



Rail Accident Investigation Branch

Rail Accident Investigation: Interim Report

**Loss of speed restrictions on the Cambrian line
20 October 2017**

Report IR1/2018
October 2018

Note: This interim report contains information obtained from the Rail Accident Investigation Branch's (RAIB) examination of the available evidence to date. Some of the information contained in this report may be refined or changed as the investigation progresses.

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

Loss of speed restrictions on the Cambrian line, 20 October 2017

Summary

- 1 On 20 October 2017, during a conversation with the controlling signaller, a train driver advised that the maximum permitted speed shown on his in-cab display was not taking account of temporary speed restrictions. This occurred on the Cambrian lines in Wales where permitted speeds are transmitted to trains by a signalling system installed as a trial for the future deployment of in-cab signalling on other parts of Network Rail infrastructure. Subsequent investigation found that temporary speed restriction information had not been provided to trains in the area since the previous evening.

The incident

- 2 Just after 23:00 hrs and near the end of passenger service on 19 October 2017, a software reset occurred in the computer based signalling system controlling the Cambrian lines and located at Machynlleth signalling control centre. This automatic reset, known as a rollover, was triggered when the equipment on-board a train at Machynlleth station, automatically requested a movement authority¹ already allocated to another train.
- 3 Such software rollovers occur between 10 and 12 times each year, and the signalling staff at the control centre followed their established processes for returning to normal service. It was necessary to stop movement authorities being given to the three trains within the area controlled by the signalling system during the rollover but normal working resumed around 23:19 hrs. The three trains continued to their respective destinations after a short delay. These were the last trains of the day.
- 4 During a rollover, the signalling system at Machynlleth takes information from a support computer system (the GEST server described at paragraph 25). This should include information about temporary speed restrictions. However, during the rollover on the 19 October 2017, the data relating to temporary speed restrictions between Dovey Junction and Pwllheli failed to reload from the support system to the signalling control system. Staff working in the signalling control centre were unaware of this when they subsequently permitted trains to begin operating again.
- 5 On 20 October, train services started at 07:17 hrs and, when the first three trains passed over the line with the missing temporary speed restrictions, none of the drivers reported problems with the signalling system.

¹ Permission to travel along a specified part of the railway.

