



Rail Accident Investigation Branch

Rail Accident Report



**Fatal accident at Moreton-on-Lugg,
near Hereford,
16 January 2010**

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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Change control	Date	Paragraph no(s).	Description of change
v2	18/07/11	10, 26, 41,43, 46, 78, 79, 92, 102, 108, 128, 157, 169, 174 and fig 2	Minor technical and typographical corrections
		44, 45, 129 and 130	Updated to reflect revised information on internal British Rail documents. Paragraphs re-numbered following deletion of paragraphs 45 (old) and 46 (old), and inclusion of 130 (new).

Fatal accident at Moreton-on-Lugg, near Hereford, 16 January 2010

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Summary

On 16 January 2010, a collision occurred between a passenger train and two cars at the level crossing at Moreton-on-Lugg, near Hereford. The front-seat passenger in one of the cars was fatally injured. The driver was seriously injured and detained in hospital.

The two occupants of the other car attended hospital as a precaution. There were no casualties on the train, which did not derail.

The level crossing is controlled from the adjacent signal box. The cause of the accident was that the signaller raised the barriers in error when the train was approaching and too close to be able to stop before reaching the level crossing. He had just been involved in an absorbing telephone call that had interrupted his normal task of monitoring the passage of the train. As a result he believed that the train had already passed over the crossing.

There was no safeguard in the signalling system to prevent this from happening. There was no plan to fit such a safeguard, and no industry requirement to formally consider the safety benefits of one.

The RAIB has made four recommendations to Network Rail. They include assessing the need for additional engineered safety measures at level crossings like Moreton-on-Lugg and targeted improvements to its processes for managing risk at level crossings, and for determining when it should bring signalling assets into line with latest safety standards.

Preface

- 1 The sole purpose of a Rail Accident Investigation Branch (RAIB) investigation is to prevent future accidents and incidents and improve railway safety.
- 2 The RAIB does not establish blame, liability or carry out prosecutions.

Key definitions

- 3 All mileages in this report are measured from a zero datum at Shrewsbury station. The directions left and right are with respect to the direction of travel of the train involved.
- 4 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 Accident

Summary of the accident

- 5 At 10:29 hrs on 16 January 2010, train 1V75, the 08:30 hrs Manchester Piccadilly to Milford Haven service, collided with two cars on the level crossing at Moreton-on-Lugg, near Hereford (figure 1).



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

- 6 There were two occupants in each car. The passenger in the first car that was struck was taken to hospital by air ambulance, but unfortunately she later died of her injuries. The driver of the car was seriously injured, and was detained in hospital. The occupants in the second car suffered no physical injuries, but attended hospital as a precaution.

- 7 The level crossing is of the *manually controlled barrier* (MCB) type, the road being protected by full-width barriers and road traffic light signals. The signaller in the adjacent Moreton-on-Lugg signal box monitors and operates it.
- 8 There were no casualties on the train, which suffered damage, but did not derail.

The parties involved

- 9 The occupants of the first car that was struck (a Volkswagen Touareg) lived locally, and were on their way to do some shopping in Hereford. The passenger, the driver's wife, was travelling in the front. The occupants of the second car (a Vauxhall Astra) were a mother and daughter. They also lived locally, and were returning home from Hereford. The mother was driving. Her daughter was in the front passenger seat.
- 10 Network Rail owns, operates and maintains the railway infrastructure where the accident occurred, which is part of its Western Route. It employed the signaller on duty at Moreton-on-Lugg at the time. Network Rail has led the industry's *Formal Investigation* of the accident, which has involved representatives of other railway duty holders.
- 11 Arriva Trains Wales was the operator of the train involved in the accident.
- 12 The British Transport Police and the Office of Rail Regulation attended the accident scene and have conducted their own investigations.

Location

- 13 Moreton-on-Lugg level crossing is north of Hereford, on the line between Severn Bridge Junction in Shrewsbury, and Maindee West Junction in Newport. It is located at 46 miles 65 chains, between Leominster station (38 miles 36 chains) and Hereford station (51 miles 03 chains). The railway, which runs approximately north-south, comprises two lines: the *up* main (towards Shrewsbury) and the *down* main (towards Newport). Train 1V75 was running on the down main.
- 14 South of Leominster, the railway runs through countryside, following the course of the River Lugg. Between 42 miles 68 chains and 43 miles 36 chains, it passes through the tunnels at Dinmore. It then goes over two *user-worked crossings*, Ox Pasture Farm No.1 (44 miles 38 chains) and Dolmeadow (44 miles 76 chains), followed by Wellington *automatic half barrier* (AHB) level crossing (45 miles 33 chains). The railway curves to the left as it approaches the level crossing at Moreton-on-Lugg. It straightens out after passing over it, and goes on to Shelwick Junction (49 miles 26 chains) and Hereford.
- 15 The signalling on the line at Moreton-on-Lugg is controlled by the signal box at the level crossing. The adjoining sections are controlled by signal boxes at Hereford (to the south) and Leominster (to the north). On the down main, the line is signalled according to *absolute block principles* between Leominster and Moreton-on-Lugg, and *track circuit block principles* between Moreton-on-Lugg¹ and Hereford. On the up main, the line is signalled using absolute block principles from Hereford to Moreton-on-Lugg, and from Moreton-on-Lugg to Leominster.

¹ ML43 is the *home signal* for Moreton-on-Lugg on the down main, and the boundary for track circuit block operation.

16 The signal box also controls access to railway sidings, and a stone loading facility beyond, which are just to the north. Figure 2 shows the main features of the railway in the area.

