

# Rail Accident Report



## Incident at Llanbadarn Automatic Barrier Crossing (Locally Monitored), near Aberystwyth, 19 June 2011

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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# **Incident at Llanbadarn Automatic Barrier Crossing (Locally Monitored), near Aberystwyth, 19 June 2011**

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## Summary

Shortly before 22:00 hrs on Sunday 19 June 2011 a passenger train, travelling from Aberystwyth to Machynlleth, ran onto the level crossing at Llanbadarn while the barriers at the crossing were raised, and came to a stop with the front of the train about 31 metres beyond the crossing. There were no road vehicles or pedestrians on the crossing at the time.

The immediate cause of the incident was that the train driver did not notice that the indicator close to the crossing was flashing red until it was too late for him to stop the train before it reached the crossing. Factors behind this included the driver's 'workload' (his need to observe a screen in the cab at the same time as he should also be observing a lineside indicator), the design of the equipment associated with the operation of the level crossing, and the re-setting of the signalling system on board the train before it could depart from Aberystwyth. An underlying cause of the incident was that the signalling system now in use on the lines from Shrewsbury to Aberystwyth and Pwllheli does not interface with the automatic level crossings on these routes.

The RAIB has made six recommendations, three directed to Network Rail, two to Arriva Trains Wales and one to the Rail Safety and Standards Board. These cover the development of engineering solutions to mitigate the risk of trains passing over automatic crossings which have not operated correctly; changes to the operating equipment of Llanbadarn crossing; the processes used by railway operators to request permission to deviate from published standards; the operational requirements of drivers as trains depart from Aberystwyth; and the way in which drivers interact with the information screens of the cab signalling used on the Cambrian lines.

# Introduction

## Preface

- 1 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.
- 2 The RAIB does not establish blame or liability, or carry out prosecutions.

## Key definitions

- 3 All dimensions and speeds in this report are given in metric units.
- 4 The zero datum point for the metric track location dimensions is at Sutton Bridge junction (west of Shrewsbury). All imperial mileages are measured from a datum of 31 miles 20 *chains* at the site of the former Buttington Junction, east of Welshpool.
- 5 The Cambrian main line runs from Shrewsbury to Aberystwyth, via Welshpool, Newtown and Machynlleth. Trains heading towards Aberystwyth are running in the 'down' direction and those towards Shrewsbury in the 'up' direction according to UK mainline railway convention.
- 6 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

- 7 At 21:54 hrs on Sunday 19 June 2011 train 2J50, the 21:30 hrs service from Aberystwyth to Machynlleth, passed over Llanbadarn crossing while the barriers were raised and the crossing open to road traffic. The train was braking heavily and stopped on the crossing.
- 8 No injuries resulted from the incident, but there was potential for a collision between the train and a road vehicle or pedestrian.

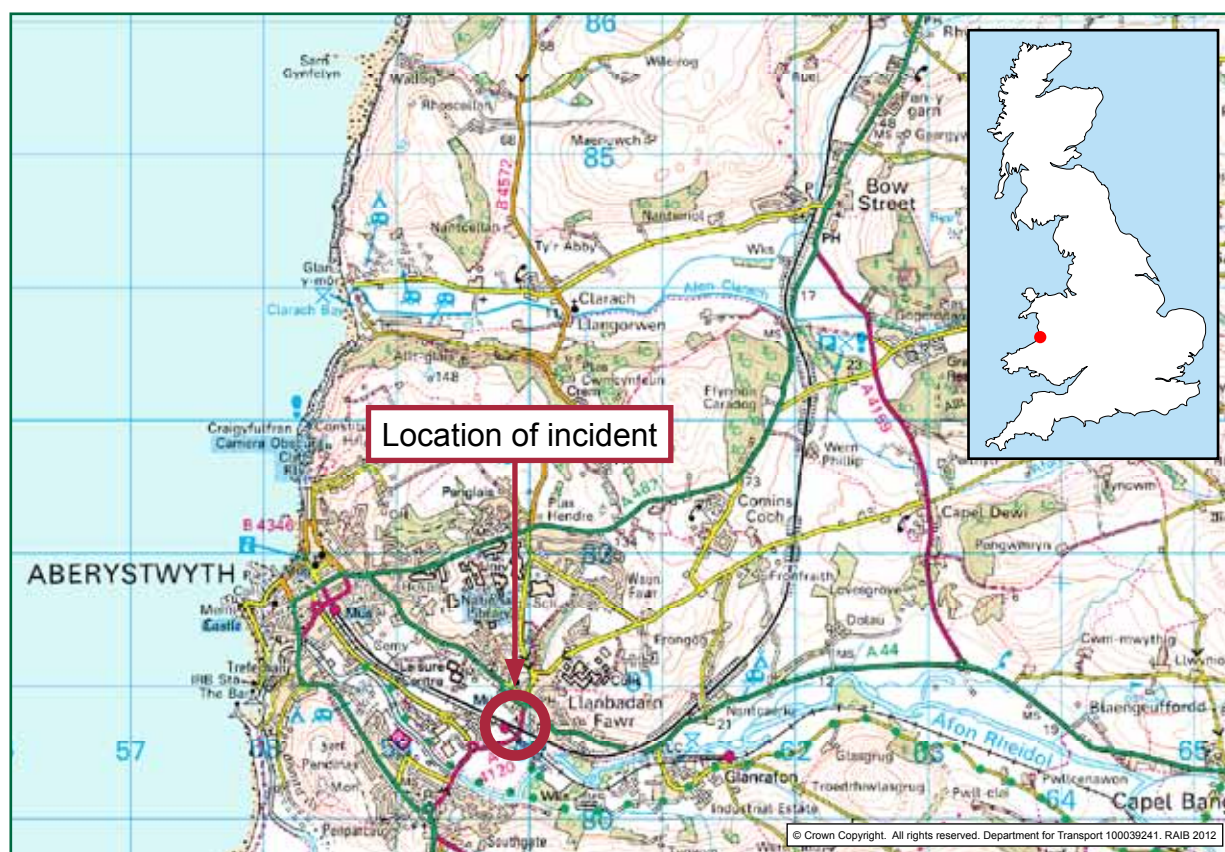


Figure 1: Extract from Ordnance Survey map showing location of incident

## Context

### Organisations involved

- 9 Network Rail owns, operates and maintains the main line infrastructure at Llanbadarn, including the level crossing. It employs the signaller at Machynlleth signalling control centre.
- 10 The Vale of Rheidol Railway Ltd operates a narrow gauge heritage railway which also has a level crossing at Llanbadarn (figure 2). The maintenance of the controls for this crossing is carried out by Network Rail, as the two crossings are interlinked (paragraph 31). The Vale of Rheidol Railway level crossing was not used by any rail vehicle during the period around the incident on 19 June, and its operation was not examined during this investigation.



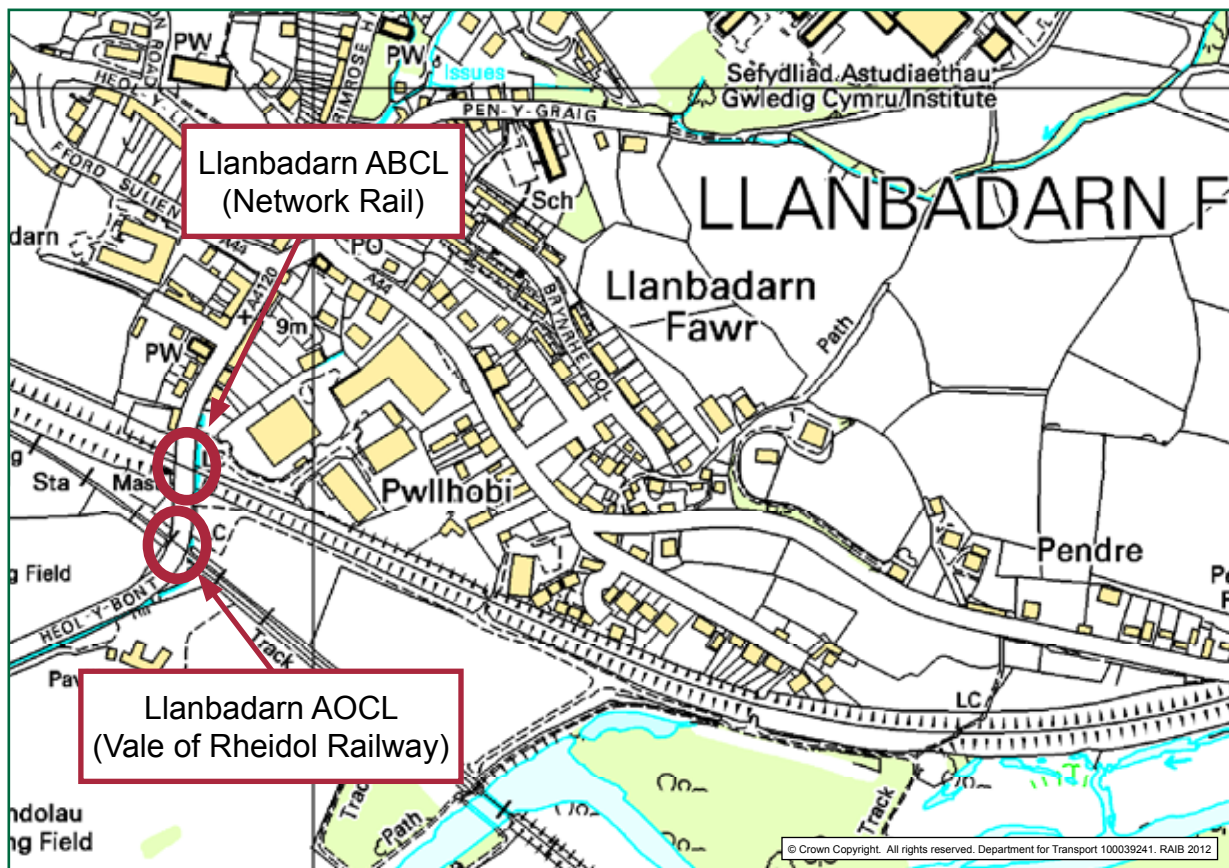


Figure 2: Extract from large-scale Ordnance Survey map showing locations of crossings at Llanbadarn

- 11 Arriva Trains Wales Ltd operates the passenger service between Aberystwyth and Shrewsbury, including train 2J50. It employs the driver of that train.
- 12 Network Rail and Arriva Trains Wales Ltd freely co-operated with the investigation.

### Location

- 13 The Llanbadarn level crossings are located where the two railways cross the A4120 road approximately one mile (1.6 km) east of their terminal stations at Aberystwyth. The two adjacent level crossings are about 60 metres apart. The more northerly crossing is on the Shrewsbury to Aberystwyth line of Network Rail, at 128,222 metres (94 miles and 56 chains) and the southern level crossing is on the Vale of Rheidol Railway, 1 mile and 15 chains (1.9 km) from Aberystwyth (figure 3).
- 14 The A4120 links the A44, entering Aberystwyth from the east, with the A487, which gives access to the south and south east of the town. It provides an effective by-pass to the centre of the town, and also gives access to an area of 'out of town' shopping and industrial premises that have been developed in recent years. The road traffic over the crossings is heavy, with both cars and lorries constantly crossing the railways during the working day. A Network Rail census on 27 October 2010, at midday, recorded a count of 186 vehicles per hour. The RAIB undertook a census on 18 July 2011 at 19:30 hrs which recorded a count of 453 vehicles per hour.
- 15 The Network Rail line rises as it approaches Llanbadarn *Automatic Barrier Crossing, Locally Monitored* (ABCL) from Aberystwyth, and continues to rise until approximately 325 metres east of the crossing (figure 4).





Figure 3: Llanbadarn ABCL crossing looking south along A4120 (with the Vale of Rheidol Railway AOCL crossing in the background)



Figure 4: Llanbadarn ABCL crossing approach in the up direction

### Train involved

- 16 The train involved in the incident was a two-car Class 158 diesel multiple unit. This is one of 182 such units, introduced into service from 1989 to 1992, and used on regional services, at speeds of up to 90 mph (140 km/h).

### Rail equipment/systems involved

#### Signalling control

- 17 The Cambrian lines of the Network Rail system run from Shrewsbury to Machynlleth, Dovey Junction and Aberystwyth (the Cambrian Main Line), and from Dovey Junction to Pwllheli (the Cambrian Coast Line). They are controlled from a signalling control centre at Machynlleth, using a system known as the Level 2 *European Rail Traffic Management System* (ERTMS). The Cambrian lines ERTMS was fully commissioned on 26 March 2011 and replaced the *Radio Electronic Token Block* (RETB) system which had been installed by British Rail in October 1988.
- 18 The ERTMS scheme on the Cambrian main and coast lines includes the installation of an *in-cab signalling* system. This consists of equipment designed to comply with the European specification for *European Train Control System* (ETCS) at Level 2 and *Global System for Mobiles-Railway* (GSM-R) for communications. At this level, ETCS does not require fixed signals along the trackside and drivers receive a *movement authority* (MA) (with maximum permitted speed), via the GSM-R, on display screens installed on the control desks in the cab. The display is known as a Driver Machine Interface (DMI).
- 19 The running lines are divided into block sections and the boundary of each section may be identified by a fixed 'block marker'. The marker indicates to the driver the position at which the train must come to a stand when a 'stop' indication is shown on the DMI. This is known as a 'closed' block marker. When the DMI indicates a MA past a block marker, that marker is defined as being 'open'. The positions of trains are detected by *track circuits* and *axle counters*. *Balises* are also installed (between the running rails) at various locations along the lines; these are detected by the train and provide additional train positioning information. A description of the ERTMS system and equipment is at appendix C.

