indicate a green signal.
Category A SPAD	A SPAD where a train proceeds beyond its authority to move and where the danger aspect or other movement authority was displayed correctly and in sufficient time for the train to be stopped safely.
Caution	A single yellow signal aspect which indicates to the driver that he should be prepared to stop at the next signal.*
Cess	The area alongside the railway.

Chain	A unit of length, being 66 feet or 22 yards (approx 20.117 metres). There are 80 chains in one standard mile.*
Conformance Certification Body (CCB)	A body authorised to issue certificates of conformance for rail vehicles.
Danger	A red signal aspect which indicates to the driver that they should stop their train at the signal.*
Derogation	At the point when Tangmere's TPWS and AWS installation was subject to design scrutiny, this was the procedure by which permanent non-compliance with a requirement of a Railway Group Standard was approved by the relevant standards committee and authorised by RSSB.
Design scrutiny	The process of assessing the design of a rail vehicle in order to determine its conformance with railway group standards.
Down	In a direction away from London, the capital, the original railway company's headquarters or towards the highest mileage.*
Driver's safety device	A system, normally incorporating a foot pedal that must be kept depressed. If pressure on the foot pedal is released, the train's brakes are applied after a delay of around five to seven seconds.
Driver's vigilance device	A system, often incorporated into the driver's safety device that sounds an alert at regular intervals (normally around 60 seconds). If the driver does not acknowledge the alert the train's brakes are automatically applied through the driver's safety device system.
Driving position	Railway Group Standard GM/RT 2161 Issue 1 defined this as the normal position from which the driver controls the train, by operating the primary controls. The driving position may be seated or standing or both, depending on operational requirements.
Driver standards manager	A manager working for a train or freight operator whose duties involve the supervision and assessment of train drivers.
Emergency indicator	A self-contained, battery operated lineside indicator designed to draw a driver's attention to the presence of an emergency speed restriction. They are coloured with bold black and yellow chevrons and display two brilliant white flashing lights.*
Emergency Speed Restriction (ESR)	A speed restriction which has not been published in the Weekly Operating Notice or which has been implemented with different arrangements to those published.
Empty coaching stock	A train consisting of empty passenger coaches being moved from one place to another for operational reasons.*

Engine cleaner	The starting grade for steam train crew in British Rail. Responsible for keeping locomotives clean and for assisting in general duties around depots. After the requisite training and experience had been gained, cleaners would be able to take an assessment to allow then to undertake the duties of a fireman.
Engineering acceptance	The process of assessing the design, construction and planned maintenance of a rail vehicle in order to determine its conformance with railway group standards.
Entity in charge of maintenance	A person or organisation responsible for the maintenance of rail vehicles that has to ensure that, through a system of maintenance, a vehicle for which is it responsible is safe to run on the mainline railway.
Firebox	The part of a steam locomotive boiler which contains the fire.
Fireman	The person responsible for keeping a steam locomotive supplied with coal during a journey, and assisting in the observation of signals when required to do so.*
Fitness-to-run examination	A daily examination of a traction unit which checks the function and condition of key systems. In some circumstances one examination may cover several days of consecutive operation. May also be known as an A exam.
Fitness-to-run examiner	A person holding a competency to conduct fitness-to-run examinations on traction units.
Four-aspect colour light signal	A colour light signal capable of displaying four different signalling aspects. Unlike a three aspect signal, a four aspect signal can display a double yellow preliminary caution aspect.
Injector	A device which uses a steam jet to create a pressurised feed of water into the locomotive's boiler.
Improvement notice	A statutory notice which states that a company is, in the opinion of a safety authority inspector, contravening a statutory provision and which requires action to be taken to remedy the contravention.
Junction indicator	An arrangement of lines of white lights mounted above a colour light signal which, when lit, displays the diverging route through a junction to a driver.
Mark 1 coach	The standard British Railways coach design introduced from 1951. The passenger compartment of these coaches relies mainly on a structural underframe for longitudinal strength. Mark 1 coaches may only be used for passenger operations if the operator has been granted an exemption by the Office of Rail and Road.
Mark 2 coach	The standard British Railways coach design introduced from 1964.