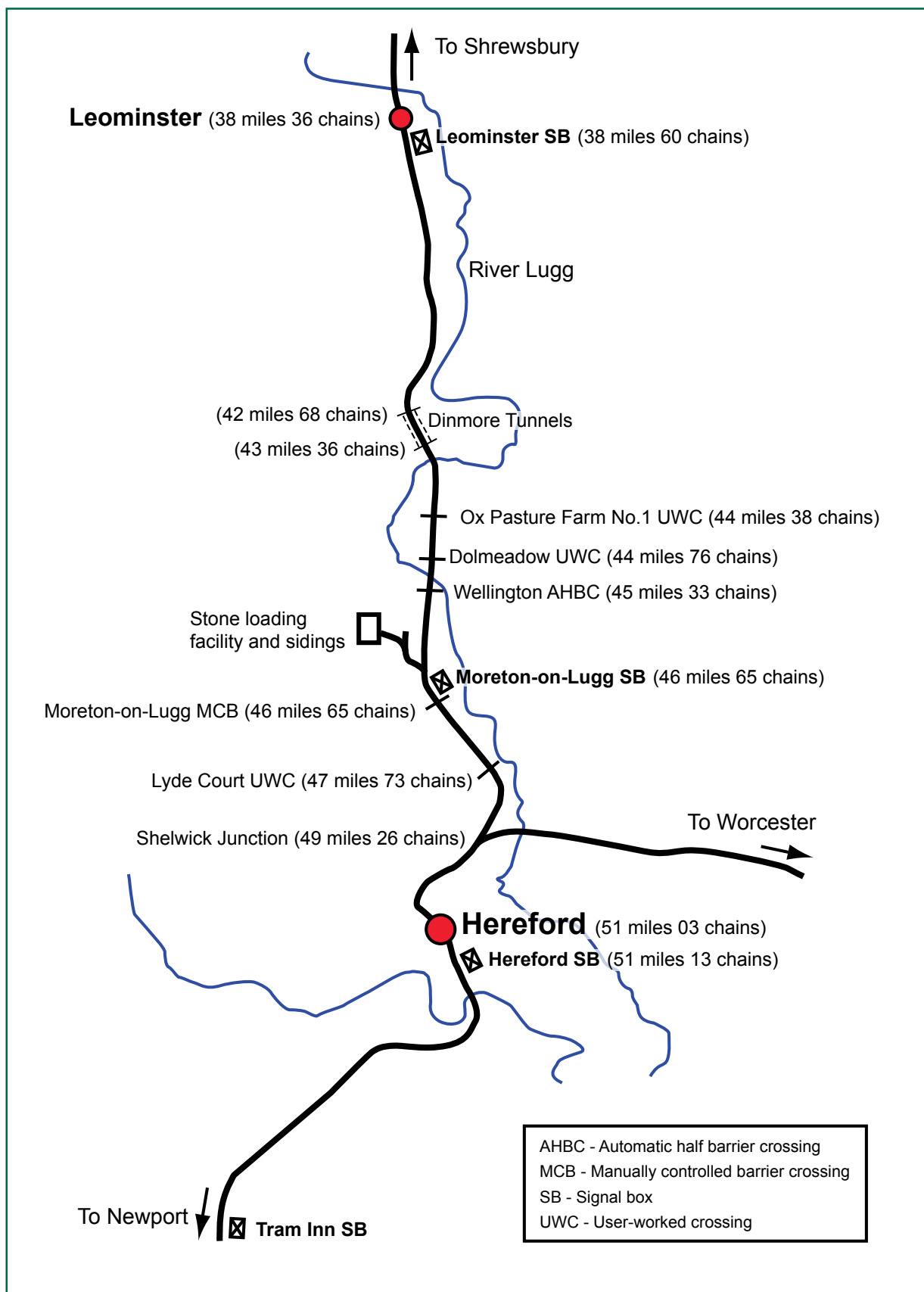


Figure 2: Diagram of the railway in the area (not to scale)

- 17 The level crossing at Moreton-on-Lugg takes the railway over an unclassified road. The road connects the villages of Moreton-on-Lugg, 1 km to the west of the railway, and Marden, around 3 km to the east. Figure 3 shows the layout of the road and railway at the crossing.