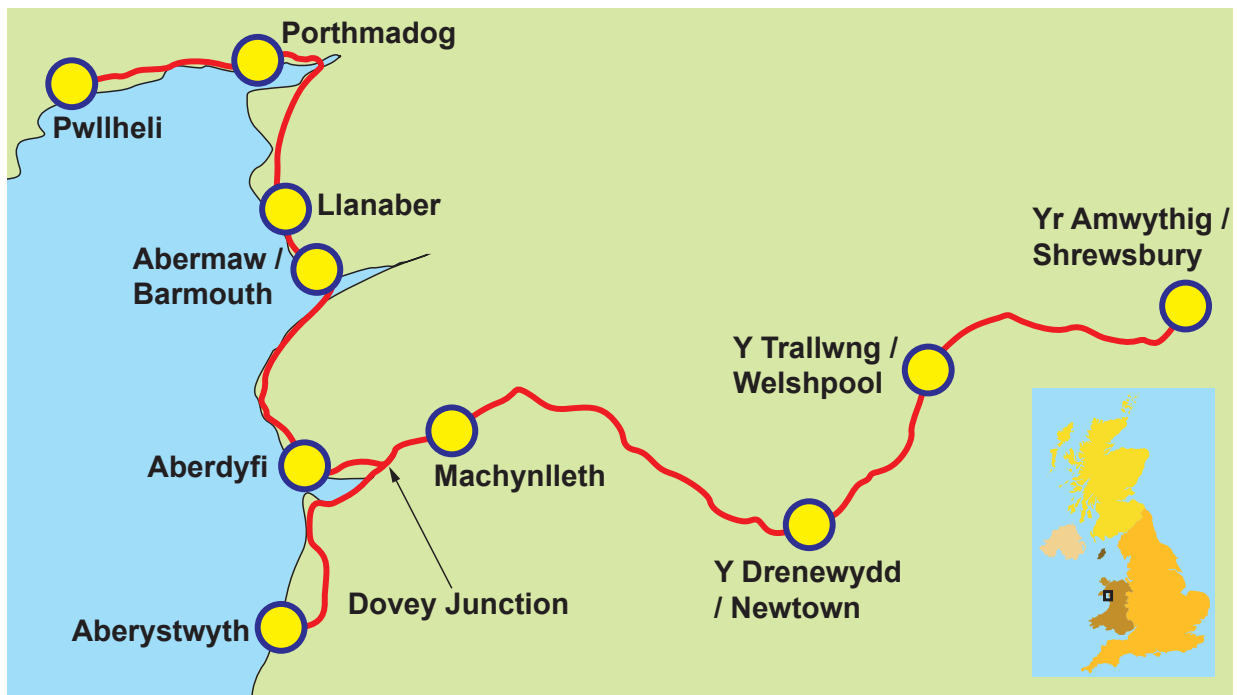


Figure 1: Geographical area controlled by Machynlleth signalling centre

- 6 The fourth train over the affected line was the 08:52 hrs Machynlleth to Pwllheli service with the reporting number 2J03. At around 10:02 hrs, train 2J03 passed through a 30 km/h (19 mph) temporary speed restriction at approximately 80 km/h (50 mph) while travelling between Barmouth and Llanaber. The temporary speed restriction had been applied at this location since 2014 to provide level crossing users with sufficient warning of approaching trains so they could cross safely.
- 7 After passing through this restriction, the driver of train 2J03 reported a fault with the speed restriction information provided to him by the in-cab display on board his train. While investigating this report, a signalling technician at the Machynlleth control centre discovered that temporary speed restriction information was not being transmitted to any trains.
- 8 The signalling technician forced a signalling system reset at around 10:11 hrs, intending that this would initiate an automatic reloading of the temporary speed restrictions. This did not resolve the problem, so the signalling technician reset the support computer system which maintains the temporary speed restriction database and initiated another signalling system reset. At around 11:51 hrs, and after several unsuccessful attempts to reload the database, the fault was reported to Ansaldo STS, the system supplier and maintenance support² provider.

² Signalling technical maintenance is undertaken by the local Network Rail maintenance staff. Ansaldo STS assist the local Network Rail staff by providing additional expertise relating to the Cambrian lines signalling system when requested.

- 9 In an effort to restore normal working after trying other options, Ansaldo STS advised the signalling technician to cleanse data from the signalling system. This instruction required all temporary speed restriction information to be manually re-entered into the support computer terminal (and so to be available to the signalling control system). The correct indication of the temporary speed restrictions on the in-cab displays was verified by a test train passing through the area at reduced speed. The temporary speed restrictions were correctly displayed to the driver of the test train, so at 15:50 hrs, normal operation was resumed.
- 10 Shortly after the incident, a new control centre instruction was issued requiring all temporary speed restrictions to be entered manually and verified by a test train before normal operations were resumed after a rollover. This has been revised to require a rollover to be followed by a second, manually triggered reset during which the correct uploading of temporary speed restrictions is checked and then independently verified by signalling centre staff. In addition, local maintenance staff carry out a daily verification that temporary restrictions are being transmitted to trains.

The RAIB's role and the context of this interim report

- 11 The RAIB is responsible for conducting independent investigations into railway accidents in the UK. The purpose of its investigations is to improve safety by establishing the causes of accidents and making recommendations to reduce the likelihood of similar occurrences in the future, or to mitigate their consequences.
- 12 Immediately after the loss of temporary speed restriction information on the Cambrian lines, the RAIB decided to monitor the Network Rail and Ansaldo STS investigations. In February 2018, the RAIB began an investigation because the potential for wider safety learning was becoming apparent.
- 13 This interim report provides findings from investigations undertaken to date. It builds upon the information already provided on the RAIB's website. A final report will be published on completion of the investigation. All RAIB investigation reports are available on the RAIB website.
- 14 The RAIB has worked closely with Ansaldo STS to independently review the laboratory test results described below. Further laboratory test results will be included in the final RAIB investigation report.