#### ERTMS operating modes

- 20 A train operating in ERTMS level 2 can be driven in different modes. These are described in detail in appendix D. The three modes of operation relevant to this incident are described below.
- 21 **Staff Responsible (SR) mode.** This is an operational mode that allows the driver to move a train under their own responsibility in an ERTMS equipped area. The driver may use it in the following circumstances:
- if the signalling system is unable to issue a movement authority;
  - when the driver is authorised by the signaller to use the override function; and
  - when the signalling system does not know the position of the train.
- 22 **On sight (OS) mode.** A movement authority is issued to the train that still gives protection through the signalling systems, but will allow entry into a section of track already occupied by another rail vehicle. The driver is responsible for stopping the train short of any obstruction ahead.

- 23 **Full supervision (FS) mode.** The normal movement authority that gives full signalling and train protection. The driver is permitted to drive the train at the maximum speed shown on the DMI, but ERTMS will normally prevent the train entering an occupied section of track.

#### ERTMS modes for trains departing Aberystwyth

- 24 The design of the ERTMS system at Aberystwyth means that trains normally start their journey in OS mode. Train 2J50, the incident train, departed the station in SR mode, because the ERTMS equipment on the train did not know the train's position (paragraph 80). If a train is started in SR mode, once position knowledge has been regained by the detection of balises by the moving train, the system will automatically step through from SR to OS and then to FS mode (to give maximum protection). The step from one mode to another will normally happen at the next balise that the train encounters as it travels along the track.

#### Cambrian lines level crossings - general

- 25 The Network Rail Llanbadarn level crossing is an Automatic Barrier Crossing, Locally Monitored, commonly known as an ABCL. The adjacent Vale of Rheidol crossing is an *Automatic Open Crossing, Locally Monitored*, commonly known as an AOCL.
- 26 On the Cambrian Main Line there are two AOCL crossings and two ABCL crossings (including Llanbadarn). There are a further 11 locally monitored crossings on the Cambrian Coast Line, and a total of 167 such crossings on Network Rail as a whole. There are also several of these types of crossings on heritage railways throughout the UK.
- 27 The intent of the design of both AOCL and ABCL crossings was to cause less delay to the road user than gates or full barriers and to normally operate automatically on the approach of a train. An installation of an ABCL type crossing is suitable for a busier road than an AOCL and is less expensive than an Automatic Half Barrier (AHB) crossing. The designs were introduced in 1963 (AOCL) and 1988 (ABCL).

#### Operation of Llanbadarn ABCL

- 28 Llanbadarn ABCL crossing operates in a similar way under ERTMS as it did under RETB signalling and is described in the following paragraphs.

- 29 Until the arrival of a train initiates its operation, the crossing is in its 'normal state'. In this state an indicator, known as the *driver's crossing indicator* (DCI), shows a flashing red light to rail traffic (figures 5 and 6), and there are no lights shown to road traffic. If, when a train approaches, the crossing sequence has initiated correctly, and the highway flashing red lights have begun to show to road traffic, and the barriers have started to lower, then the flashing red light at the DCI will be replaced by a flashing white light. This flashing white light informs the driver that the crossing is functioning correctly. The maximum permitted speed of trains as they pass over the crossing (known as the crossing 'permitted' speed) is limited by the ETCS<sup>1</sup>, and a 'sighting board' is placed a set distance before the crossing. This board should be positioned so that a train travelling at the permitted speed<sup>2</sup> can be stopped before reaching the crossing if the DCI has not displayed a flashing white light by the time the front of the train passes the board. This board is referred to in the Office of Rail Regulation Guidance<sup>3</sup> as the special speed restriction board (SSRB). This board is known in the Rule Book as a 'sighting board'. Another board, known as the 'warning board' (paragraph 37) warns the driver that the train is approaching the sighting board.

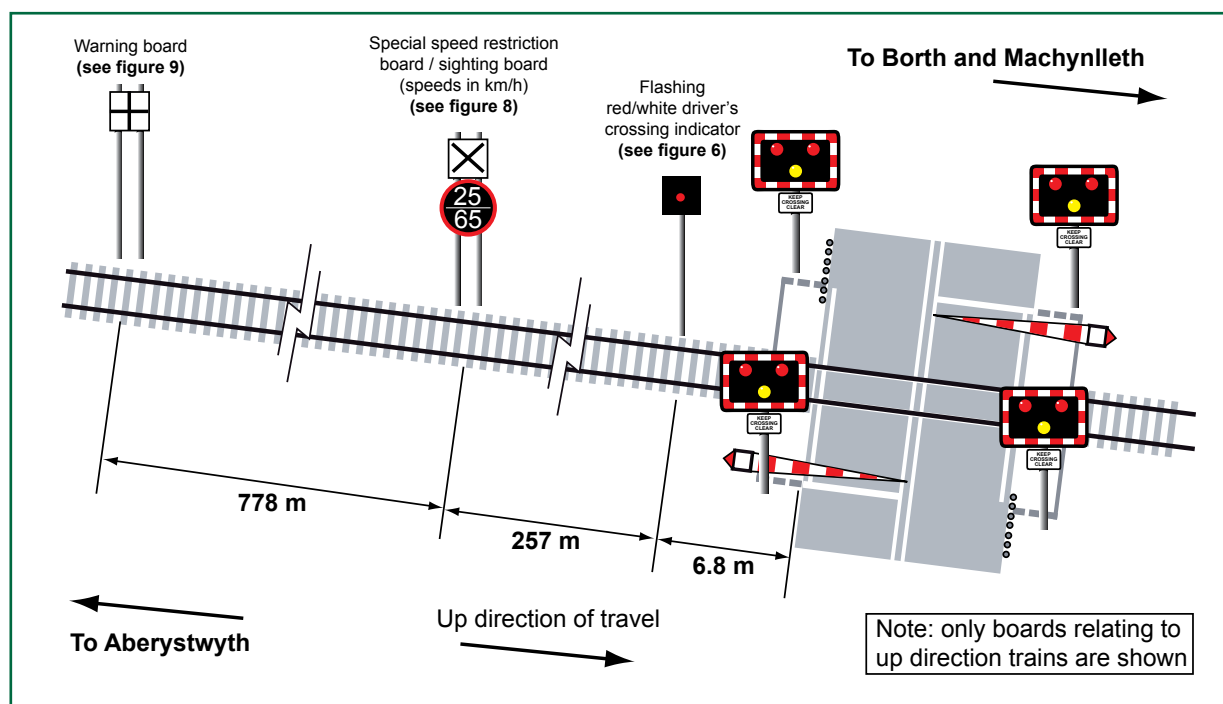


Figure 5: Schematic diagram of Llanbadarn ABCL

- 30 If the driver observes that there is a flashing white light at the DCI, and also that the crossing is clear, he or she may then drive the train across the crossing at the speed shown on the DMI (and the sighting board). At Llanbadarn the speed for up passenger trains, as defined in the *level crossing order*, is 40 mph (approximately 65 km/h).

<sup>1</sup> On the Cambrian ERTMS lines, the 'permitted speed' is displayed to the driver on his DMI.

<sup>2</sup> At Llanbadarn, the permitted speed is also displayed at the sighting board (figure 8). However the speed information shown on the sighting board is only used for degraded mode operation.

<sup>3</sup> The Office of Rail Regulation Guidance, 'Level Crossings: A guide for managers, designers and operators', Railway Safety Publication 7 August 2011 (ref: <http://www.rail-reg.gov.uk/server/show/nav.1567>). The guidance at the time of the incident was 'Railway Safety Principles and Guidance part 2E: Guidance on level crossings', produced by HSE in 1996. The guidance on this topic is the same in both documents.





Figure 6: Llanbadarn ABCL showing driver's crossing indicator (DCI) flashing red

- 31 The two crossings at Llanbadarn are interlinked so that the activation of one crossing will prevent the activation of the other until the first train has passed. This is so that only one crossing can be closed to road traffic at any time, since the heavy road traffic could back up over the other crossing when one is shut.
- 32 The interlinking of the crossings is designed so that trains on Network Rail will have priority over those on the Vale of Rheidol Railway. To achieve this for main line trains ready to depart from Aberystwyth station, the driver must press a plunger<sup>4</sup> (situated on the platform, 53 metres from the buffer stops – figure 7) to start a nominal 10 minute timer. The timer's circuitry prevents the Vale of Rheidol crossing from operating, although it does not activate any lights or barriers at the Cambrian crossing. The crossing sequence will then begin if the train reaches the *strike-in point* within the 10 minute time-out.

<sup>4</sup> A plunger (push button) that is operated by a member of train crew, when the train is ready to depart. The plunger operates signalling equipment associated with Llanbadarn ABCL and AOCL crossings.



Figure 7: Plunger on platform

- 33 Trains approaching from Aberystwyth on Network Rail are detected at the 'strike-in point' by a track circuit that starts at 128,769 metres (95 miles 4 chains), 547 metres on the Aberystwyth side of the crossing. The occupation of this track circuit (known as 'AA' track circuit) by a train activates the crossing sequence. After the crossing is activated, the DCI should show a white flashing light 11 seconds after strike-in, provided that the crossing has begun to operate normally (paragraph 29). If a train is travelling at the permitted speed of 65 km/h, the white flashing light will have been illuminated for approximately 4.6 seconds before a driver passes the sighting board.
- 34 However, if a train does not reach the strike-in point within the 10 minute timer window, the crossing sequence will not activate, the crossing remains open to the road and the DCI continues to exhibit a flashing red light to the approaching train.
- 35 The Vale of Rheidol crossing will only operate:
  - if the Network Rail crossing is not being operated (paragraph 32); and
  - when the Vale of Rheidol train driver has depressed a plunger, after stopping the train before the crossing.
- 36 The sighting board for up direction trains at Llanbadarn ABCL is located 257 metres before the DCI (figures 5 and 8), which, in turn, is located 6.8 metres before the crossing. Thus the board is approximately 264 metres before the crossing. The DCI can be seen by a driver approximately 950 metres before the train reaches it. The warning board is located 778 metres on the approach to the sighting board.



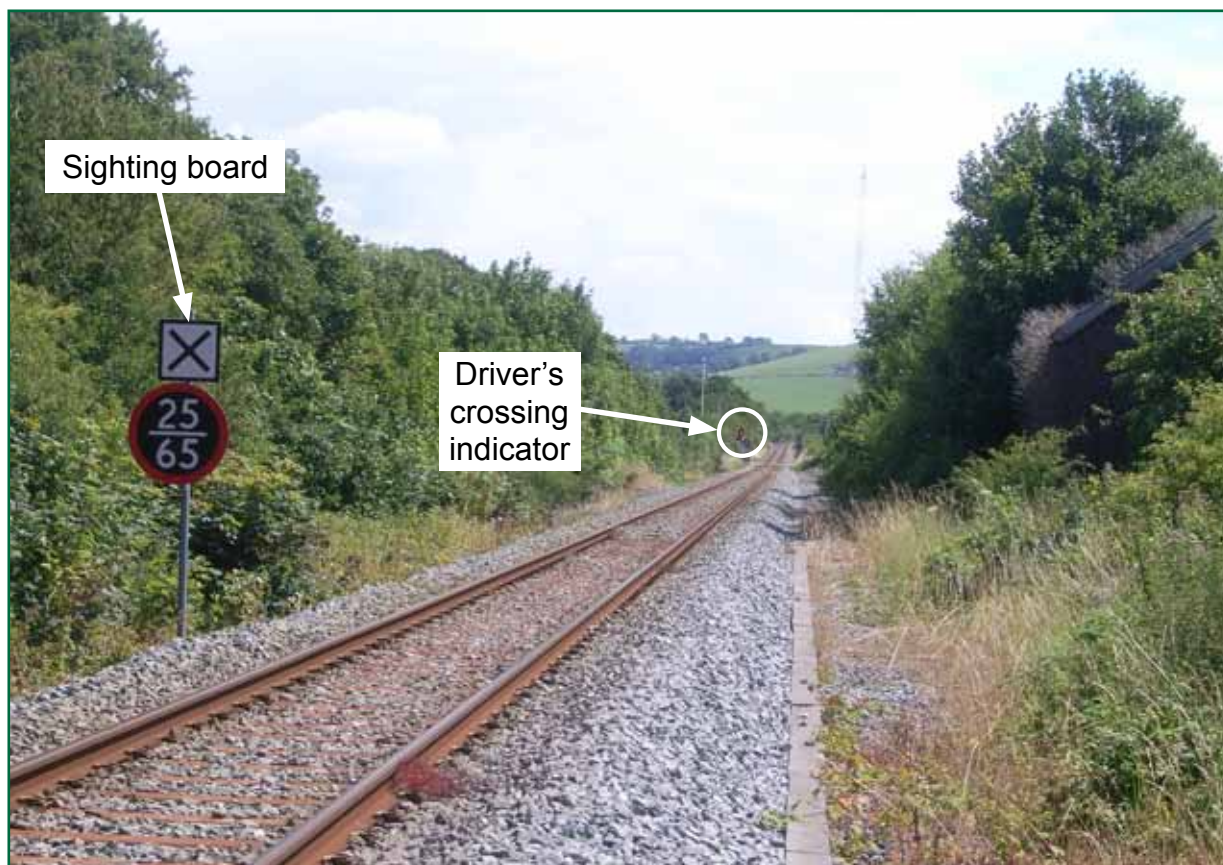


Figure 8: The Sighting board on the up approach to Llanbadarn ABCL (with the driver's crossing indicator displaying a flashing red)