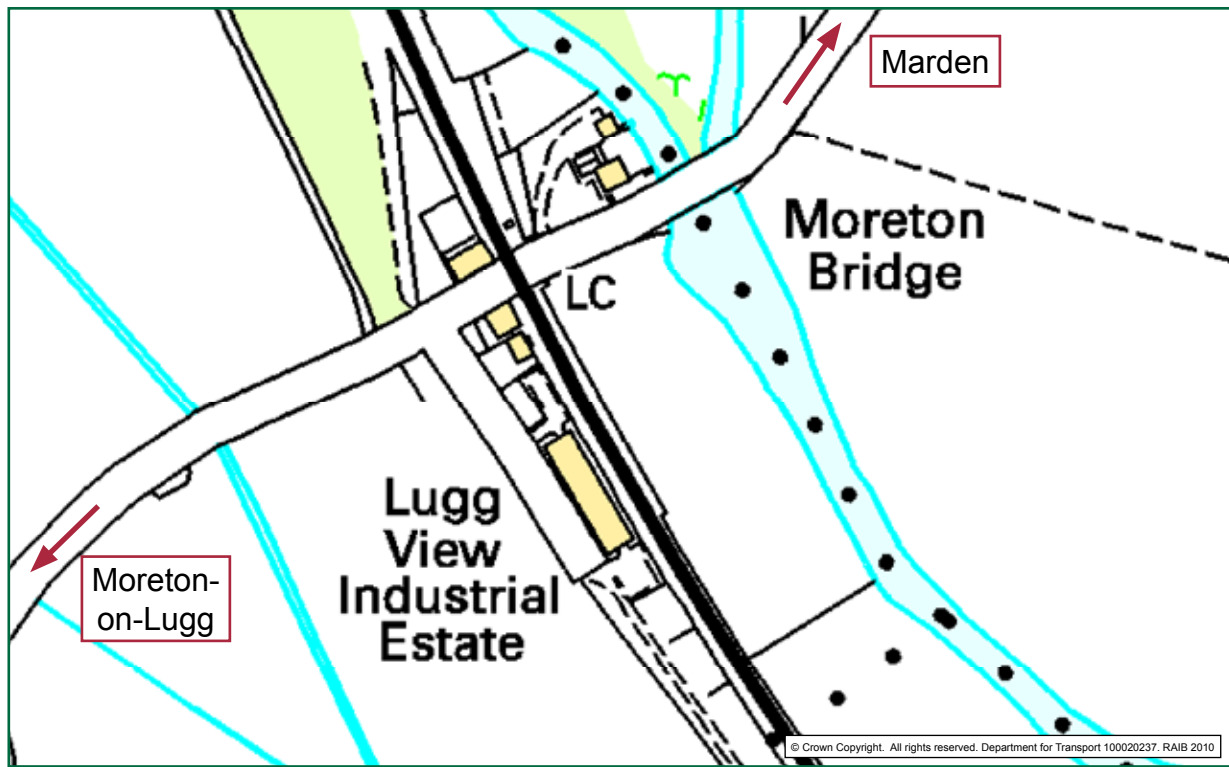


Figure 3: Map showing the layout of the road and the railway

- 18 The *permanent speed restriction* on the railway at the crossing is 75 mph (121 km/h) on the up main, and 85 mph (137 km/h) on the down main.

External circumstances

- 19 The weather at the time of the accident was damp with a light wind. It was overcast, although there was no significant fog. The temperature was around 5 - 7 °C. There had been recent snow, but this had cleared. There were reports of flooding in fields adjacent to the railway, which may indirectly explain a telephone call the signaller had requesting permission to cross sheep over the railway (paragraph 71). Other than this, the weather played no part in the accident.
- 20 There was no evidence of other road traffic in the vicinity at the time.

Train involved

- 21 Train 1V75 was formed of a 3-car class 175 diesel multiple unit, number 175 103 (figure 4). There were 32 passengers on board and a train crew of three.
- 22 The train was designed, built and maintained by Alstom. It entered service in 2000.



Figure 4: The train involved in the accident

Infrastructure involved

Level crossing

23 The level crossing at Moreton-on-Lugg (figure 5) has two *BR 843 Mk 2 barrier units*, one on each side of the railway. When lowered, the barriers extend across the full width of both the road and adjacent footways. There are two sets of road traffic light signals in front of each barrier, one on each side of the road. The traffic light signals have *light emitting diode* (LED) light units. Stop lines, on the approach side of the road, are marked 2 metres in front of each pair of traffic light signals. There is an audible warning for pedestrian users. Figure 6 is a plan view of the crossing.