Background information

Parties involved

- 15 Network Rail owns and maintains the Cambrian lines infrastructure and employs the Machynlleth signalling control centre staff.
- 16 Arriva Trains Wales Ltd operated the trains and employed the drivers affected by the loss of speed restrictions.
- 17 Ansaldo STS supplied the signalling system and provides maintenance assistance to the local Network Rail signalling maintenance staff.

Signalling system

- 18 The Cambrian lines run from Shrewsbury to Machynlleth, then from Dovey Junction to Aberystwyth (the Cambrian Main Line), and from Dovey Junction to Pwllheli (the Cambrian Coast Line) (figure 1). The area is controlled by the Machynlleth signalling control centre, using a signalling system compliant with a European suite of standards for railway signalling known as 'European Rail Traffic Management System (ERTMS) level 2'.
- 19 The Cambrian lines ERTMS signalling provided by Ansaldo STS was installed as a pilot scheme in the UK and became fully commissioned in March 2011. This application of ERTMS includes the provision of in-cab signalling displays. The equipment is designed to comply with the European specification for European Train Control System (ETCS) using the Global System for Mobiles-Railway (GSM-R) system for communication between the trackside infrastructure and the trains. This 'level 2' signalling system does not require lineside signals but a limited number of trackside signs are needed.
- 20 Instead of trackside signals, drivers receive their movement authority and maximum permitted speed information on display screens installed in the driving cab. This display is known as a Driver Machine Interface (DMI) (figure 2).



Figure 2: Typical driving cab layout and driver machine interface (DMI) screen

- 21 The DMI provides the driver with the current train speed and the maximum permissible speed, including any temporary speed restrictions, on a simulated analogue speedometer (figure 3). The standard analogue speedometer is retained for degraded operation and operation on non-ERTMS equipped infrastructure.
- 22 The ERTMS signalling implemented on the Cambrian lines, although new to Network Rail infrastructure, was based on a system already in operation elsewhere in Europe. Implementation in the UK was reliant on the product validations already achieved in Europe with the differences unique to the Cambrian lines being subject to the UK railway approval procedures.