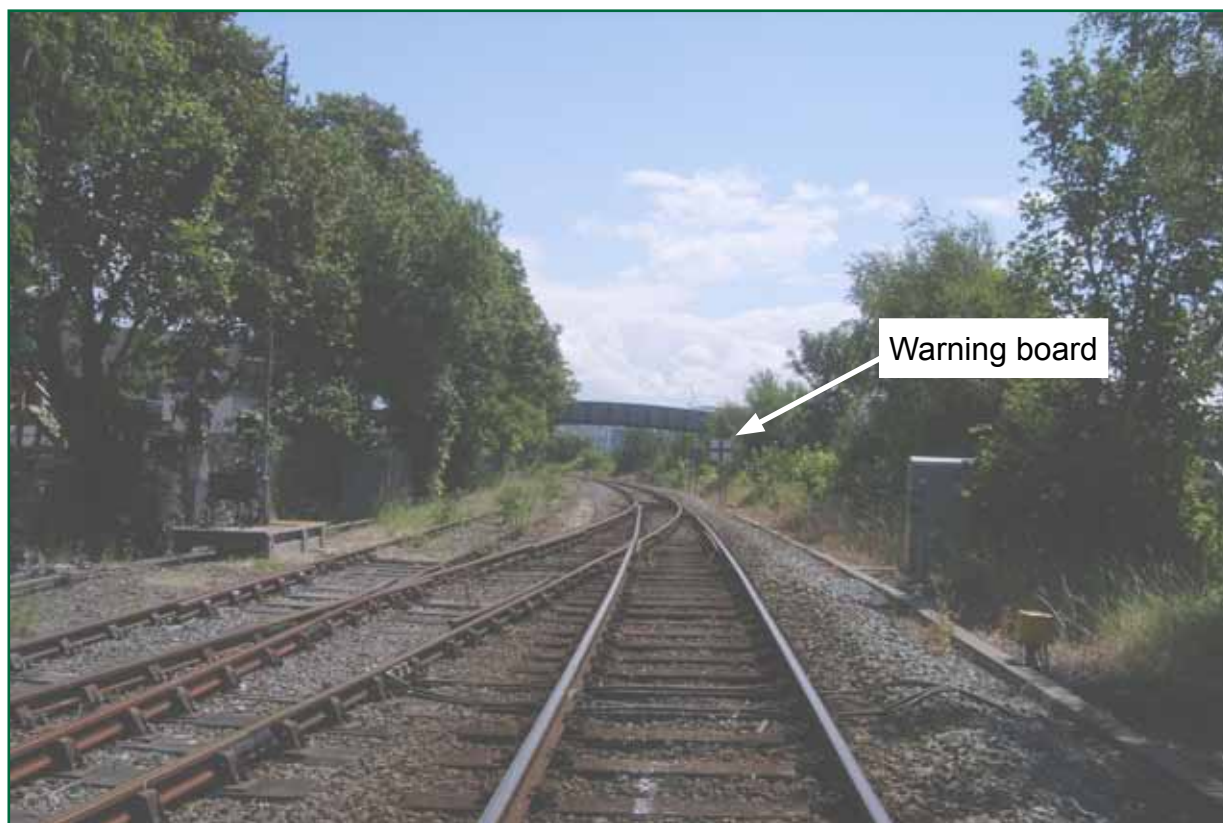


Figure 9: Warning board - as seen by an approaching train driver after leaving Aberystwyth station

### The ABCL warning board

- 37 A warning board (figure 9) warns the driver that the train is approaching the sighting board<sup>5</sup>. Under ERTMS operation, on the approach to the warning board, an audible alarm is sounded in the driver's cab and a text message, 'ABCL ahead' appears on the driver's DMI screen. This text message disappears from the DMI when it is acknowledged by the driver by pressing a button on the DMI. If the message is not acknowledged within 3 seconds, then the brakes on the train will automatically apply.

### Staff involved

- 38 The driver of train 2J50 had been fully qualified as a driver for just over two years. He was based at Machynlleth depot.
- 39 The signaller had 11 years experience, originally at Machynlleth signal box (controlling the RETB system) and latterly (since its opening in October 2010) at the ERTMS signalling control centre.

### External circumstances

- 40 The weather at Llanbadarn at the time of the incident was clear (with some scattered clouds) and it was shortly after sunset. There had been no rainfall in the previous 12 hours and visibility was in excess of 1 km. The weather played no part in the incident.

## **Events preceding the incident**

- 41 The driver of train 2J50 booked on duty at Machynlleth station at 15:18 hrs on 19 June. He drove several trains that day until, at approximately 19:47 hrs, he left Shrewsbury 20 minutes late with train 1J27, which subsequently became 2J50 at Aberystwyth. On arrival at Machynlleth, the train was further delayed by a late running train from Aberystwyth and arrived at Aberystwyth at 21:41 hrs (approximately 21 minutes late). The train had been due to depart Aberystwyth at 21:30 hrs.
- 42 Train 2J50 finally departed from Aberystwyth at 21:51:35 hrs and reached Llanbadarn ABCL crossing (with the road barriers raised and open to road vehicles) at 21:54:07 hrs. The train was braking heavily and stopped on the crossing.

## **Consequences of the incident**

- 43 There were no injuries to train crew or passengers. There were also no reported near misses with road or pedestrian traffic.

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<sup>5</sup> Warning board and sighting board are both referred to in the Rule Book, GE/RT8000/TW8 ERTMS, 'Level crossings on ERTMS lines', Issue February 2010, section 4.

## Events following the incident

- 44 The train came to rest at 21:54:13 hrs, standing on the crossing. The front of the train was approximately 31 metres on the Machynlleth side of the crossing and the rear of the train was 4.5 metres on the Aberystwyth side.
- 45 After it was clear that no collision had taken place the driver drew his train clear of the crossing at 21:54:19 hrs, to allow road traffic to resume.
- 46 The driver then telephoned the signaller at Machynlleth, while the train was still moving towards Borth (the next station), and reported the incident. When the train stopped at Borth station, the driver realised how serious the incident was and telephoned the signaller again to request relief. The driver was subsequently relieved, and another driver was provided to drive the train to Machynlleth.

## The investigation

### Sources of evidence

47 The following sources of evidence were used:

- witness statements;
- the train's *On Train Data Recorder* (OTDR) and ERTMS data;
- *Forward Facing Closed Circuit Television* (CCTV) recordings taken from train 2J50;
- telephone voice recordings from Machynlleth signalling control centre;
- Llanbadarn ABCL data logger;
- site photographs and survey measurements;
- RAIB reconstruction of trains departing Aberystwyth in different ERTMS modes;
- weather reports;
- Network Rail level crossing information for Llanbadarn ABCL;
- staff training and competence records;
- documents and information concerning the ERTMS project, infrastructure maintenance, and train operation supplied by Network Rail, Arriva Trains Wales, RSSB and the Office of Rail Regulation (ORR); and
- a review of previous RAIB investigations that had relevance to this incident.

## Key facts and analysis

### Background information

#### The ERTMS project

#### ERTMS trial installation

- 48 The Cambrian lines in Wales were chosen in the early 2000's by Network Rail for the pilot installation of the European Rail Traffic Management System in the UK. The route was chosen because it was a self contained part of the rail network, the existing RETB signalling system was approaching the end of its economic life and the radio frequencies that it operated on were being withdrawn.
- 49 The first phase of the pilot scheme was the commissioning of the Pwllheli to Harlech section in October 2010. The rest of the scheme, which included the line between Machynlleth and Aberystwyth, was commissioned in March 2011.

#### Level Crossings and ERTMS

- 50 As part of the ERTMS project, four existing crossings (of various types, but none of them ABCL) were converted to barrier crossings with CCTV (controlled from Machynlleth) and protected by the ETCS in-cab signalling system. This means that when the crossing is closed to road traffic, the barriers are down and the crossing is proved to be clear, a movement authority will be given to an approaching train.
- 51 As described in paragraph 143 the operation of the ABCLs (and AOCLs) on the Cambrian lines was not changed to interface with the ETCS in-cab signalling as part of the new ERTMS cab signalling project. However the permitted speed of the crossing was supervised by the ETCS system (paragraph 28). The driver of an approaching train was still required to monitor the crossing and the DCI. No indication of the status of the crossing was provided on the driver's DMI screen.
- 52 This means that a movement authority can be granted over crossings of this type, with the train driver expected to stop his train before the crossing, if the crossing remains open to road traffic (paragraph 29).

#### Requirements for ABCLs

#### Railway Safety Principles and Guidance

- 53 At the time of the incident (and when the Cambrian Lines ERTMS system was designed and commissioned) guidance for level crossings in Great Britain was contained in the HSE 1996 publication 'Railway Safety Principles and Guidance, Part 2, Section E, Level Crossings' (see footnote 3).
- 54 In August 2011, two months after the incident, the guidance was withdrawn and re-issued as ORR Guidance 'Level Crossings: A guide for managers, designers and operators'. The safety principles and guidance in respect of automatic crossings remained the same.
- 55 Paragraph 93 of the 1996 document specified the need for a SSRB (also known as a sighting board) for ABCLs. The SSRB was to be located at the 'point from which the crossing (permitted) speed begins.'



- 56 The document did not specify what form of indication should be given to train drivers if an ABCL crossing is not working correctly. However, it did state that 'the indication to the train driver should only be displayed when the barriers have begun to descend and at least one of the intermittent red lights of each road traffic signal is lit, and the main power supply has not failed'.

### Railway Group Standards

- 57 The rail industry's own requirements are laid down in *Railway Group Standard* GK/RT0192, issue 1, dated April 2010 'Level Crossing Interface Requirements'. Part 2.7.3 of this standard gives the general requirements for a level crossing sighting board for lines with ETCS level 2. It states in particular:
- 'The crossing (permitted) speed(s) applicable to each level crossing approach shall be compatible with the requirement for trains to stop before reaching the level crossing if the train driver cannot confirm that it is safe to pass over the level crossing when the train reaches the level crossing sighting board.'
- 58 Another Railway Group Standard, GE/RT8026, issue 1, dated December 2000 'Safety Requirements for Cab Signalling Systems' defines the safety requirements for the provision and use of rail traffic management and control systems which make use of cab signalling. This includes the use of automatic train protection at ABCL crossings and states:
- 'On AOCL and ABCL crossings, the ATP<sup>6</sup> sub-system shall prevent the train proceeding over the crossing unless the driver's indication shows that it is safe to proceed.'

### Network Rail Standards

- 59 Network Rail's internal standards also specify requirements for locally monitored crossings. Standard NR/L2/OPS/100, issue 2 of June 2008, 'Provision, Risk Assessment and Review of Level Crossings' states:
- 'Speed of trains to be limited so that drivers can stop short of the crossing from the point at which the crossing comes fully into view.'
- 60 Network Rail standard NR/L3/SIG/30018 issue 1 (which was in force at the time of the incident) gives technical design guidance for level crossing signalling and operational telecommunications. Section 7 deals with ABCLs, and the positioning of the special speed restriction board. This gives a detailed process which determines the location of the speed restriction board and the speed to be displayed.

### The Rule Book and locally monitored automatic crossings

- 61 Railway Group Standard GE/RT/8000, the Rule Book, includes module TW8 ERTMS, Level Crossings. Section 4 of module TW8 describes the duties of train drivers at ABCL crossings.

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<sup>6</sup> ATP (*Automatic Train Protection*) is a communication and control system which utilises lineside equipment to transmit permissible speed and signal aspect information to trains.



- 62 Paragraph 4.2 a, which deals with normal working of locally monitored crossings, tells the driver that:

‘On passing the level crossing sighting board, you must make sure that you can see that the crossing is clear; and the white light next to the crossing is flashing.’

- 63 Paragraph 4.2 b, which deals with situations when the crossing is not working normally, and informs the driver that:

‘You must stop before reaching the crossing if:

The white light next to the crossing is not flashing or, at an ABCL and some AOCLs, the red light is flashing.’

### Competence and fitness of the train driver

- 64 The driver of the train was employed by Arriva Trains Wales, and had always been based at Machynlleth depot.
- 65 The driver had been involved in a safety incident in 2009 (details are given in paragraph 121) and had subsequently received further training, monitoring and assessments.
- 66 The RAIB has reviewed the driver’s roster for the two weeks leading up to the incident. This has provided no evidence that the driver would have been fatigued by his work at the time of the incident. No evidence has been found indicating the presence of other factors likely to have affected his performance.
- 67 The driver was tested for drugs and alcohol after the incident, in line with normal industry practice, and found to be clear for both.

### The train

- 68 The Class 158 was one of the first multiple unit trains to be fitted with disc brakes, which can be applied by a four position control. *Step* one is an initial application with step three a full service application, and step four an emergency stop application. The deceleration between step three and step four is, in practical terms, identical, as the same braking force is applied in each case. However, the brake force is applied more quickly in the emergency application. The train is also fitted with a separate power controller, and power can be applied in seven separate notches from 1 to 7 (full power).
- 69 The distance within which a train should stop after brakes are applied is specified in Railway Group Standard GM/RT2044, ‘Braking system requirements and performance for multiple units’ (currently issue 4 dated June 2001). Class 158 braking performance is measured against the *braking curve* A3 from figure 3 of GM/RT2044, one of the curves shows the expected braking performance from different speeds for various types of train. This shows that a train travelling at 40 mph (65 km/h), should come to a stop in 205 metres after the brake is first applied (the distance travelled while brake pressure rises is included within the 205 metres).
- 70 The train came to a halt 218 metres after the brakes were initially applied, a distance consistent with the values defined by curve A3, given the stepped way (evidenced by the OTDR) in which the step 3 and emergency brake was applied.
- 71 There is no evidence of any *wheel slide* from the OTDR record.