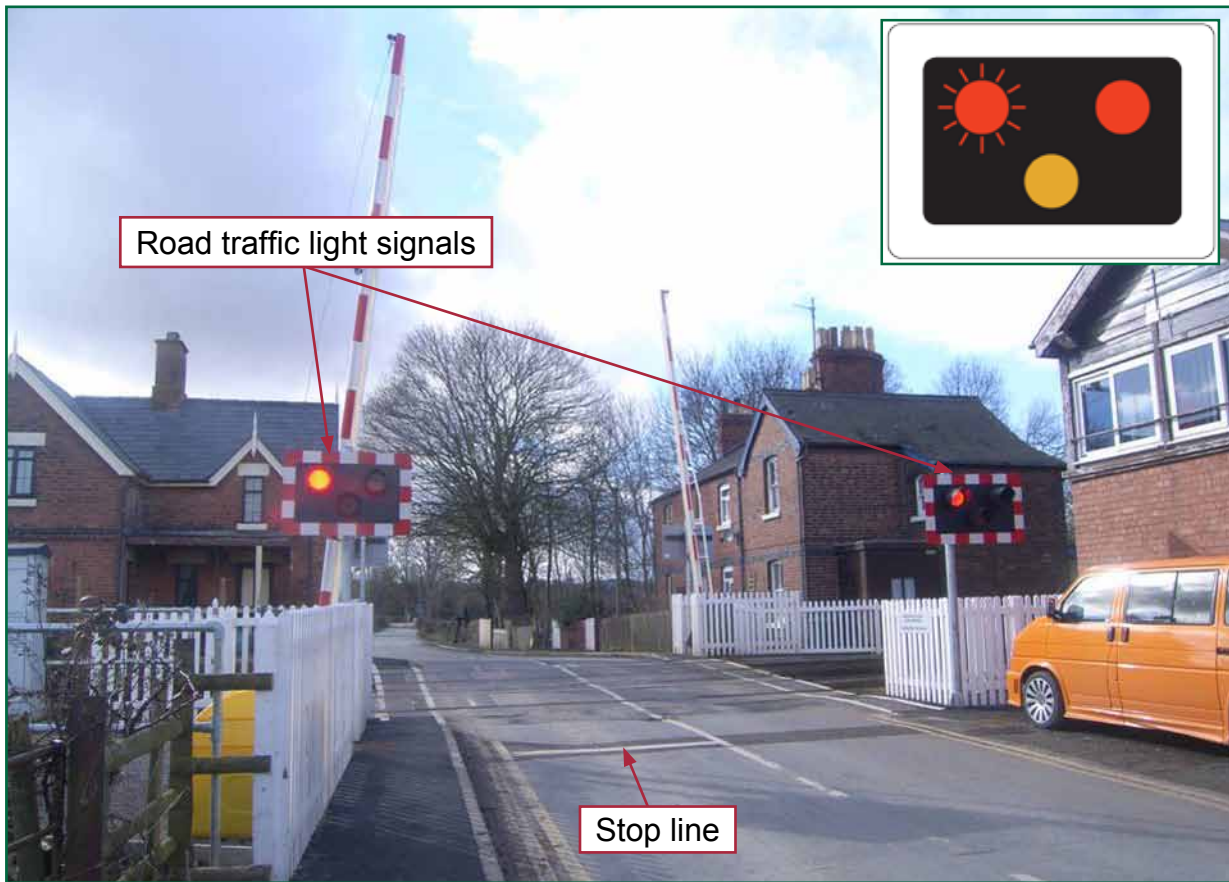


Figure 5: Moreton-on-Lugg level crossing from the east (inset: road traffic light signal from Highway Code)

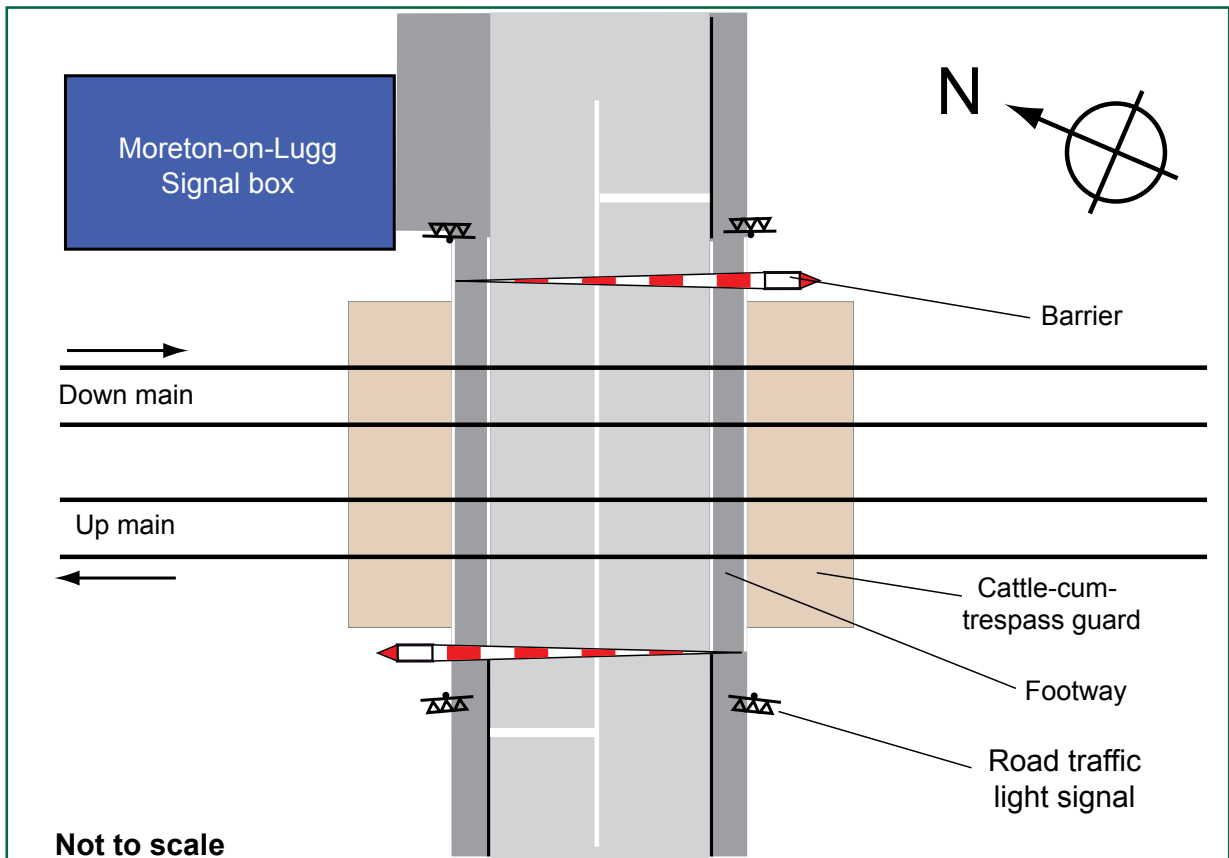


Figure 6: Plan view layout of Moreton-on-Lugg level crossing

- 24 When the signaller commands the crossing to open ('barriers raise') or close ('barriers lower'), the barriers and lights operate in a set sequence, see table 1.

Closing the crossing		
Start condition	Barriers: fully raised	
	Road traffic light signals: extinguished	
Time after start of sequence	0 s	Barriers commanded to lower - Road traffic light signals immediately show steady amber
	6 s	Road traffic lights show flashing red; amber lights extinguish
	14 s	Barriers start to lower; road traffic light signals continue to show flashing red
	21 s	Barriers fully lowered; road traffic light signals continue to show flashing red
Opening the crossing		
Start condition	Barriers: fully lowered	
	Road traffic light signals: showing flashing red	
Time after start of sequence	0 s	Barriers commanded to raise - Barriers immediately start to raise; road traffic light signals continue to show flashing red
	4 s	Road traffic light signals extinguish
	7 s	Barriers fully raised; road traffic light signals extinguished

Table 1: Moreton-on-Lugg level crossing operating sequence²

- 25 Originally the level crossing had mechanical gates, which the signaller opened and closed by means of a manually-operated wheel in the signal box. There were no road traffic light signals associated with the crossing at the time.
- 26 In 1975, as part of a modernisation policy, British Rail's *Western Region* (the owner of the railway infrastructure at the time) converted the crossing to manually controlled barrier operation. This involved:
- replacing the gates with two *Western Region barrier units* and full-width barriers;
 - replacing the operating wheel with a control panel with electrical push buttons for raising and lowering the barriers (the barrier control panel, which is shown in figure 7);
 - fitting an electrical interface to retain the *interlocking* between the railway signalling and crossing controls; and
 - installing road traffic light signals.