On Train Data Recorder (OTDR)	Equipment fitted on-board a traction unit which records train speed and the status of various controls and systems relating to the unit's operation. This data is recorded to a crash-proof memory and is used to analyse driver performance and train behaviour during normal operations or following an incident or accident.
Operational safety file	A file which contains details of a staff members' training and assessments, medical examinations and any other information which is relevant to operational safety.
Out-of-correspondence	In relation to points, the situation that exists when a point end is not in the position commanded by the signaller or which incorrectly shows detection.
Overlap	The distance beyond a signal that is proved clear prior to the signal on the approach to it being cleared.*
Personal track safety	A qualification required by people who need to go on or near the railway line.
Possession	A period during which the operation of normal service trains is suspended on a designated section of line for the purposes of maintenance and/or engineering works.
Power signal box	A large signal box which controls the points and signals over a large area by electrical means.
Proceed	A green signal aspect which authorises a driver to pass that signal.*
Product acceptance	An indication by Network Rail that a product, equipment or system has been assessed as fit for its intended application so as not to introduce unacceptable risk to the railway operation, staff or member of the public
Prohibition notice	A statutory notice which requires an activity to stop in order to prevent risk of serious personal injury.
Propelling	The act of pushing a train from the rear using a locomotive.*
Proportional relay valve	A valve fitted to a train's braking system that varies the application or release of the brakes in one part of the system in proportion to the application or release commanded in another part of the system.
Railway group standard	A document mandating the technical or operating standards required of a particular system, process or procedure to ensure that it interfaces correctly with other systems, process and procedures. Railway group standards are maintained by the RSSB on behalf of the railway industry.

Rail industry standard	Rail industry standards offer examples of suitable arrangements which can be adopted by railway companies in areas where there is no applicable railway group standard or other mandatory requirements.
Regulator	A valve which controls admission of steam to the cylinders. It is operated by a lever in the cab and is effectively the locomotive's throttle.
Responsible officer	A person who serves as point of contact for the support crew and who is responsible for managing their activities.
Route and traction knowledge card	The card which records the routes and types of traction unit that a driver is considered competent to drive when unaccompanied.*
Route knowledge	The knowledge and appropriate practical operating experience necessary to enable staff to work trains safely over a route.
Rule Book	Railway Group Standard GE/RT8000, which describes the duties and responsibilities of staff and the regulations in force to ensure the safe operation of the railway.
Run-through	A movement through a set of trailing points that are not correctly set for the movement.
Safety certificate	A certificate issued by a safety authority under the Railways and Other Guided Transport Systems (Safety) Regulations 2006. Transport undertakings are required to hold a safety certificate before they can operate on the mainline railway.
Sectional appendix	A Network Rail publication which details the layout, direction and maximum permitted speed of running lines. It also shows the location of stations, tunnels, level crossings and other relevant lineside features, but not lineside signals. Running lines are shown schematically and are not to scale.
Signal overrun risk assessment tool (SORAT)	A computerised quantitative risk assessment tool which forms part of Network Rail's signal overrun risk assessment process. SORAT calculates and stores signal overrun risk assessments for train-on-train collisions but does not include assessment of derailment or level crossing collision risks.
Signal Passed at Danger	A train movement in which any part of the train proceeds beyond its authority to move, eg when a train passes a colour light signal which is displaying a danger aspect.
Specially monitored driver risk register	A register of drivers who have been identified as potentially requiring additional support or monitoring in respect of their duties.
Temporary speed restriction (TSR)	A speed restriction which has been published in the Weekly Operating Notice.