## Sequence of events

- 72 The sequence of events has been derived from the following:
  - witness evidence;
  - data from the ERTMS and signalling systems; and
  - data from the OTDR and other train recording systems.
- 73 On arrival at Aberystwyth, the driver immediately changed ends and as he did so he pressed the plunger (on the platform) at 21:42:37 hrs. Having entered the east-facing cab of the train, the driver switched on his control desk, which included the ERTMS system. The ERTMS system subsequently booted up correctly and the driver entered train departure data via his DMI.
- 74 Once the ERTMS system was operating correctly, the train automatically connected to the signalling control centre at Machynlleth and began requesting movement authorities in anticipation of departure. These requests were automatically generated by the train every few seconds.
- 75 At this time, the signaller at Machynlleth had not cancelled the inbound route (for train 1J27) into Aberystwyth and had not set an outbound route (for train 2J50 to Machynlleth). This prevented any movement authorities from being granted.
- 76 At 21:44:27 hrs the driver completed his data entry and the DMI displayed a text message, 'Waiting for Movement Authority'.
- 77 At 21:45:19 hrs the driver of train 2J50 telephoned the signaller to request an alternative train headcode to enter via the DMI, as the one he had entered had not been accepted by the signalling system. During the telephone call, the driver's DMI text message changed to 'No authorisation given by the RBC'. This was because the requests for movement authorities sent by the train had not been responded to (by the *Radio Block Centre* (RBC)) after one minute after the text message, 'Waiting for Movement Authority' had been displayed.
- 78 After the telephone call ended, the signaller cancelled the inbound route, and the ERTMS completed this by 21:47:24 hrs. The signaller had to cancel the route manually because the position of the 'stop' marker board at Aberystwyth station meant that the train had been stopped in a position occupying track circuits which prevented automatic cancellation of the route.
- 79 At 21:47:13 hrs, the driver (who was unaware that the inbound route was cancelling) again telephoned the signaller to inform him of his new DMI text message. During the conversation (which only lasted 27 seconds) the signaller began to set the route from Aberystwyth towards Machynlleth, and advised the driver to reset the ERTMS system on the train. The driver then telephoned Arriva Trains Wales control to request authority (as required by Arriva Trains' procedure) to reset the ERTMS system. Authority was granted and the driver began the reset at 21:49:27 hrs.
- 80 When the ERTMS system was reset, and although the train was able to reconnect with the signalling control centre, its positional data was not available for use and the system did not know the exact location of the train. In this situation, a train can only be moved in staff responsible (SR) mode (paragraph 21). Once the train has passed over a balise group, the system will know the position of the train, and its direction of movement.

- 81 By 21:50:35 hrs, the ERTMS system on board the train had reset and the driver telephoned the signaller to request authority to start in SR mode. The signaller gave permission for the driver to use SR mode and pass block marker MH1155 (paragraph 19). The driver correctly selected 'end-of-authority over-ride' on the DMI. This allowed the train to pass MH1155 without an automatic brake intervention.
- 82 At 21:51:35 hrs, with the power controller placed into notch 5, train 2J50 began to move.
- 83 The driver drove the train slowly past block marker MH1155 (halfway down the platform at Aberystwyth) at approximately 2 km/h and briefly accelerated to 27 km/h. He then selected notch 0 on the power controller before braking and decelerating to 13 km/h. This was in anticipation of stopping at the next block marker (at the end of the platform) which was still closed. At 21:52:08 hrs, the system switched to on sight (OS) mode and the block marker opened. This was shown on the DMI and allowed the train to pass the block marker at the end of the platform, MH1153 (with authority to go as far as the next block marker, MH1151). The driver then selected notch 7 on the power controller and the train began to accelerate to 35 km/h, which was reached at 21:52:29 hrs. Shortly before achieving this speed, the driver selected notch 1 on the power controller.
- 84 At 21:52:31 hrs, when the train was 277 metres from the warning board, an audible alarm sounded in the driver's cab and the text message, 'ABCL ahead' appeared on the driver's DMI screen<sup>7</sup>. The driver acknowledged the message immediately, and it then disappeared from his screen.
- 85 At 21:52:46 hrs (with the train still travelling at 35 km/h), the system switched to full supervision (FS) mode. This was acknowledged by the driver, and this then allowed him to pass block marker MH1151 (with authority to go as far as Borth station). The driver then selected notch 7 on his power controller to accelerate the train to 65 km/h in readiness for a '*running brake test*'.
- 86 In FS mode, movement authority is displayed to the driver on the DMI and a maximum speed (known as the 'speed hook') is also displayed next to the speedometer needle (figure 10).
- 87 Once FS mode had been achieved, the driver concentrated his attention on the rising speedometer needle in relation to the maximum speed shown on the speed hook. He stated that he did this to avoid overspeeding.
- 88 The train subsequently passed the warning board for Llanbadarn crossing at 21:52:57 hrs at 40 km/h, still accelerating.
- 89 At 21:53:18 hrs, the train reached 65 km/h<sup>8</sup> (with the speed hook and speedometer needle corresponding – figure 11) and the driver applied the brakes (brake step 2) for the start of the running brake test. Four seconds later the train passed block marker MH1151 still travelling at 65 km/h.

<sup>7</sup> The text message, 'ABCL ahead' is automatically displayed to the driver when the train calculates it is in a certain position on the approach to a warning board.

<sup>8</sup> Arriva Trains Wales mandated that trains should reach a speed of 65 km/h (and then the speed should be reduced by 15 km/h) as part of the running brake test.

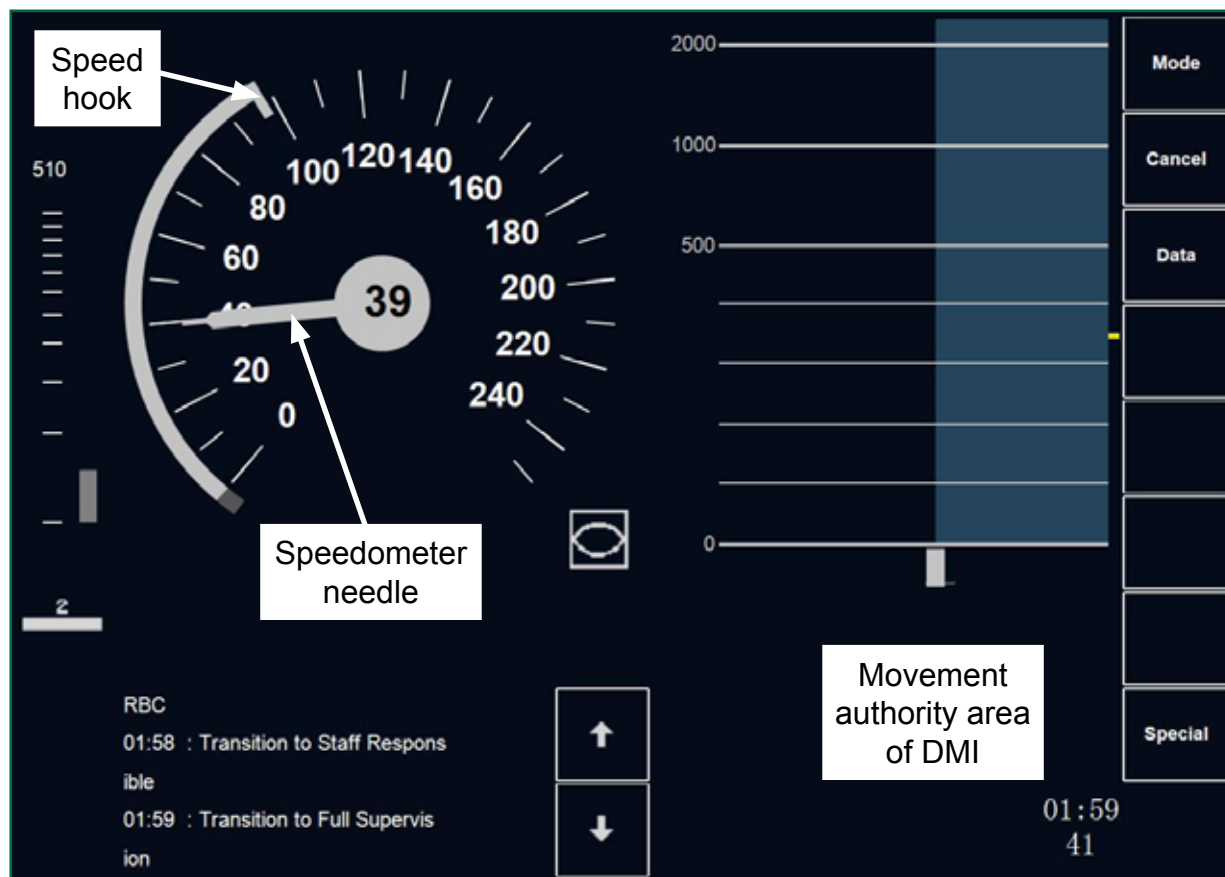


Figure 10: ERTMS DMI screen showing movement authority and speedometer needle and speed hook.  
 Note: The speedometer is showing 39 km/h and the speed hook (maximum speed) is indicating 98 km/h



Figure 11: ERTMS DMI screen showing movement authority and speedometer needle and speed hook.  
 Note: the speedometer is showing 64 km/h and the speed hook (maximum speed) is indicating 65 km/h

- 90 At about the same time (21:53:22 hrs), the ABCL 10 minute timer timed out after 10 minutes and 45 seconds. The corresponding signalling circuitry then disabled the automatic up direction strike-in (which prevented Llanbadarn ABCL crossing sequence from starting). The driver was not provided with any in-cab or lineside indicator capable of showing this had occurred.
- 91 By 21:53:30 hrs, the train had slowed to a speed of 50 km/h and the driver, satisfied that the running brake test was complete, re-applied the power handle to notch 7. One second later, the train occupied AA track circuit (the strike-in point for Llanbadarn ABCL). The crossing sequence did not begin (paragraph 34).
- 92 The train then began to accelerate to 65 km/h (the permitted speed) and the driver again concentrated on the rising speedometer needle in relation to the maximum speed shown on the speed hook. At 21:53:46 hrs (as the train's speed neared 65 km/h and the speedometer needle and speed hook indicated the same speed) the driver moved the power controller to notch 0 and immediately to notch 2 (to keep the train at a constant 65 km/h).
- 93 Two seconds later, at 21:53:48 hrs, the front of the train passed the sighting board for Llanbadarn ABCL (paragraph 36). The driver had not noticed that the DCI was still flashing red.
- 94 One second later, at 21:53:49 hrs, the driver moved his power controller to notch 3, because he was now satisfied that the train was at a constant 65 km/h. At about the same time, he looked up, saw the red flashing light on the DCI and the road barriers raised, and realised that he had passed the sighting board.
- 95 The driver then applied brake step 3, and at 21:53:55 hrs, when he realised that the train would not stop before the crossing, applied the emergency brake.
- 96 At 21:53:59 hrs, the driver sounded the horn for three seconds. The train passed onto Llanbadarn ABCL (with the barriers raised) at 21:54:07 hrs. The train was travelling at approximately 25 km/h, and braking heavily.

## Identification of the immediate cause<sup>9</sup>

- 97 **The immediate cause of the incident was that the driver did not notice that the driver's crossing indicator (DCI) was flashing red until it was too late to stop at the crossing.**
- 98 Forward facing CCTV evidence confirms that at the time of the incident the DCI was flashing red and that the crossing was operating as designed.
- 99 The driver did not apply the brakes until four seconds after passing the sighting board. Had he applied the brakes at the time he reached the sighting board, he would have been approximately 50 metres further from the crossing in the braking sequence and would have stopped 46 metres before the crossing and 39 metres before the DCI.

## Identification of causal factors<sup>10</sup>

### The driving of train 2J50

- 100 **The driver's workload (on departing Aberystwyth) was such that he was distracted by concentrating on the ERTMS DMI screen. This was a causal factor.**

### Drivers tasks when departing Aberystwyth in ERTMS modes

- 101 Figure 12 is a pictorial representation of the tasks and activities undertaken by the driver of train 2J50 departing Aberystwyth in SR mode, alongside the corresponding information for a departure in OS mode (the normal departure mode from Aberystwyth station). The latter uses data from a normal OS departure (by another driver) until the running brake test commences, followed by data reflecting the incident driver's actions during and after the incident running brake test.
- 102 The departure time for both modes has been allocated zero (0) seconds. They have been presented in this manner to allow direct comparison of the driver's workload in the different ERTMS modes.
- 103 The driver of train 2J50 stated he was driving his train with his attention generally focused on the DMI screen. This was due to his pre-occupation with undertaking the following tasks (in order from Llanbadarn crossing back towards the station):
- running brake test and re-accelerating to the permitted speed following the brake test;
  - not passing closed block markers; and
  - the additional change of ERTMS mode on departure (due to starting in SR rather than OS mode).

Each of these is now considered in more detail.

<sup>9</sup> The condition, event or behaviour that directly resulted in the occurrence.

<sup>10</sup> Any condition, event or behaviour that was necessary for the occurrence. Avoiding or eliminating any one of these factors would have prevented it happening.