The *signalling plan* for the conversion indicates that the focus was the replacement of the crossing equipment, and that no significant change was made to other parts of the signalling system. British Rail converted a large number of gated level crossings on its Western Region on this basis.

² The timings in table 1 are taken from observations of the operation of the crossing after the accident. These were used in the investigation to understand the causal significance of the actual operating sequence.

- 27 In 2009, Network Rail installed the barrier units and road traffic light signals that were in use at the time of the accident, renewing the equipment that was fitted in the mid-1970s. It identified the need for the renewal because of increasing reliability and maintainability problems with the Western Region barrier units. Network Rail planned and undertook the work as part of a renewal programme involving a number of other barrier crossings in the area. It did not change the barrier controls in the signal box.
- 28 The *Level Crossing Order* for Moreton-on-Lugg came into force on 24 October 1975. Network Rail prepared a new order for the crossing after the 2009 renewal work; this was principally so that legal responsibilities placed on the highway authority as a consequence of the Road Safety Act 2006 could be included. The new document was still a draft at the time of the accident.

Signal box and its controls

- 29 The signal box at Moreton-on-Lugg is located on the east side of the railway, figure 6. Normally it is operated by a single signaller, working a 12-hour shift. Routine shift handovers are at 06:00 hrs and 18:00 hrs each day.
- 30 The signaller controls the signals and *points* from a *lever frame*; there are 15 levers currently in use. The barrier control panel (paragraph 26) is located to the south side of the frame, between the road and lever 1. Lever 1 provides the interlocking between the railway signals and the barrier controls. The signaller pulls it so that, via the electrical interface (paragraph 26), the barrier control panel is made active. The signaller can only push lever 1 back (*replacing* it in the frame) if the barriers are fully down. There are *block instruments* on a shelf over the frame for *offering* and *accepting* trains to and from Hereford and Leominster (paragraph 15). The controls are shown in figure 7.



Figure 7: Signalling and level crossing controls in Moreton-on-Lugg signal box

- 31 The signal box has full-width windows on its north, west (behind the levers) and south sides, through which the signaller can observe the passage of trains. Above the lever frame is a diagram of the railway. It has lamps which indicate when certain *track circuits* in the area are *occupied*. These provide an additional indication of the passage of trains. The diagram shows approaching trains on the down main when they are within 2.2 km of the signal box.
- 32 The *train register book*, which the signaller uses to record train movements, is kept on a small desk on the east side of the signal box (opposite the levers); above it is a digital clock. There are three telephones near the desk. Two are for external and internal calls to the signal box. The third is the *telephone concentrator* that is used for calls from operational telephones, including those in Hereford and Leominster signal boxes and adjacent to local signals. The telephone concentrator is also used to receive calls from four remote level crossings in the area: Ox Pasture Farm No.1, Dolmeadow and Wellington (paragraph 14), and a user-worked crossing south of Moreton-on-Lugg, Lyde Court. The *occurrence book*, which signallers use to record calls from the crossings, is normally kept on the lower shelf of the small desk used for the train register book. To the left of the telephone concentrator is the *TRUST* computer which gives the status of approaching trains: this is presented as the time of arrival, departure or passing at a number of reporting points (for instance stations, signal boxes and junctions).
- 33 The arrangement of the items described in paragraph 32 is shown in figure 8.

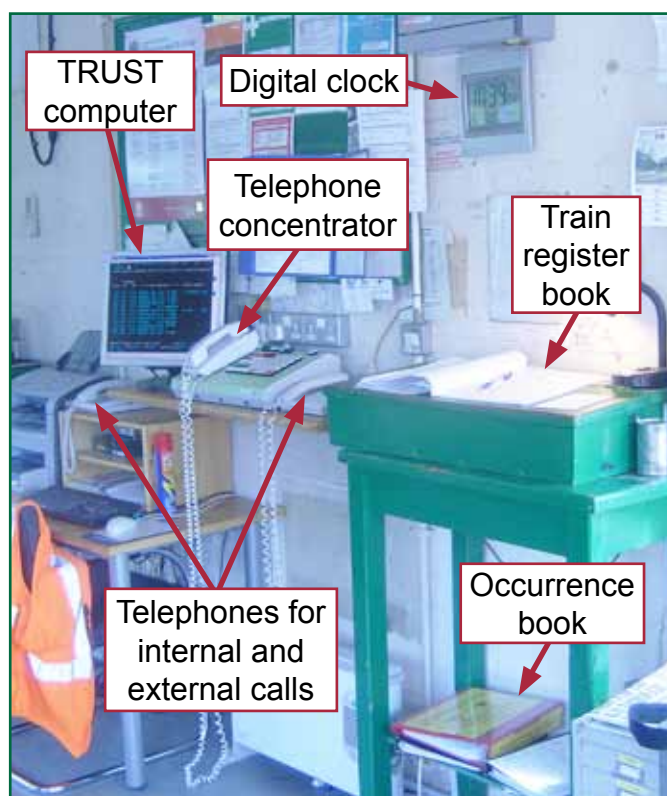


Figure 8: Desk, telephones and other equipment on east side of signal box

Normal operation for signalling trains on the down main³

34 Figure 9 shows the layout of the signalling on the down main between Leominster and Moreton-on-Lugg, the line on which train 1V75 was approaching. It also shows the location of the track circuits and their indication on the diagram in the signal box (paragraph 31).