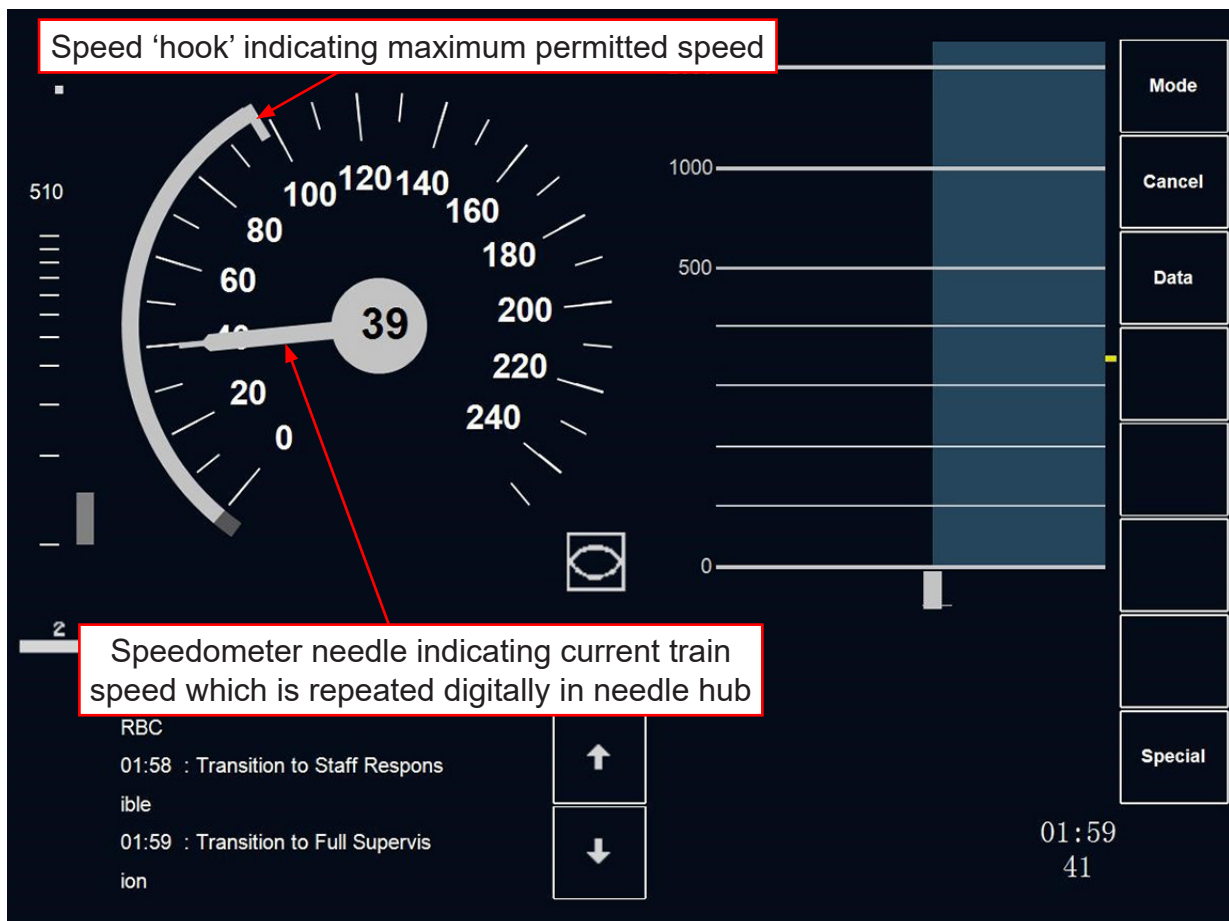


Figure 3: DMI screen showing speedometer with maximum speed supervision and actual speed

Temporary speed restrictions

- 23 In addition to permanent speed restrictions, it can also become necessary to apply temporary speed restrictions on the rail network. The railway rulebook requires drivers to be made aware of these restrictions in the weekly operating notices (WONs) issued to them. The restrictions are also marked by trackside signs in areas with traditional trackside signalling. For in-cab signalling areas, such as the Cambrian lines, it is not necessary to provide the trackside signage because the temporary speed restrictions should be included in the permitted speed provided to the driver by the DMI.
- 24 At the time of the incident, seven temporary speed restrictions had been implemented on the Cambrian lines. All were located on the Cambrian Coast Line and all related to level crossing sighting times (ie providing level crossing users with sufficient time to see an approaching train). There were no temporary speed restrictions on the Cambrian lines for engineering reasons such as track defects.
- 25 To apply a temporary speed restriction on the Cambrian ERTMS system, the signallers use a computer system called the 'poste de GEstion des Signalisations Temporaires' (GEST) terminal. This terminal acts as an interface between the signalling control system and the signalling staff (figure 4). The GEST terminal is also used by the signalling staff to perform other tasks associated with the operation of the ERTMS signalling system, such as those required to return the signalling system to service after a rollover.