## Incident train starting in staff responsible (SR) mode

## Probable events if the incident train had started in on sight (OS) mode

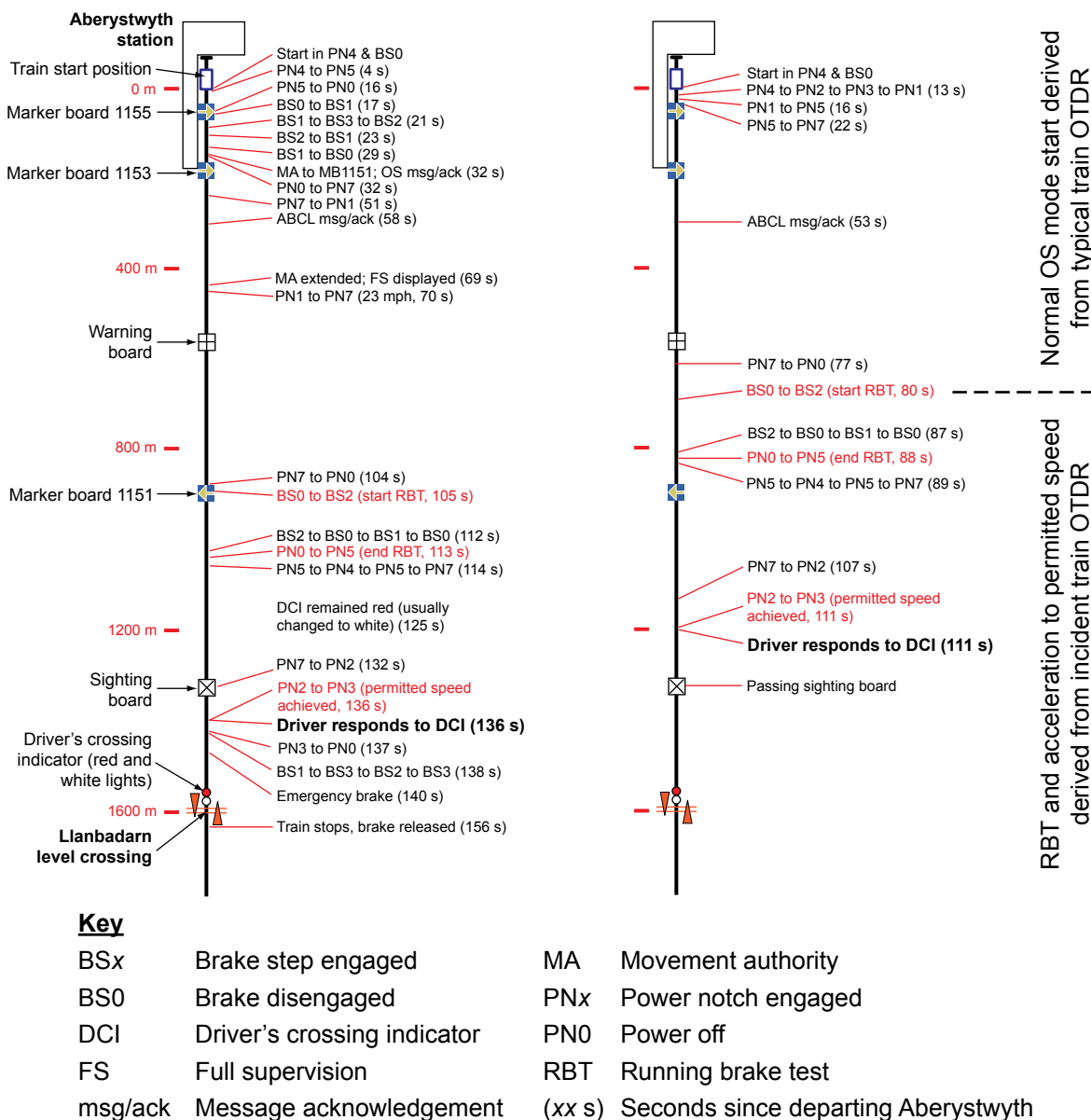


Figure 12: Driver's tasks for incident train (The start and end of the RBT and achieving the permitted speed are highlighted in red)

### Running brake test

104 The running brake test involved (in task order):

1. Increasing the train's speed. The driver was concentrating on the DMI, in particular the speed hook and the speedometer needle, and watching them until they showed the same speed before applying the brakes.
2. Watching the speedometer needle fall until the train's speed had dropped by 15 km/h.
3. Concentrating on the DMI again, in particular the speed hook and the speedometer needle – and watching them until they showed the same speed – to achieve the permitted speed of 65 km/h.

105 Because the train started in SR mode, the running brake test had begun at a later stage after departing Aberystwyth station (and thereby closer to the ABCL crossing) than was normal for a departure in OS mode (figure 12).

#### Block marker boards not to be passed when closed

106 The driver carefully controlled the train's speed to avoid passing block markers MH 1153 and MH 1151 while they were still closed. This resulted in the running brake test being started later than would have been the case if the train had started in the usual OS mode.

107 Block marker MH1153 is situated at the end of the platform at Aberystwyth. Analysis of the OTDR data revealed that the driver reduced the speed of the train on the approach to it, because he had not received movement authority to pass it at that time. The train then passed over a balise group which allowed the ERTMS to open block marker MH1153 and offer OS mode to the train. The driver accepted this mode and moved passed the block marker. The driver then moved the power controller to notch 7 to accelerate the train.

108 In a similar way, the driver correctly held the speed of the train at just under 40 km/h (the maximum speed permitted in OS mode) until he received FS mode (and movement authority to Borth). Once received, this meant he could safely pass block marker MH 1151. MH1151 is the block marker protecting the single line to Borth and cannot (in normal circumstances) be passed in OS mode.

109 Both of these events limited the speed of the train on departure from Aberystwyth. This resulted in the running brake test beginning at a later stage and hence physically nearer to Llanbadarn ABCL crossing (than if the train had departed in OS mode).

#### Departure in SR mode

110 The train departed Aberystwyth station in SR mode for various reasons:

- The position that the train had stopped at Aberystwyth.
- The late cancelling of the in-bound route by the signaller. This resulted in the driver receiving warning text messages on the DMI.
- The signaller did not know how to avoid the need to re-boot the train's ERTMS systems and instructed the driver to reset the equipment. This resulted in the train losing its positional information.

111 The position of the *stop board* at Aberystwyth meant that trains (which had correctly stopped at the board) would occupy track circuits which prevented the automatic cancellation of the in-bound route into the station.

112 Even though the incident train arrived at Aberystwyth at 21:41 hrs, the signaller did not cancel the in-bound route until 21:46:17 hrs. The RAIB has been unable to establish why he did not do this immediately.

113 Evidence shows that the ERTMS system on the train was operating correctly and did not require to be reset. By resetting the equipment, the departure of train 2J50 was further delayed by approximately 3 minutes (in addition to the 4 minutes while the driver initially switched on his cab at the departing driving end of the train).

- 114 The signaller unnecessarily instructed the driver to reset the train ERTMS equipment. The driver reported the DMI text messages to the signaller but the signaller did not appreciate that the reason the driver had received these text messages was that the outbound route from Aberystwyth had not been set. There was no need to reset the ERTMS system.
- 115 Although the signaller had been trained to operate the signalling control systems at Machynlleth control centre, he had limited operational experience because the ERTMS signalling on the route into Aberystwyth had only been commissioned in March 2011. This resulted in him instructing the driver to reset the train's ERTMS equipment because of:
- his inexperience of the situation which had developed at Aberystwyth; and
  - his mistaken belief that instructing the train driver to reset the ERTMS equipment was necessary to solve the problem.
- 116 The driver assumed that the signaller had set a route for him (because of the late running of the train and the need for a quick turn around at Aberystwyth) and that it was the train that was not operating correctly. The driver correctly requested authority from Arriva Trains control before resetting the ERTMS equipment.

### Driver task analysis

- 117 The departure in SR mode, rather than OS mode, meant that the driver of the incident train had more tasks to complete, and some activities had to be undertaken nearer to the ABCL crossing. Figure 12 shows that, when approaching the sighting board, the incident driver was undertaking actions needed to achieve the permitted speed. This was at a time when he should have been concentrating on the light being displayed by the DCI. The figure also shows that, if the train had departed in OS mode, the permitted speed would have been achieved before the driver was required to concentrate on this indicator.
- 118 No formal task analysis of drivers' workload under different ERTMS modes had been undertaken by Arriva Trains Wales for trains departing Aberystwyth. However, witness evidence indicates that there is a general perception that ERTMS has resulted in an increased focus on cab displays. This is sometimes described as a 'head down' style of driving.

### Control of train overspeed

- 119 On a class 158 train (as on many other trains) there is a lag between the operation of controls and the train's response. This can occur when either the power controller or the brakes are operated. Prior to ERTMS fitment on the class 158 trains, drivers would identify an overspeed on their speedometer and control the speed of their train by the occasional movement of the power controller handle until the target speed was achieved. There was no specific overspeed allowance or train control system to monitor speed apart from a system known as the Train Protection and Warning System (TPWS)<sup>11</sup>.

<sup>11</sup> TPWS automatically applies a train's brakes if it approaches a fitted signal at danger too fast or fails to stop at a signal set at danger. It also automatically applies the brakes if a train is travelling too fast on the approach to certain speed restrictions and buffer stops.

- 120 Under ERTMS, the class 158 trains are fitted with a sensitive overspeed detection system. If a train overspeeds by 3 km/h an audible and visual warning occurs, and if there is no immediate intervention by the driver (and the overspeed increases to 5 km/h), then the train's brakes will be applied. It is difficult to 'trim' the speed of the train to keep a steady speed when travelling up and down gradients and around the many curves on the Cambrian lines.
- 121 The driver of train 2J50 had been involved with one safety incident in 2009 which had resulted in a 2 mph (3 km/h) overspeed of his train. This was with the TPWS and before the ERTMS had been commissioned. Subsequently, the driver was focussing on close compliance with the speed limits and this may have influenced his behaviour of concentrating on the DMI to avoid an overspeed situation.
- 122 The 5 km/h limit of overspeed has been designed into the ERTMS to enable the system to correctly calculate (within tolerances of the 5 km/h) stopping distances for the trains running on the Cambrian lines.

### Llanbadarn ABCL crossing design and operation

#### **123 Llanbadarn ABCL crossing closure sequence did not start when train 2J50 reached the strike-in point. This was a causal factor.**

- 124 The train reached the strike-in point 10 minutes and 54 seconds after the plunger had been operated and 9 seconds after the timer had timed out. Because of this the crossing did not operate. If the train had reached the strike-in point before the timer had expired, then the crossing sequence would have started and this incident would not have occurred.
- 125 However, the signalling circuitry is designed to cancel the operation of the crossing sequence if the strike-in point is not reached within the timer's nominal 10 minute 'window' (as described in paragraphs 33 and 34)<sup>12</sup>.
- 126 The driver of train 2J50 pressed the plunger on the platform at Aberystwyth as he changed ends. This was normal practice as the driver knew his train had arrived late and anticipated that it would be departing within a couple of minutes.
- 127 In cases where the time between arrival and departure was greater than two to three minutes, drivers were unclear on when they should operate the plunger. Arriva Trains Wales had issued instructions to drivers to operate the plunger before departure, but these did not state exactly when the driver should do this. It was anticipated that drivers would get out of their cabs to press the plunger, once the train's ERTMS was operating correctly and a movement authority had been granted. The majority of drivers operated the plunger before they entered the cab, and therefore before the ERTMS was switched on.
- 128 The plunger and timer circuitry had been installed at Llanbadarn ABCL in 1989, and have remained unchanged since then, even after ERTMS was commissioned in March 2011.

<sup>12</sup> The RAIB tested the timer at Llanbadarn ABCL (on a hot day at midday) and recorded a time of 11 minutes 20 seconds, compared with 10 minutes 45 seconds when it was operated by the incident driver. The timer relay is an electro-pneumatic type timing relay and witness evidence suggests that the timer value of 10 minutes will vary slightly with the ambient temperature in the equipment building in which it is installed.

## Identification of underlying factors<sup>13</sup>

- 129 Although the applicable Railway Group Standard required the train's systems to prevent a train proceeding over an automatic crossing unless a movement authority had been given to a train, a derogation removed this requirement for all automatic crossings on the Cambrian lines.**

### Safety approvals

#### Approval regime

- 130 The Railways and Other Guided Transport Systems (Safety) Regulations 2006 (ROGS) came into force in 2006. ROGS provide the regulatory regime for rail safety, including mainline railways, metros, tramways and light rail and heritage railways. The Regulations are designed to implement the requirements of the European Railway Safety Directive (2004/49/EC), the aim of which is to establish a common approach to rail safety that will help support the development of a single market for rail transport services in Europe.
- 131 The regulations require railway operators to maintain a safety management system (SMS) and hold a safety certificate or authorisation indicating that the SMS has been accepted by the Office of Rail Regulation.
- 132 Any person or organisation that operates a rail vehicle in relation to any rail infrastructure must comply with these regulations. Such bodies are known as railway undertakings, and include Arriva Trains Wales. Persons or organisations responsible for developing, maintaining or managing infrastructure are known as infrastructure managers and must also comply. These include Network Rail.
- 133 Railway undertakings and infrastructure managers must show that they have procedures in place to introduce new or altered vehicles or infrastructure, safely.
- 134 In parallel with the ROGS verification process, European Directive 2008/57/EC implemented by the Railways (Interoperability) Regulations 2006 required a demonstration that the sub-system and the interface with the rest of the system met the essential safety requirements for a railway system, and that applicable requirements of the European Technical Specifications for Interoperability (TSIs) and any notified national standards (known as Notified National Technical Rules) had been complied with. For the Cambrian line ERTMS project, this information was compiled by Network Rail, Arriva Trains Wales and the supplier of the ERTMS train and trackside equipment.
- 135 In the United Kingdom, notified national standards include Railway Group Standards. These standards define mandatory requirements for mainline railways and are managed on behalf of the railway industry by the *Rail Safety and Standards Board* (RSSB).
- 136 Applications for deviations against Railway Group Standards are made to the RSSB. Applications are then considered by the relevant standards committee, comprising industry experts, in accordance with section 6 of the Railway Group Standards Code. If approved by this committee the deviation is then authorised by RSSB provided that appropriate administrative processes have been followed.
- 137 The following paragraphs describe how organisations involved with the ERTMS Cambrian lines safety approval verification process carried out their duties.

<sup>13</sup> Any factors associated with the overall management systems, organisational arrangements or the regulatory structure.