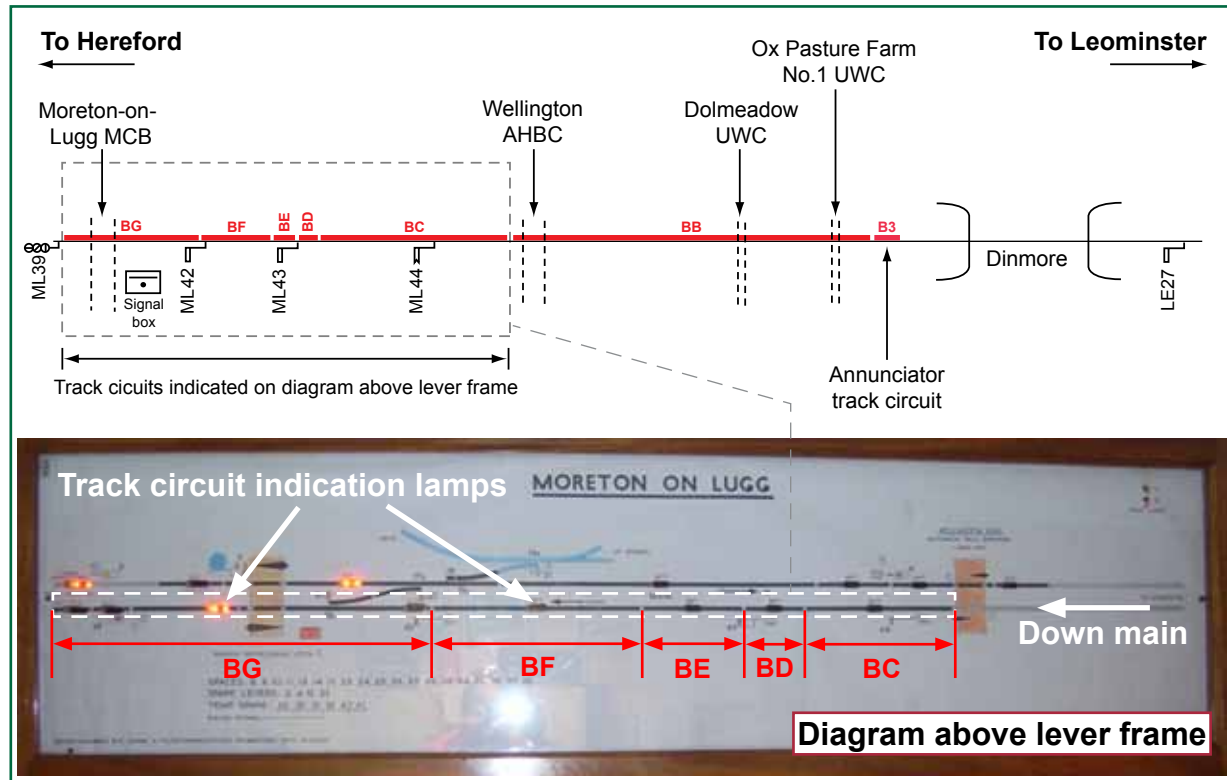


Figure 9: Signalling on the down main approaching Moreton-on-Lugg (not to scale)

35 The signaller at Moreton-on-Lugg is offered a train from Leominster by means of *bell-code* communication. If he can accept the train (because the previous train has cleared the *block section*), he sets his block instrument to 'line clear'. When the train has passed the *section signal* at Leominster, LE27, the Leominster signaller then sends the bell code 'train entering section'. The signaller at Moreton-on-Lugg acknowledges this, and sets his block instrument to 'train on line'. The next indication of the approaching train is when it occupies track circuit B3 after the Dinmore tunnels. This sounds an audible alarm (the annunciator), which prompts the signaller to start the sequence of tasks that enable him to *clear* the signals for the approaching train. The sequence involves the signaller:

- checking that Moreton-on-Lugg level crossing is clear of road traffic and then holding down the 'barriers lower' push button, continuing to check as the crossing goes through its set closure sequence (see table 1), until the barriers are fully down across the road;
- replacing lever 1 in the frame, to unlock the lever for the protecting signal, ML42; and

³ For simplicity, this operating sequence presupposes that a train on the down main will be the next to pass by the signal box at Moreton-on-Lugg, that there are no other trains in area and that the level crossing is open to road traffic.

- then pulling levers 43, 42, 39 and 44, to clear ML43 (the home signal), ML42 (the *stop signal* immediately before the signal box), ML39 (the last signal controlled by Moreton-on-Lugg) and finally the *distant signal*, ML44; when the distant signal is clear, it indicates to the train driver that all the associated stop signals (ML43, ML42 and ML39) are also clear.
- 36 The signaller then has to monitor the passage of the train (signallers use different methods, including the track circuit indicator lamps and external visual cues), and sequentially replace levers into the frame, putting signals ML44 to *caution*, and ML43 and ML42 to *danger*, as the train passes. Replacing lever 42 (for ML42) unlocks lever 1.
- 37 After watching the complete train pass by the signal box, and over the crossing, the signaller can then pull lever 1 and press the 'barriers raise' push button to start the crossing open sequence (see table 1). He then sends the bell code 'train out of section', to advise the signaller at Leominster that the train has left the block section, and, after acknowledgment, sets his block instrument to 'normal'. Throughout the process of signalling the train, the signaller enters in the train register the times of all the bell codes exchanged with the adjacent signal boxes. For trains on the down main, he finally enters the time for 'train out of section sent' in the train register book to record the passage of the train.
- 38 ML39 is a *colour light signal* that automatically *reverts* to danger when the train passes it. However, the signaller has to later replace its lever before he can clear the signal for another train.