Three-aspect colour light signal	A colour light signal capable of displaying three different signalling aspects. These are a red danger signal, a single yellow caution signal and a green proceed signal.
Total Operations Processing System (TOPS)	A mainframe based computer system used to track rail vehicles. It deals with destination, load, location and maintenance information for vehicles on the network.*
TPWS+	A version of TPWS, which has been enhanced by the fitting of an additional overspeed sensor on approach to the signal.
Traction inspector	A person responsible for the direct supervision and assessment of train drivers during a journey.
Train protection and warning system (TPWS)	A system fitted to certain signals which will automatically apply a train’s brakes if it approaches the signal at too high a speed, fails to stop at it, when the signal is displaying a danger aspect.
Transport operator	Any transport undertaking or infrastructure manager.
Transport undertaking	A company or person who operates a vehicle on railway infrastructure outside of engineering possessions, eg train operating companies.
TRUST	Train Running System on TOPS, a computer system that processes reports of train running and compares it with the timetable.
Vehicle Acceptance Body (VAB)	A body authorised to issue certificates of engineering acceptance for rail vehicles.
Weekly Operating Notice (WON)	A Network Rail document which provides information about engineering work, speed restrictions, alterations to the network and other relevant information to train drivers.
Working timetable	The version of the timetable for use by railway staff which gives full details of all trains, including empty coaching stock movements.*
Wrong-side failure	A failure that results in the protection provided by the signalling system being reduced or removed.
Zero-hours contract	A contract of employment under which work is undertaken conditional on the employer making it available but where there is no certainty that such work will be made available.

Appendix C - AWS and TPWS

The Automatic Warning System (AWS)

1 The British Rail Automatic Warning System (AWS) came into use from 1952. It uses the principle of electromagnetic induction to transfer information about the aspect displayed by signals from the track to the train and also provides a visual reminder of the aspect shown by the most recent AWS-equipped signal that the train has passed. Most lines are now fitted with AWS track equipment[47], although alternative systems are used in some areas. AWS trainborne equipment is fitted to all traction units authorised to operate on Network Rail managed infrastructure.

How AWS operates

2 AWS track equipment is normally fitted around 180 metres (but may be found up to 253 metres) on the approach to almost all colour light signals and to distant semaphore signals. The equipment fitted to the track consists of a permanent magnet and an electromagnet, which is energised only for a green proceed signal. The AWS equipment installed on trains consists of an AWS receiver (generally mounted around the leading bogie), a combined AWS/TPWS control unit and an audible warning indicator unit, which create either a bell tone or a warning horn tone. The system will also include an LED or a mechanical visual indicator, which can show either an ‘ALL BLACK’ or a ‘YELLOW-BLACK’ (sunflower) indication, and a reset button.

3 A train moving in the right direction over the track equipment will pass over the permanent magnet first. The AWS receiver on a train will detect the permanent magnet and enter the ‘PRIMED’ state and the visual indicator will show ‘ALL BLACK’. If the AWS receiver detects the energised electromagnet (ie if the signal is showing a proceed aspect) within around 1 second then the AWS system will enter the ‘CLEAR SIGNAL RESPONSE’ state. The visual indicator will remain ‘ALL BLACK’ and the audible warning indicator will sound the bell for 0.5 to 1.5 seconds.

4 If, however, the AWS receiver does not detect the energised electromagnet (ie if the signal is showing a restrictive aspect or the electrical feed to it has failed) then the AWS system will enter the ‘RESTRICTIVE RESPONSE’ state. In this state the visual indicator remains ‘ALL BLACK’ but the audible warning indicator will sound the horn in order to give an ‘AWS warning’. The driver has a response time of between around 2 to 2.7 seconds (depending on the type of traction unit and the standard in force when the system was fitted) to acknowledge the warning by pressing and releasing the AWS reset button.

[47] The RAIB’s investigation into a near-miss at Butterswood level crossing, Lincolnshire, on 25 June 2013 (RAIB report 12/2014) found that AWS had not been fitted to signals on the Ulceby to Barton-on-Humber route, for reasons which Network Rail was unable to explain. There are also some complex station areas where the permitted speed is 30 mph or less, where AWS is not fitted. These areas are listed in the sectional appendix and indicated to drivers by lineside signs.

5 If the driver responds in time then the AWS system enters the 'RESTRICTIVE ACKNOWLEDGEMENT' state. The horn will stop sounding and the visual indicator changes to 'YELLOW BLACK' (to remind the driver that the train has passed a restrictive aspect). If they do not respond in time, then the AWS system enters the 'RESTRICTIVE NON-ACKNOWLEDGEMENT STATE'. This means that the horn will continue to sound and an AWS brake demand will be initiated. Once the driver acknowledges the warning, the horn will cease to sound. The AWS brake demand will be cancelled 59 seconds after the driver's acknowledgement.