Network Rail

- 138 The Cambrian lines in Wales were chosen in the early 2000s by Network Rail for the pilot installation of the ERTMS in the UK. This is more fully described in paragraph 48.
- 139 In 2003, Network Rail produced two documents entitled, 'Cambrian Line Project Scope Definition' and 'Conceptual Signalling Principles for Cambrian Line Project'. Both of these documents stated that there would be no interface between ERTMS (ETCS) and automatic crossings, including Llanbadarn ABCL.
- 140 In 2004, Network Rail produced a document entitled 'Cambrian Lines ERTMS Early Deployment Scheme: Preliminary System Safety Risk Assessment', issue 1, dated June 2004. The document was written to identify and evaluate the principal safety risks associated with the system in order to support the development of the safety strategy, options in the design and overall engineering safety management.
- 141 Appendix 1 of the document, entitled 'Safety Opportunities', stated:
- 'It is believed that the integration of level crossing indications to train drivers with the ERTMS system could be achieved with no significant alteration to the ERTMS system. It would, however, require the level crossing control equipment to be connected to the *interlocking* so that the interlocking could supply the relevant control information to the ERTMS system, and this may be relatively expensive. A deeper risk and cost/benefit study would be needed to support a decision on this safety opportunity.'
- 142 An analysis of movement incidents was also recorded in the report. The section applicable to ABCLs stated:
- 'At crossings where the train driver is required to observe a lineside light (flashing white or red) on the approach to the crossing (AOCL or ABCL) there is also potential for a safety loss if concentration on the in-cab ERTMS display causes the driver to be less observant of the lineside indications, or where differences between the information provided in-cab and from the lineside lead to confusion and inappropriate driver behaviour. The controls of the white and red lights displayed to train drivers on the approach to AOCL and ABCL crossings could be connected to the interlocking so as to modify the movement authority given to the train by the ERTMS system according to the status of the crossing.'
- 143 By 2007, Network Rail decided that interlocking automatic crossings (including ABCLs) with ETCS was 'not reasonably practicable'. No evidence documenting the reasons for this decision has been provided by Network Rail.
- 144 Following the near miss incident at Llanbadarn in October 2008 (RAIB report: 'Near miss at Llanbadarn Automatic Barrier Crossing, Locally Monitored', ref: 20/2009), Arriva Trains Wales wrote to Network Rail asking if the crossing could be interlocked with the ERTMS system (paragraph 176). Network Rail replied that this was not feasible for the initial project due to the high cost of interfacing the ERTMS system to the ABCL.
- 145 In early 2009, the project team developed an ERTMS hazard risk analysis log, related to a set of scenarios. One of the top level scenarios was 'train proceeds across level crossing when not safe to do so.'



- 146 Those hazards relevant to the incident at Llanbadarn ABCL are shown in appendix E. All of these hazards were mitigated by using risk mitigation statements by the project prior to the March 2011 commissioning. These statements were deemed sufficient to close out the risks without requiring an interface between Llanbadarn crossing and the ERTMS. However, it was recognised that such an interface was required by Railway Group Standard, GE/RT8026: 'Safety Requirements for Cab Signalling Systems' (paragraph 58).
- 147 For this reason, in July 2009, Network Rail produced a document<sup>14</sup> intended to support an application for a derogation from clauses 7.14 and 10.3.6 of standard GE/RT8026. This document had been reviewed by groups involved with approving the derogation (paragraph 153), and comments from these groups had been included before its final issue at version 2.2.
- 148 The clauses against which derogations had been applied for read as follows:
- 7.14 'The MA (movement authority) shall not be given to the train unless all manned and automatic level crossings over which the train is to pass are safe for the passage of the train.'
  - 10.3.6 'On AOCL and ABCL crossings, the ATP sub-system shall prevent the train proceeding over the crossing unless the driver's indication shows that it is safe to proceed.'
- 149 Network Rail's proposed alternative action for both clauses was:
- 'For Automatic Open Crossings – Locally monitored (AOCL) and Automatic Half Barrier Crossings – Locally monitored (ABCL), signage and indicators will be provided as per conventional signalling. The driver will be required to observe that the crossing is clear of obstruction and that the DCI is flashing white before driving over the crossing.'
- 150 No supplementary documents were produced by Network Rail as part of its derogation application and no reference was made to human factors associated with ERTMS at level crossings or the particular issues at Llanbadarn (explained further in paragraph 166).
- 151 The outcome of Network Rail's application for derogation from Railway Group Standard GE/RT8026 is described at paragraphs 152 to 157.

#### *Rail Safety and Standards Board (RSSB) and standards committee*

- 152 Advice on the proposed derogation from the requirements laid down in GE/RT8026 (clauses 7.14 and 10.3.6) was provided by the RSSB's staff to the Control Command and Signalling Standards Committee. In respect of clause 10.3.6, RSSB stated:
- 'Clause 10.3.6 is not a reasonable request. The crossing indications can be enforced by the ATP system and should be enforced by the ATP system. In the context of the global project costs, the purpose of the ATP function and the practicality of enforcing the indications, the derogation request is not reasonable.'
- Although this advice was not based on any detailed analysis, it reflected the views of specialists employed by the RSSB.

<sup>14</sup> 'ETCS Deviations Against GE/RT8026: Safety Requirements for Cab Signalling Systems', ERTMS/CCMS/8707697, issue 2.2 dated 14 July 2009.

- 153 The Control Command and Signalling Standards Committee consisted of representatives of Network Rail, passenger and non-passenger train operators, rolling stock owners and suppliers. It was chaired by the RSSB. This committee was aware that Network Rail's submission had been altered in response to comments by three specialist groups convened by the RSSB. These groups comprised industry experts and RSSB staff, including some individuals who also sat on the Control Command and Signalling Standards Committee. The specialist groups were the Infrastructure System Review Group, Operations Review Group and the ERTMS Engineering and Operations Standards Review Group.
- 154 The Control Command and Signalling Standards Committee approved the derogation in August 2009. The minutes from this meeting stated:
- ‘The comments of the technical commentary are noted by the committee. This derogation applies to a specific route application. The intent of the original railway group standard still stands subject to further experience with cab signalling railways. The committee understand the extensive analysis work that has been carried out for this derogation and associated cross industry review.’
- 155 The RAIB has not been able to establish the grounds on which the Control Command and Signalling Standards Committee chose not to follow the recommendation made by RSSB experts that the request for derogation should be rejected. Furthermore, it is unclear how the committee had confirmed that the project had fulfilled each of the criteria listed at clause 6.2 of the Railway Group Standards code. In particular, clause 6.2.5 requires that applicants:
- demonstrate why the proposed alternative provisions are reasonable, including a suitable and sufficient supporting analysis; and
  - include the results of any consultation that has been undertaken with affected parties.
- 156 The submission to the Control Command and Signalling Standards Committee (paragraph 147) did not include any supporting analysis dealing with the potential for ERTMS to introduce additional risks at specific locations. The application listed the organisations consulted, but did not give the consultees' responses.
- 157 However, a derogation certificate was issued on 15 September 2009 and can be found at [www.rssb.co.uk](http://www.rssb.co.uk). This certificate states:
- ‘Clause 7.1.4 and Clause 10.3.6 Interlocking of automatic crossings would introduce additional equipment in the form of new interlocking functionality and additional communication channels between the crossing and the RBC. This would add additional cost to re-signalling projects, eroding the business case for re-signallings. The additional functionality may also decrease the reliability of the crossing therefore increasing the frequency of degraded mode operation and the consequent safety hazards associated with it. By convention, it is considered acceptable on conventionally signalled railways for automatic level crossings to remain un-interlocked, provided that the circumstances in which such crossings are used fall within the constraints set out in Railway Safety Principles & Guidance part 2E. All existing crossings will be assessed for compliance with these requirements during scheme design.’

### Office of Rail Regulation (ORR)

- 158 The ORR did not have any involvement in the analysis or decision making associated with the derogation application relating to automatic crossings that Network Rail successfully applied for in 2009. However, the ORR was in attendance (as an observer) at the Control Command and Signalling Standards Committee meeting in August 2009, when the decision to approve the derogation was made. The ORR did not intervene in the decision.
- 159 On 15 October 2009, following the RAIB's report into the 2008 near miss at Llanbadarn ABCL, the ORR wrote to Network Rail to voice its concern and to discuss a possible engineering solution to the ongoing problem of trains travelling over the crossing with the barriers raised and open to road traffic.
- 160 On 5 November 2009, in response to ORR concerns, Network Rail undertook a risk review workshop to review recommendation 1 of the RAIB report into the near miss at Llanbadarn in 2008 (paragraph 144). The review considered the following (only those issues relevant to this incident are listed):
- Whether the crossing should be linked to the ERTMS control system. The review concluded that 'the cost of interlocking ERTMS with the crossing DCI was discounted for the whole route as beyond reasonably practicable. The costs of doing Llanbadarn alone are not insubstantial and would create inconsistency with no certain outcome. The group was of the opinion that providing a unique solution would not be operationally acceptable due to the risk it would export to other crossings'; and
  - Whether the interlink with the Vale of Rheidol crossing needs to be maintained (kept). The review concluded that 'to remove the interlink with the Vale of Rheidol AOCL crossing would increase the likelihood of blocking back by road vehicles over Llanbadarn ABCL crossing, and in turn would increase the likelihood of the crossing operating with a road vehicle stationary on it'. The review requested further work (by Network Rail) to consider a possible design change that would reduce the occasions when a driver would encounter a red DCI at the crossing.
- 161 Although a Network Rail signalling engineer looked at a possible design solution for the removal or change to the interlink between the two crossings at Llanbadarn, no work at the crossing was undertaken.
- 162 Network Rail wrote to the ORR on 18 November 2009 with its findings and conclusions from the risk review workshop. These were:
- The *All Level Crossing Risk Model* (ALCRM) tool score<sup>15</sup> for Llanbadarn ABCL was reviewed with new census data, and a lower risk score was achieved.
  - The new ALCRM score has been used to model the safety benefit to be had from upgrading the ABCL to a MCB-CCTV<sup>16</sup> crossing. The cost of installing a full barrier CCTV solution greatly outweighs the safety benefits – this will not go ahead.
  - The possibility of implementing additional measures under ERTMS was discussed, but again the cost of this greatly outweighs the safety benefit. However this option is still being explored by Network Rail.

<sup>15</sup> ALCRM only models risks imported by road users and pedestrians. The effect of railway staff errors and railway equipment faults should also be considered when ALCRM results are assessed.

<sup>16</sup> Manually Controlled Barriers monitored Closed Circuit Television.

- Other means of intervening with other safety systems were considered, but are not included under the ERTMS installation.
- Count down markers (for train drivers) to the level crossing are being considered as well as traffic calming measures for road traffic’.

163 In January 2010, the ORR and Network Rail met to discuss proposed actions to improve safety at the crossing and to deal with recommendation 1 from the RAIB report on the 2008 near miss incident (paragraph 144). The meeting concluded that the crossing could not be converted to either (a) interface with the ERTMS system or (b) be converted to a MCB crossing (thereby interfacing with the ERTMS automatically) without disproportionate cost in relation to the risks involved and hence no further action would be taken.

### Summary of Safety Approvals

164 Paragraphs 130 to 163 describe the work done by the railway industry in safety analysis, cost benefit analysis and subsequently to support an application for a derogation (against a Railway Group Standard), for Llanbadarn ABCL crossing.

165 The overall analysis concluded that it was not possible to justify the cost of converting the level crossing to the full barrier type (supervised by CCTV) or to provide an ETCS in-cab signalling interface at the existing crossing. The RSSB derogation reiterates this conclusion and confirms that the additional cost would erode the case for future re-signallings (under ERTMS).

### Llanbadarn automatic crossing safety record

166 Network Rail reports<sup>17</sup> that since 1999, there have been 17 serious near misses at the 167 ABCL crossings in the UK where the main causal factor(s) were related to railway failings (on the part of both Network Rail and train operators). Five of these have been at Llanbadarn ABCL, including this incident on 19 June 2011, the first to have occurred after installation of ERTMS on the Cambrian lines. Details of the other incidents are given in paragraph 173.

167 The number of near misses at Llanbadarn ABCL, combined with the high levels of road traffic using the crossing (paragraph 14), leads the RAIB to conclude that there is a case for interfacing the crossing with the ERTMS at this location. The interface would, under normal operating conditions, prevent the ERTMS providing a movement authority over the crossing, and therefore prevent a train using the crossing, until the crossing is closed to road traffic. For ABCL and AOCL crossings, this corresponds to the condition when the DCI is displaying a flashing white light. This type of interface would have prevented the incident on 19 June 2011 and is likely to prevent future similar incidents caused by train driver error.

<sup>17</sup> These figures come from the Safety Management Information System (SMIS) database, which is managed by RSSB. Data is uploaded to it by both Network Rail and train and freight operating companies.

## Observations<sup>18</sup>

### Actions of the driver post incident

- 168 After moving his train away from Llanbadarn ABCL crossing, the driver of train 2J50 continued to drive the train towards the next station while talking to the signaller to report the incident.
- 169 The signaller at Machynlleth believed that train 2J50 was stationary (and clear of the crossing) when the driver rang him to report the incident. It is normal practice for drivers involved in incidents to stop their trains before contacting the signaller to report the event.

### The plunger at Aberystwyth

- 170 The plunger at Aberystwyth will not reset and begin timing again, if pressed again after its 10 minute timing period has started. This information has not been passed to drivers and their lack of knowledge of it may lead to potential confusion.
- 171 There is also no indication to drivers of what state the timer is in, ie 'operating – in use' or 'available for use'.

### General experience of drivers on the Cambrian lines

- 172 Since March 2011 (when ERTMS was commissioned) witness evidence indicates that there have been several occasions when the ABCL crossing has not operated and the driver of the approaching train has had to stop before the crossing (paragraph 34). These incidents have all been as a result of the timer timing out before the train has reached the strike-in point, mainly due to a delay in the departure of a train from Aberystwyth after the plunger had been operated. The majority of delays have been attributed to a reset of the ERTMS on the train and the additional delay caused by departing in SR mode.