Signalling protection in use on MCB crossings

- 39 A number of engineered safeguards are used in signalling systems on Network Rail's infrastructure to prevent the barriers of an MCB crossing being raised when a train is approaching. They can be categorised as follows:
- interlocked protecting railway signals;
 - approach locking; and
 - other systems for locking the route.

Run-by controls are a fourth safeguard. However, while these could mitigate the consequence, they would not prevent the barriers being raised.

Interlocked protecting railway signals

- 40 Interlocking the last stop signal either side of a crossing (the protecting signals) with the level crossing controls can ensure that:
- the protecting signals cannot be cleared unless the barriers are fully lowered; and
 - the barriers cannot be raised with the protecting signals cleared.

The 1975 Level Crossing Order for Moreton-on-Lugg (paragraph 28) mandates interlocked protecting signals that provide this assurance. It is achieved by means of mechanical locking between the signal levers and lever 1, and the electrical interface with the barrier controls (paragraph 30).

Approach locking

- 41 While the interlocking at Moreton-on-Lugg prevents the barriers being raised if the protecting signals are showing a clear indication, it does not stop the barriers being raised in error if a protecting signal is replaced to danger when the driver of a train approaching it is unable to stop before the level crossing. Approach locking is used to achieve this. Once the signaller has set the route and cleared the signal at the entrance, the signal interlocking prevents the opening of level crossings in the route ahead (as well as the moving of any points). In this condition the route is said to be 'approach locked', and, if the signal is then replaced to danger, the route remains so:
- until the signalling system detects that an approaching train has passed the protecting signal and entered the route; at which point the route ahead is locked by other means (paragraph 47); or
 - until a preset time period has elapsed that gives reasonable assurance that an approaching train has come to a stand at, or before, the signal; or
 - until there is proof that there is no approaching train.
- 42 The current industry safety requirements for approach locking at level crossings are defined in Railway Group standard GK/RT0063 'Approach Locking & Train Operated Route Release', issued in November 1996⁴. This describes the need for approach locking on new signalling schemes and for it to be considered if an existing scheme is altered (paragraph 137).
- 43 Prior to this, a regulatory document entitled the 'Railway Construction and Operation Requirements, Level Crossings', published by the Department of Transport in 1981⁵, had included a general reference to the use of approach locking on new and modernised 'vehicular level crossings'. However, there had been no such reference in the equivalent document that had applied in the mid-1970s when the crossing at Moreton-on-Lugg was converted to barrier operation: 'Requirements of the Secretary of State for the Environment for Public Level Crossings Equipped with Manually Controlled Barriers' (published in April 1973). There was also no reference to this safeguard in the 1975 Level Crossing Order⁶.
- 44 GK/RT0063 replaced an internal document used by British Rail (and later Railtrack) entitled 'Standard Signalling Principle No 19' (SSP19). The last version of SSP19 was issued in 1992, but the RAIB is aware that there were equivalent documents going back to the 1960s. It is also aware of other internal British Rail documents that refer to the use of approach locking at MCB-type crossings (one of these is a document entitled 'Principles for Manned Barrier Crossings' that was issued by the British Rail Chief Signal & Telecommunications Engineer's Department in September 1975).

⁴ Railway Group standard GK/RT7012 'Requirements for Level Crossings' (August 2004), and Network Rail's company standard NR/L2/SIG/30017 'Requirements for Level Crossings' (September 2009), which has replaced it, also refer to the use of approach locking (paragraph 136).

⁵ Railway Safety Principles and Guidance documents (paragraph 49), which directly replaced these published requirements, refer to the need for interlocked railway protecting signals at manually operated barrier crossings, but do not mention approach locking.

⁶ There was also no requirement in the draft of the new order prepared after the 2009 renewal work (paragraph 28).

- 45 Although there was no regulatory requirement that mandated approach locking at Moreton-on-Lugg when the barriers were originally installed, the documents reviewed by the RAIB indicate that the provision of approach locking at MCB-type crossings was already a requirement of British Rail standards at around this time. Overall, the various documents in paragraphs 42 and 44 seem to reflect the intention that signalling arrangements at level crossings should be brought into compliance with modern standards when alterations are carried out. However, with the exception of GK/RT0063, issued in 1996, none precisely defined the nature of an alteration that would necessitate such a step.
- 46 An examination of records and post-accident testing confirmed that there was no approach locking fitted to either of the protecting signals at Moreton-on-Lugg (ML42 and ML5).

Other locking systems

- 47 Approach locking is released once a train has passed the signal at the entrance to a route. Other locking systems are then required to maintain the route ahead, including preventing the opening of level crossings. However, because in this accident the signal at the entrance to the route (the protecting signal for the crossing) was replaced to danger before the train had passed it (paragraph 78), such locking systems would not have prevented the barriers being raised.

Run-by controls

- 48 Run-by controls cause the road traffic light signals to show flashing red if a level crossing is open to the road and an approaching train passes a protecting railway signal at danger. So that road vehicles are not trapped on the crossing, the barriers do not lower in this situation (unless the 'barriers lower' push button is pressed). While this safeguard does not prevent the risk of the barriers being raised when an approaching train is unable to stop, it could give road vehicle drivers (if the traffic signals show red in time) the opportunity to stop before reaching the railway.
- 49 Run-by controls at new signalling installations are a requirement of Network Rail's current company standard NR/L2/SIG/30017 'Requirements for Level Crossings', issued in September 2009, and also Railway Group standard GK/RT7012 'Requirements for Level Crossings' that it replaced. Also, for new installations, there is reference to them in the Office of Rail Regulation's 'Railway Safety Principles and Guidance'⁷ part 2 section E, originally published in October 1996. There is no requirement for this safeguard in the 1975 Level Crossing Order or in the draft of the new order (paragraph 28). An examination of records and post-accident testing confirmed that run-by controls were not provided at Moreton-on-Lugg.