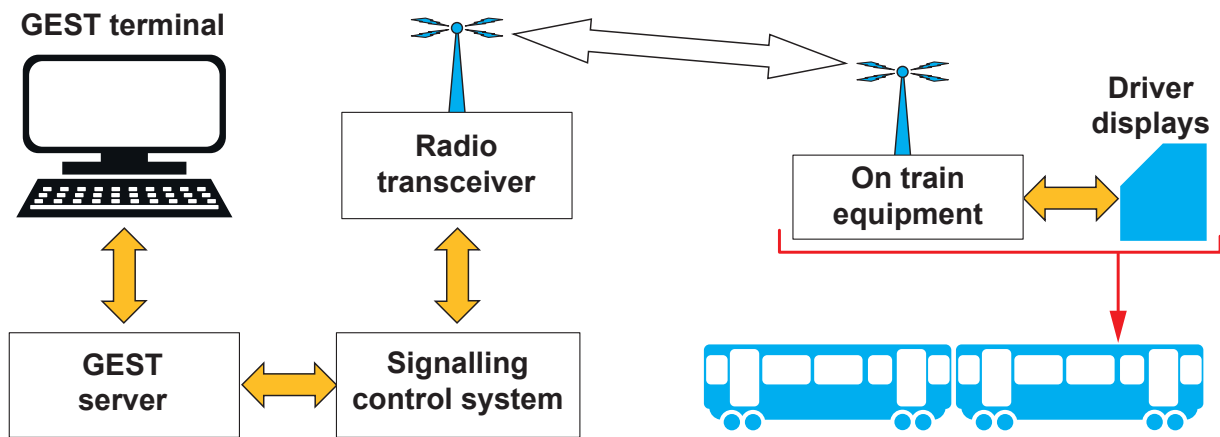


Figure 4: Simplified arrangement of GEST and signalling control system interface

26 The GEST terminal has a computer screen incorporating a geographical representation of the line under control. The infrastructure shown on this diagram includes the track layout, stations, level crossings and 'flags' marking the beginning and end of temporary speed restrictions (figure 5).