6 For vehicles designed to meet the requirements of GE/RT 8035 (such as Tangmere) the driver's acknowledgement of the warning during the brake demand will also return the AWS system into the 'RESTRICTIVE ACKNOWLEDGEMENT' state, where it can detect subsequent AWS permanent magnets.

Train Protection and Warning System (TPWS)

7 In the period immediately before and after the privatisation of British Rail (BR), the principal safety risk on the network arose from SPADs, with the possibility of colliding with other trains or with buffer stops[48]. It was recognised that the mitigation provided by AWS was limited, because it relied on the driver reacting appropriately to the AWS warning, and reducing the train's speed accordingly. With a view to establishing the best method of reducing the risk that a driver might fail to do this, BR had implemented two pilot schemes of Automatic Train Protection (ATP), on the Great Western Main Line between Paddington and Bristol/Bristol Parkway, and on the Chiltern line between Marylebone and Aynho Junction. ATP provides full supervision of the driver's actions, and intervenes to apply the brakes if the train's speed is greater than the calculated safe speed for the current situation.

8 These two systems remain in use, but extending either of them to the rest of the network was not considered reasonably practicable, and in the mid-1990s the industry developed a more cost-effective solution which was intended to address a large proportion of the risk from SPADs, by stopping a train which passes a signal at danger before it reaches a point at which it could collide with another train. This solution, the Train Protection and Warning System (TPWS), is also intended to enforce observance of speed restrictions and to control the speed at which trains approach buffer stops.

How TPWS operates

9 TPWS uses radio frequency transmitters (known as 'loops') placed between the rails. One pair of loops is placed at the signal itself – this is known as the train stop system (TSS). At some signals deemed to be higher risk, another pair of loops is placed at a specified distance on the approach to the signal – this is known as the overspeed sensor system (OSS). The distance between the OSS and the signal is calculated so that it will permit an approaching train to be stopped within the within the calculated safe overrun distance of the signal (based on the line speed, gradient and braking curve of the trains using the line). Both the TSS and the OSS loops are activated if the signal is showing a stop aspect.

[48] A buffer stop is treated as a signal for the purposes of TPWS installation.

10 At some signals assessed as being at very high risk from signal overruns, a second OSS is fitted at a further distance from the signal. This enhancement is known as TPWS+.

11 The TPWS equipment installed on trains consists of a TPWS receiver, a combined AWS/TPWS control unit and a TPWS visual indicator in the cab.

12 OSS loops are set between 4 and 36 metres apart. When the train passes over the first (arming) loop the TPWS receiver will detect this and the system will enter the 'PRIMED' state. This will start an electronic timer in the control unit. When the train passes over the second (trigger) loop, the control unit checks if the timer has expired. If it has, then the system resets and the driver receives no indication. If the timer has not expired (ie if the train has travelled too quickly between the two loops) however, then the system triggers a TPWS brake demand and the driver receives a flashing indicator that this has occurred. Once the driver acknowledges the brake demand (using the AWS reset button), the TPWS brake demand will be cancelled after 59 seconds.

13 TSS loops are placed adjacent to each other at the signal. If the TPWS receiver detects both loops when they are energised then a TPWS brake demand is generated as before. It is possible for the driver to over-ride the TSS if the train is required to pass a signal at danger with permission of the signaller.

The integration of AWS and TPWS

14 AWS and TPWS have different objectives and are treated as separate systems within the Rule Book and relevant standards. However the introduction of TPWS in the early 2000s meant that the two systems became substantially integrated and that existing AWS equipment on traction units had to be modified as a consequence. This means that the AWS and TPWS systems on trains, although separate in function, share a number of components, such as the combined AWS/TPWS control unit.

15 One consequence of this integration is the 59 second duration of AWS brake demands. This represents a change from the way in which AWS originally operated, which allowed the driver to cancel an AWS initiated brake demand at any time. The rules in force at the time also meant that the driver was not required to stop the train or inform the signaller when an AWS brake demand took place. TPWS was fitted to trains from 2002, and the Rule Book was amended in 2008 to require the driver to stop the train and inform the signaller in the event of an AWS brake intervention.

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