## Previous occurrences of a similar character

- 173 Since 2001 there have been four previous occasions recorded when a train ran through Llanbadarn level crossing in an uncontrolled manner when the barriers were not lowered. These occurred on 17 August 2001, 8 November 2005, 24 April 2007 and 21 October 2008. Although none resulted in any collision with a road vehicle, the incident in 2008 resulted in a near miss involving a tanker lorry carrying liquefied petroleum gas. The 2005 incident involved an up train, and the other three down trains. In three of the four cases, the immediate cause of the crossing not having operated was the effect of a train crossing the Vale of Rheidol Railway AOCL, which meant that, in accordance with its design, the Network Rail crossing did not initiate closure. In the fourth case, in 2008, the crossing failed to operate because it had been disconnected by Network Rail technicians.
- 174 In all four cases the DCI correctly displayed a flashing red aspect to the oncoming train on Network Rail, but the driver did not stop the train in time.

<sup>18</sup> An element discovered as part of the investigation that did not have a direct or indirect effect on the outcome of the accident but does deserve scrutiny.



- 175 In 2001 the industry investigation concluded that the driver misjudged the braking because he had become distracted and lost concentration, possibly due to domestic problems. In the 2005 incident the industry investigation concluded that the driver did not stop before reaching the flashing red aspect because he was distracted by the train conductor making announcements after the train had left Aberystwyth. In the 2007 incident the Arriva Trains Wales report concluded that the driver was late in reacting to the red flashing aspect not changing to white. In the 2008 incident (which was investigated by the RAIB, paragraph 144) the RAIB report concluded that the driver did not apply the brakes until 9.7 seconds after the train had passed the sighting board and that the driver anticipated that the DCI would change to a flashing white aspect after he had passed the board.
- 176 In the RAIB report into the incident in 2008, the situation at the time the report was published was described as:
- 'Following the ALCRM assessments Network Rail has studied the possibilities of closing the Llanbadarn crossing, or of converting it to a CCTV controlled crossing. The highway authority has stated that closure of the crossing is not an acceptable option, and Network Rail considers that the cost of carrying out a conversion is grossly disproportionate to the potential safety benefits identified, so no changes to the crossing are currently proposed'.
  - 'Arriva Trains Wales Ltd has suggested that Llanbadarn ABCL should be linked to the new ERTMS control system, so that the brakes would automatically be applied on any train that was running too rapidly towards the crossing. Network Rail stated that this change could not be included in the initial ERTMS project, but was considering whether it can be included as a future, separate, project. Network Rail was also reviewing whether the interlink with the Vale of Rheidol crossing needs to be maintained'.

As described in paragraph 144, Network Rail has since reported that no action is being taken.

## Summary of conclusions

### Immediate cause

177 The driver did not notice that the DCI was flashing red until it was too late to stop at the crossing (**paragraph 97**).

### Causal factors

178 The causal factors were:

- a. The driver's workload (on departing Aberystwyth) was such that he was distracted by concentrating on the ERTMS DMI screen (**paragraph 100, Recommendations 3 and 4**);
- b. Llanbadarn ABCL crossing closure sequence did not start (barriers or lights) when train 2J50 reached the strike-in point (**paragraph 123, Recommendation 2**);
- c. The driver was pre-occupied with accelerating after the running brake test (**paragraphs 104 and 117, no recommendation made (paragraph 182)**); and
- d. The ERTMS system (on-board the train) was reset by the driver on instructions of the signaller (**paragraph 110, no recommendation made (paragraph 181)**).

### Underlying factors

179 The underlying factors were:

- a. The ETCS cab signalling system does not interface with automatic crossings on the Cambrian ERTMS lines. It is probable that some, or all, of the following influenced this decision:
  - Although there had been a number of near misses at Llanbadarn ABCL (paragraph 166), Network Rail's review concluded that the cost of implementing additional measures under ERTMS outweighed the safety benefits (paragraph 162).
  - The Network Rail and Arriva Trains joint project team had closed out all recognised risks without requiring an ERTMS interface at the crossing and without carrying out a human factors analysis (paragraphs 146 and 118).
  - The derogation against Railway Group Standards was granted by the Control Command and Signalling Standards Committee contrary to advice from RSSB staff (paragraphs 152 to 154).
  - Neither a human factors report nor other risk assessment was undertaken by Network Rail as part of the derogation application process (paragraph 150). (**paragraph 167, Recommendation 1.**)

- b. The documentation supplied by Network Rail to the Control Command and Signalling Standards Committee in support of its derogation application did not contain any risk assessments or human factors reports. It did not consider the particular issues related to the crossing at Llanbadarn (**paragraph 150, Recommendation 5**).
- c. The Control Command and Signalling Standards Committee did not request any additional task analysis or risk assessments from Network Rail as part of the derogation process (**paragraph 155, Recommendation 6**).

### Additional observations

180 Although not linked to the incident on 19 June 2011, the RAIB observes that:

- a. The plunger at Aberystwyth will not reset and begin timing again, if pressed again during its 10 minute timing period. The absence of a train driver's awareness of this may lead to potential confusion (**paragraph 170, Recommendation 2**).
- b. The RSSB were unable to provide the RAIB with information concerning why the Control Command and Signalling Standards Committee chose not to follow the RSSB's recommendation (**paragraph 155, Recommendation 6**).

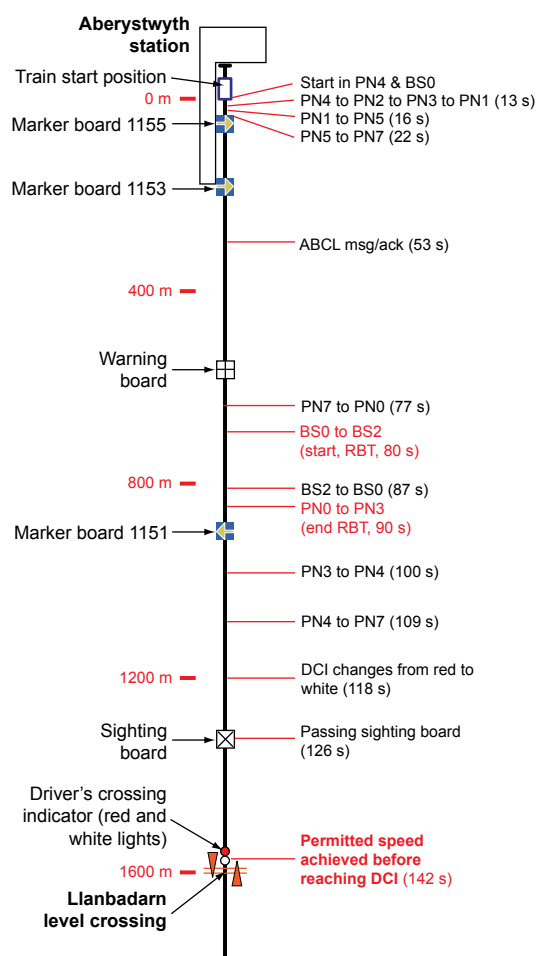
## Actions reported that address factors which otherwise would have resulted in a RAIB recommendation

181 Network Rail has instructed its signallers to cancel the in-bound route into Aberystwyth as soon as is practicable after a train has arrived at the station.

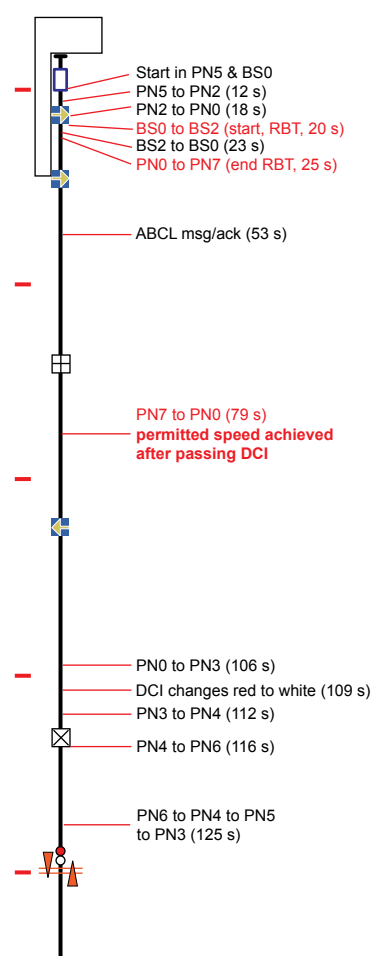
182 Arriva Trains Wales has:

- Requested Network Rail to move the stop board marker nearer to the buffer stops at Aberystwyth to allow auto cancellation of an in-bound route (applicable only to short trains, of one or two carriages). To date, the work to move the stop marker has not been undertaken.
- Instructed drivers that they should operate the plunger at Aberystwyth station when their cab is set up correctly and they are ready to depart.
- Issued all drivers with an instruction concerning lower speed running brake tests. At Aberystwyth, a small speed reduction (2-3 km/h) is required and can be completed in time for the train to accelerate to the permitted speed before the driver is required to concentrate on the DCI (figure 13). The instruction to reach 65 km/h (the standard running brake test which applied at the time of the incident) is no longer required for Arriva Trains Wales trains departing from Aberystwyth.

## Typical train starting in on sight (OS) mode with standard running brake test (RBT)



## Typical train starting in OS mode with reduced speed RBT



### Key

BSx	Brake step engaged	MA	Movement authority
BS0	Brake disengaged	PNx	Power notch engaged
DCI	Driver's crossing indicator	PN0	Power off
FS	Full supervision	RBT	Running brake test
msg/ack	Message acknowledgement	(xx s)	Seconds since departing Aberystwyth

Figure 13: Driver's tasks for standard and reduced speed running brake tests following an OS mode departure (The start and end of the RBT and achieving the permitted speed are highlighted in red)



## Previous RAIB recommendations relevant to this investigation

183 The following recommendations were made by the RAIB as a result of previous investigations, which address factors identified in this investigation. They are therefore not remade so as to avoid duplication:

*Near miss at Llanbadarn Automatic Barrier Crossing, Locally Monitored, near Aberystwyth 21 October 2008, RAIB report (20/2009) published July 2009*

### Recommendation 1

Network Rail should complete its reviews of Llanbadarn ABCL and implement any actions that it deems reasonably practicable to improve the safety of the crossing.

*The ORR has reported that the following actions have been taken in response to the above recommendation:*

***Implemented (Network Rail undertook a cost/benefit review – no proposal to change the crossing) – ORR proposes to take no further action against Network Rail unless it becomes aware that the information provided has become inaccurate.***

### Recommendation 3

The Rail Safety and Standards Board should make a proposal, in accordance with the Railway Group Standards Code, to amend paragraph 4.2 of module TW8 of the Rule Book so as to make explicit that a driver should start to control his speed at once if he observes a flashing red aspect when passing the special speed restriction board of a locally monitored automatic crossing.

*The ORR has reported that the following actions have been taken in response to the above recommendation:*

***Implemented (no amendment was made by RSSB to the rules) – ORR proposes to take no further action against RSSB unless it becomes aware that the information provided has become inaccurate.***

## Recommendations

184 The following recommendations are made<sup>19</sup>:

- 1 *The intention of this recommendation is that high risk locally monitored automatic crossings in areas signalled by ERTMS should be provided with an engineered safeguard to reduce the risk of train driver error.*

Network Rail should develop an engineered safeguard to reduce the risk of trains being operated under ERTMS passing over locally monitored automatic crossings (ie AOCL and ABCLs) when the crossings have not operated. This solution should then be applied at Llanbadarn ABCL crossing and, if appropriate, at higher risk crossings on the Cambrian lines and as part of future ERTMS installations. Assessments of risk should include an evaluation of human factors, previous history, including recorded incidents and accidents (paragraph 179).

- 2 *The intention of this recommendation is to provide automatic protection at Llanbadarn crossing (similar to that provided at manned barrier crossings) and to remove the plunger at Aberystwyth station.*

Network Rail should change the design of circuitry at Llanbadarn ABCL to remove the need for a train driver on Network Rail to operate the plunger before departing Aberystwyth station, but still retain an interface between Network Rail and Vale of Rheidol Railway at the crossing to avoid 'blocking back' of road vehicles (paragraphs 178 and 180).

- 3 *The intention of this recommendation is that the train operating company undertake a study into drivers workload when departing Aberystwyth station.*

Arriva Trains Wales should carry out a human factors analysis and risk assessment of the workload of drivers when departing Aberystwyth station under different ERTMS modes and implement any findings (paragraph 178).

*continued*

<sup>19</sup> Those identified in the recommendations, have a general and ongoing obligation to comply with health and safety legislation and need to take these recommendations into account in ensuring the safety of their employees and others.

Additionally, for the purposes of regulation 12(1) of the Railways (Accident Investigation and Reporting) Regulations 2005, these recommendations are addressed to the Office of Rail Regulation 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 167 to 171) can be found on RAIB's website [www.raib.gov.uk](http://www.raib.gov.uk).

4 *The intention of this recommendation is to improve the style of driving.*

Arriva Trains Wales should review the way in which drivers interact with ERTMS and DMIs and develop new training and on-going competence checks to encourage a move away from the 'head down' style of driving undertaken by some drivers under ERTMS (paragraphs 118 and 178).

5 *The intention of this recommendation is to clarify the type and quality of documents being submitted as part of a deviation (including a derogation) from Railway Group Standards.*

Network Rail should review its processes for seeking deviation (including derogation) from Railway Group Standards and Technical Specifications for Interoperability. The review should include consideration of the extent and nature of the risk assessments that should be carried out, and the supporting information provided, for each deviation request (paragraph 179).