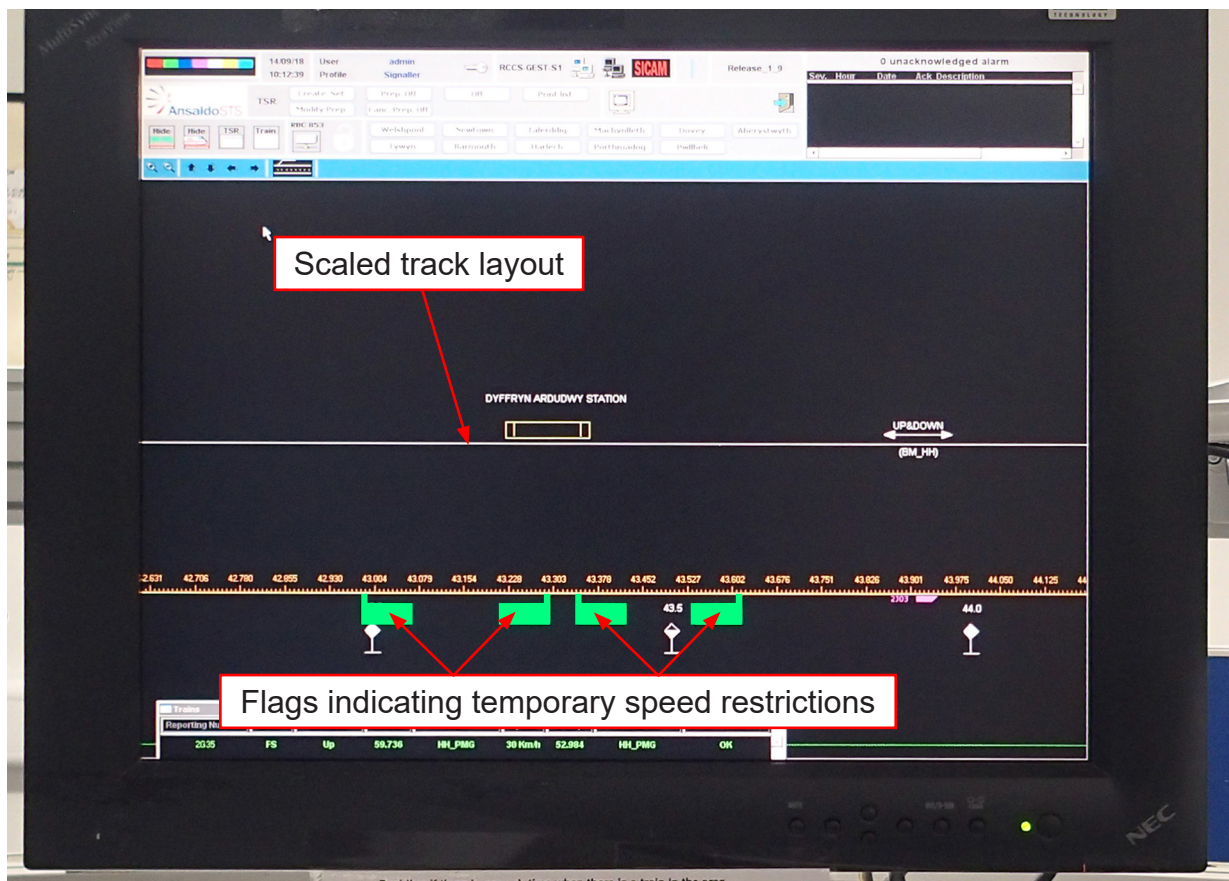


Figure 5: GEST terminal interface screen, here showing a single track with a station and flags at the beginning and end of two temporary speed restrictions

GEST status indicators

27 As well as real-time application and removal of temporary speed restrictions, it is possible for signallers to set speed restrictions to be applied or removed at a later date and time. To avoid confusion between indicated restrictions, the GEST terminal interface uses a colour coding of the flags (figure 5). The meaning of each status colour is given in table 1.

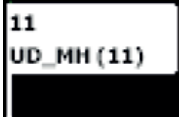
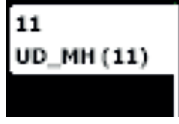
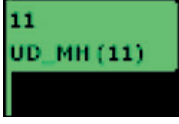
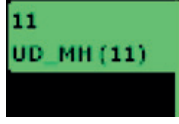
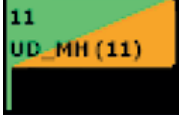
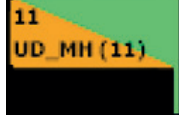


Colour meaning	Start flag	End Flag
Restriction prepared, but not yet implemented, so not transmitted to trains		
Restriction applied and confirmed as being transmitted to trains		
Restriction pre-prepared to be removed, but still being transmitted to trains		
Requested restriction not implemented, an error has been detected		

Table 1: Status colour coding for temporary speed restrictions on GEST terminal interface

- 28 To apply a speed restriction on the GEST terminal, a signaller inputs the start and end points along with an identity and the maximum permitted speed. At that moment, the restriction flags are coloured white and the restriction is not transmitted to the trains. The restriction flags should only turn green after the restriction has been uploaded from the GEST system to the signalling control system which transmits permitted speeds to trains for display on the DMI. Signallers remove restrictions using the GEST terminal. When this is done, the flags initially turn green and orange before disappearing when the removal is confirmed by the signalling control system.
- 29 The restriction flags are coloured red if a temporary speed restriction has been applied by the signaller, but an error has occurred and so the information is not available to the signalling control system. The signalling control system will not permit trains to operate when implementation errors have been detected and red flags are indicated on the GEST terminal.