6 *The intention of this recommendation is to ensure that location specific risks are considered when standards committees approve, and RSSB authorise, deviations (including derogations). The outcome of these considerations should be recorded.*

RSSB should review and, if necessary, amend the processes and guidance applicable to Standards Committees and RSSB when taking decisions about applications to deviate from Railway Group Standards. This should include:

- considering the provision of guidance for Standards Committees on how to make the necessary judgement about whether the risk assessment and supporting analysis is suitable and sufficient and the extent to which location specific risks should be taken into account; and
- guidance on how the basis of the Standards Committee's decisions should be recorded.

(paragraphs 179 and 180.)

# Appendices

## Appendix A - Glossary of abbreviations and acronyms

ABCL	Automatic Barrier Crossing, Locally Monitored
AHB	Automatic Half Barrier crossing
ALCRM	All Level Crossing Risk Model
AOCL	Automatic Open Crossing, Locally Monitored
ATP	Automatic Train Protection
AWS	Automatic Warning System
CCTV	Closed Circuit Television
DCI	Driver's Crossing Indicator
DMI	Driver Machine Interface
ERTMS	European Rail Traffic Management System
ETCS	European Train Control System
FS	Full supervision mode
GSM-R	Global System for Mobile Communications - Railway
MA	Movement Authority
MCB	Manned Crossing with Barriers
OTDR	On Train Data Recorder
ORR	Office of Rail Regulation
OS	On Sight mode
RAIB	Rail Accident Investigation Branch
RBC	Radio Block Centre
RBT	Running Brake Test
RETB	Radio Electronic Token Block
ROGS	Railways and Other Guided Transport Systems
RSSB	Rail Safety and Standards Board
SMIS	Safety Management Information System
SMS	Safety Management System
SR	Staff Responsible mode

SSRB

Special Speed Restriction Board

TPWS

Train Protection and Warning System

TSI

Technical Specifications for Interoperability



## Appendix B - Glossary of terms

All definitions marked with an asterisk, thus (\*), have been based on Ellis's British Railway Engineering Encyclopaedia © Iain Ellis. [www.iainellis.com](http://www.iainellis.com).

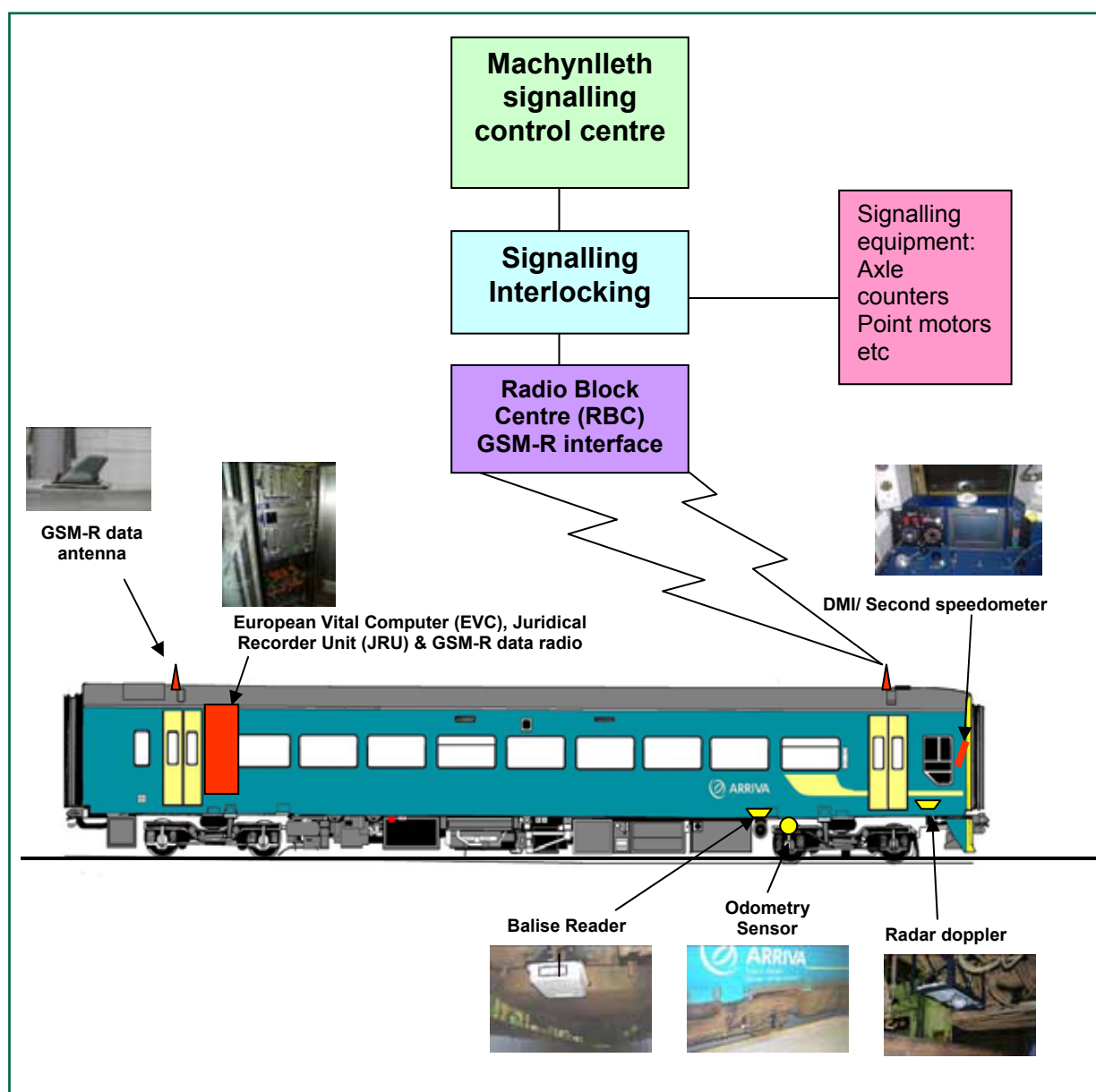
All Level Crossing Risk Model	A computer model on a central database used to compute the risk at level crossings and to evaluate reasonably practicable improvements to reduce the risk.*
Automatic Barrier Crossing, Locally Monitored	An automatic level crossing fitted with automatic barriers and traffic lights on the highway, the correct operation of which is monitored by the train driver.*
Automatic Open Crossing, Locally Monitored	A level crossing without barriers, that is equipped with a flashing white light which is observed by the train driver to confirm that the road lights are functioning before the train proceeds over the crossing.*
Automatic Train Protection	A communication and control system which utilises lineside equipment to transmit permissible speed and signal aspect information to trains.
Axle counter	A track mounted device that accurately counts passing axles.*
Balise	A data transmitter located close to the track or in the fourfoot that provides information to passing trains.*
Braking curve	The graphical representation of the deceleration of a particular train when velocity is plotted against distance.*
Chain	A unit of length equal to 66 feet or 22 yards (approximately 20 m). There are 80 chains in one standard mile.*
Driver's crossing indicator	A signal provided on the approach to an automatic barrier crossing, locally monitored, and an automatic open crossing, locally monitored, to convey the status of the level crossing to the driver.*
European train control system (for ERTMS levels 2 and 3)	A harmonised system of 'signalling' based on GSM-R radio and balises, intended to allow full interoperability of all trains on all routes within the European Union.*
European rail traffic management system (level 2)	A standardised system of rail traffic control which supplements or replaces the existing conventional fixed signalling system.*
Forward Facing Closed Circuit Television	A CCTV system that is situated at the front of a train and records moving images.

Global System for Mobile Communications - Railway	A time division multiple access radio system using 876 MHz to 880 MHz for data transmission from trains and 921 MHz to 925 MHz for data reception by trains. It is used as the basis for the European Rail Traffic Management System (ERTMS).*
In-cab signalling	The provision of signals in the driving cab. This may supplement or replace traditional fixed signals placed at the lineside.*
Interlock(ing)	Controls fitted between points and signals that prevent the signaller from setting conflicting routes. This can be achieved by either mechanical, electrical relay or computer based systems*
Level Crossing Order	A statutory instrument made under the Level Crossings Act 1983 describing in detail the method of operation and control to be employed at a particular level crossing.*
Movement authority	An indication made to a driver giving them permission to make a particular movement (subject to certain conditions imposed on the driver by the nature of the indication).*
On Train Data Recorder	A data recorder fitted to traction units collecting information about the performance of the train. Including: <ul style="list-style-type: none"> <li>● Speed</li> <li>● Regulator and brake control positions</li> <li>● Activations of horn, DSD and AWS cancel button, etc.*</li> </ul>
Radio Block Centre	This system (which is part of the ERTMS) that issues a movement authority to the train via the GSM-R.
Radio Electronic Token Block	A modern development of Electric Token Block signalling in which the token takes the form of an encoded data message transmitted to a receiver on the train. The system ensures that only one train is in possession of any single radio token at one time, and that the preceding train is clear of the section concerned before re-issuing it to the next train. It was developed to allow cost effective signalling on sparsely populated lines, particularly the Highlands of Scotland and Welsh coastal areas.*
Railway Group Standard	A document mandating the technical or operating standards required of a particular system, processes or procedure to ensure that it interfaces correctly with other systems, process and procedures.*
Rail Safety and Standards Board	A not-for-profit company, whose objective is to co-ordinate the railway industry's work in achieving continuous improvement in the health and safety performance of the national railway network, and thus facilitate a reduction of risk to employees and passengers. The Rail Safety and Standards Board is responsible for the control of Railway Group Standards.

Running brake test	A brake test performed by the driver while the train is in motion.*
Sectional Appendix	The publication produced by each Network Rail territory containing layout and location details for running lines, stations, speed restrictions, tunnels etc.
Signalling control centre	The control centre for all the signalling systems associated with ERTMS including the signallers who operate the equipment to manage the train service.
Step (Brake)	The different positions on the driver's brake controller representing progressively greater brake demands.*
Stop board	A lineside sign instructing a driver to stop.*
Strike-in point	The location on the approach to an automatic level crossing at which an approaching train triggers the operating sequence of the level crossing.*
Track circuit	An electrical or electronic device used to detect the absence of a Train on a defined section of track using the running rails in an electric circuit.*
Wheel slide	Condition where the rotational speed of the wheel is lower than that corresponding to the actual linear speed of the train.

## Appendix C - ERTMS system equipment description

The ERTMS system transmits to the train the distance that the train may travel safely; the limit of which becomes the end of authority. The train uses transmitted information called a movement authority and knowledge of its location (from passing over balises in the track and onboard odometer calculations), to calculate the permitted speed that it can travel. The onboard equipment then displays the appropriate speed to the driver through the driver machine interface in the active driving cab of the train. The signalling interlocking controls the signalling systems and responds to commands from the signaller and from external trackside information eg axle counters. It also interfaces to the train via the Radio Block Centre (GSM-R) with safety related information.



## Appendix D - Rule book GE/RT8000/S6 ERTMS (extract)

'ERTMS cab signalling', Issue 1 dated October 2009, sections 4.3 & 4.4 (part)

### **Section 4.3**

#### **Full supervision (FS)**

The normal movement authority that gives comprehensive protection. The display of this indication tells you that you are permitted to run at the maximum speed shown.

The permitted speed is shown in the *Sectional Appendix*, traction specific instructions, train lists or operating instructions. Where technical constraints or the rules or procedures require a lower speed, you must not exceed the lower speed.

#### **On sight (OS)**

A movement authority that still gives protection but will allow entry into an occupied section. The display of this indication tells you that you are permitted to run at a speed which you are able to stop short of any obstruction such as a train standing on the line ahead.

You must not allow your train to exceed the ceiling speed and you must ensure that you can stop short of any obstruction ahead, making proper allowance for darkness or poor visibility conditions.

#### **On sight received in transit**

When you receive on sight in transit the following will occur:

- The train will automatically be supervised down to the ceiling speed.
- Warning of an approaching on sight mode will be displayed to you, which you must acknowledge.

A brake intervention will take place if you fail to acknowledge the warning.

#### **On sight received at 'start of mission'**

When you select "Start" (assuming the train has a valid position) on sight mode will be displayed to you, which you must acknowledge. A brake intervention will take place if you fail to acknowledge the on sight mode.

### **Section 4.4**

#### **Staff responsible (SR)**

This is an operational mode that allows you to move the train under your own responsibility in an ERTMS equipped area. You may use it in the following circumstances:

- When the signalling system is unable to issue a movement authority.
- When you are authorised by the signaller to use the override function.
- When a train is awakening in a position which is invalid or unknown to the system.



## Appendix E - Cambrian project hazard risk analysis (part) detail

1. **Warning margin on DMI being routinely exceeded, the driver having to pay closer attention to the speedometer and control of train speed, reducing attentiveness to other driving activities.**

Included in ERTMS driver training and assessment and Professional Driving Policy.

Feedback to date has demonstrated that this is not an issue, however it will be monitored as part of the trial and should continue to be considered by the Railway Undertakings.

- 
2. **Driver distraction in ETCS FS or OS mode, or SR mode.**

Company standard processes for signal and sign sighting have been adhered to with the exception of agreed derogations.

Drivers existing route knowledge makes it unlikely that a failure of the process would be unrevealed before an incident occurred.

- 
3. **While approaching an AOCL/ABCL ERTMS distracts the driver from duties.**

Human machine interfaces of the equipment supplied, and the nature of user interaction shall be designed to support specific task and process requirements of the user. Thereby ensuring the risk of entering an unsafe state is reduced to a level that is acceptable.

The risk of unexpected or anomalous behaviour by the DMI is very low.

The movement authority will supervise the train to the correct speed for the crossing sighting board for the driver to observe the DCI and if present any obstruction and be able to brake to a stand. During this stage of approach it is unlikely that any updates to the DMI will occur.

In ERTMS the driver is warned by a text message about the approach to the ABCL at a distance from the warning board in FS, OS and SR modes. This message must be acknowledged if the train is not to be brought to a stand, but this is sufficiently far from the crossing that it does not cause a conflict in the visual task of monitoring the crossing.

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