The incident

- 30 Following the initial rollover shortly after 23:00 hrs on 19 October 2017, the automated process to upload temporary speed restrictions from the database in the GEST system failed. Such failures should have been revealed to the signallers by the signalling control system and trains should have been prevented from resuming service. However, on this occasion the failure to upload the temporary speed restriction database was not recognised by the signalling system.
- 31 The signallers should have been alerted to the failure to transmit the restrictions by the restriction flags turning red on the GEST terminal interface screen. When asked by the Ansaldo STS engineer the following day, several members of staff at the control centre checked and confirmed that the restriction flags were green on the GEST terminal screen. Although this was several hours after the initial rollover had occurred, there is no evidence that the flags were any colour other than green since the rollover the previous evening.
- 32 The GEST system is an integral part of the overall signalling system and safety related decisions relating to the management and control of trains are made based on the information displayed by the GEST terminal screen. Checks within the safety critical system software should have prevented the incorrect displaying of the green restriction flags on the GEST terminal interface screen.
- 33 Arriva Trains Wales downloaded the journey data from the trains which travelled between Dovey Junction and Pwllheli on the morning following the rollover. This data indicated that no temporary speed restrictions were being transmitted to trains, and so none were shown on train DMIs, from the start of service until after the fault was discovered and corrected.
- 34 Many of the missing temporary restrictions were at locations where actual train speeds are reduced by nearby station stops or other permanent speed restrictions. In these locations the difference between the actual speed of trains and the intended, but missing, temporary restriction was small. However, in locations where the temporary speed restriction was significantly less than the normal train speed, the consequences could have been serious if people had been using the associated level crossing or if a temporary speed restriction had been required due to defective infrastructure.
- 35 The loss of temporary speed restrictions was initially reported as affecting only the Cambrian Coast Line between Dovey Junction and Pwllheli. No emergency or other temporary restrictions were required elsewhere in the area controlled by the ERTMS system at Machynlleth but, if required, they would also have been omitted from the drivers DMI screens.

Initial findings

System supplier's investigation

- 36 The initial investigations into the failure of the system by the supplier, Ansaldo STS, were hampered by having only very limited data from the time shortly before and following the initial rollover. After several attempts to resolve the issue failed, data was cleansed from the system. This cleanse included the deletion of information stored within system memory and associated databases.
- 37 No action was taken to download copies of the GEST event log or the databases intended to store temporary speed restriction data, before these were deleted during the data cleanse. Subsequent investigation has shown that this information would have assisted finding the cause of the incident.
- 38 The GEST system was developed in Spain for the Madrid to Lerida high speed line project several years before its use on the Cambrian lines. The limited availability of design information meant that the Ansaldo STS investigation has been time consuming because of a need to reverse engineer the GEST system software to understand how the system operates.
- 39 To conduct their investigation it was necessary for Ansaldo STS to construct a replica system similar to that installed at the Machynlleth control centre. This laboratory based system, located in France, has allowed the Ansaldo STS system engineers to run different test scenarios in an attempt to emulate the failure which occurred on the Cambrian lines.
- 40 Ansaldo STS has concluded from testing on the replica system that the cause of the failure exists solely within the GEST system and not in other parts of the ERTMS signalling infrastructure. Ansaldo STS engineers have examined the GEST system software programming to identify potential programming errors which were then tested on the laboratory system. The testing has also included manipulating system inputs, its operating environment and the introduction of software bugs mimicking possible hardware failures.
- 41 In August 2018, Ansaldo STS successfully recreated a condition which mimics the failure experienced on the 19/20 October 2017. Ansaldo STS is continuing to test for other similar failures and to determine whether data generated by these simulated failures matches the limited data captured before the data cleanse.

RAIB's future action in the investigation

42 The RAIB's ongoing investigation is considering:

- the degree of certainty which can be placed on the Ansaldo STS initial findings;
- how the correct operation of the GEST terminal and its computer interfaces were monitored within the overall system, and why this did not detect the absence of temporary speed restriction data;
- the data available to signalling staff indicating the loss of safety critical data provided by the GEST terminal;
- how the system designers intended to manage the risk of loss of data relating to temporary speed restrictions, and why the safety validation process did not identify this potential failure mode;
- the extent to which existing European and industry standards governing the development of high-integrity software and software based systems adequately cover management of interfaces with other systems, including those operating at a lower level of integrity;
- the loss of diagnostic data in safety critical software systems;
- the reporting of such failures and how the safety implications are managed by the railway industry;
- lessons learnt from previous similar incidents involving high integrity software based systems; and
- circumstances resulting in the long term retention of temporary speed restrictions and some drivers not reporting the absence of temporary speed restriction information on their train DMI screen.

43 The RAIB's investigation report will include recommendations to reduce the likelihood and/or consequence of similar events occurring in the future.

Rail Accident Investigation Branch

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