Routine level crossing maintenance and risk management

- 50 The level crossing and its equipment were subject to regular maintenance and inspection. An examination of the maintenance records after the accident found all were in date, and no work was recorded as outstanding.

⁷ This documentation is available on the Office of Rail Regulation's website: www.rail-reg.gov.uk.

- 51 Network Rail's company standard NR/L2/OPS/100 'Provision, risk assessment and review of level crossings' defines the ongoing process it uses to manage risk at level crossings (Network Rail's level crossing risk management process). The standard requires that a valid risk assessment is in place for every existing level crossing. For this, it mandates use of the company's standard tool, the *All Level Crossing Risk Model (ALCRM)*⁸, supported, as necessary, by additional risk assessment and expert judgement. The ALCRM tool calculates two risk levels for a crossing:
- the individual risk, which represents the risk that an individual crossing user is exposed to as a probability, on a scale of A (highest) to M (lowest); and
 - the collective risk, which represents the average number of fatalities and injuries (where one fatality is equivalent to a specified number of injuries) that would be expected to occur to all users (road and rail) from a hazardous event, on a scale of 1 (highest) to 13 (lowest).
- 52 Network Rail's operations function is responsible for ensuring that ALCRM assessments are undertaken, reviewed and periodically updated. The supporting standard, NR/L3/OCS/041 'Operations Manual', requires public vehicular crossings, like Moreton-on-Lugg, to be assessed every 18 months.
- 53 The last ALCRM assessment for Moreton-on-Lugg, prior to the accident, was completed by Network Rail on 10 February 2009. It used site data collected on 13 January 2009. ALCRM calculated a score of J for individual risk, and 6 for collective risk. Network Rail considered the risk level to be low, and found no justification for further improvement to the crossing. Network Rail did a new ALCRM assessment after the accident, on 3 February 2010. The calculated score was not significantly different: I for individual, 6 for collective.

⁸ There is a description of ALCRM in appendix B of the RAIB's report on its investigation of the fatal accident at Fairfield crossing, Bedwyn, 6 May 2009 (report 08/2010).

The signaller

- 54 The signaller was recruited by British Rail in March 1991, and, in June 1991, successfully completed a five-week internal training course on absolute block signalling. Around a month later, British Rail examined him on the regulations and other aspects relating to the operation of Moreton-on-Lugg signal box. He was judged 'competent to take charge' of the signal box from 18 July 1991. On 3 September 1991, after a six-month probationary period, he was made a permanent member of staff.
- 55 At the time of the accident, he had had almost 19 years railway experience, all of which had been as a signaller at Moreton-on-Lugg. Over this period, he was subject to regular assessments of his competence, with his employer periodically issuing certificates confirming this. Network Rail issued the certificate he had at the time of the accident, entitled 'Authority to Work', on 20 December 2008; it was valid until 19 March 2010.
- 56 Network Rail uses a competence management process described in its standard NR/L3/OCS/041 'Operations Manual'. This requires the signaller's line manager, the Local Operations Manager at Hereford, to collect evidence, on a three-year cycle, demonstrating:
- knowledge and understanding of operating rules and regulations; and
 - competence against performance criteria for a pre-defined set of elements relevant to the signaller's specific duties (signalling elements); for instance 'manage service disruptions' and 'dealing with dangerous goods incidents'.
- 57 For around three years, Network Rail has been using a computer-based tool, 'Cognisco', to test signallers' understanding of operating rules and regulations. Tests are divided into individual modules, which signallers periodically take throughout the year. The latest Cognisco records for the signaller on duty at the time of the accident showed that his understanding met the benchmark set for all the modules he had completed. However, he recorded that he had low confidence in some of the answers he had given. By doing this, but meeting the benchmark for understanding, the signaller was classified 'management focus' for some modules. This required his manager to agree development action plans for improvement.
- 58 The signaller's line manager had been seconded to the post since June 2009, but had only recently been formally appointed. However, records show that his previous manager had identified the low Cognisco confidence scores, established development action plans, and met with the signaller to discuss improvements.
- 59 The signaller's explanation for his low level of confidence was his wariness of the Cognisco tool itself. He felt that the results it gave were not a true reflection of his understanding and knowledge.
- 60 Network Rail periodically collected the evidence to show that the signaller met the competency criteria for each relevant signalling element. It used a variety of means, including workplace observation and question and answer sessions.

- 61 The RAIB found the signaller's employment record contained details of three operational incidents:
- September 1991: the *signalling inspector* drew attention to an incorrect entry made by the signaller in the train register book, although he stated he had completed it in the way he had been taught.
 - December 1998: the signaller was formally disciplined by Railtrack (his employer at the time, and the owner and operator of the railway infrastructure) for an operational irregularity, in which he allowed a train into a *T2 possession* that he had earlier granted; the signaller did not appeal. He was suspended for one day and was required to undertake a full rules examination before returning to duty.
 - March 2000: when the signaller reported a failure of Wellington AHB crossing to the British Transport Police and *fault control*, he failed to also inform the control office at Swindon; Railtrack wrote to remind him of the importance of doing this.
- 62 There are a number of more recent records formally commending the signaller for his performance at work, and also thanking him for his role in the reporting and subsequent prosecution of individuals following incidents of misuse at the level crossing. The signaller was proud of his job performance; he had never before caused the driver of a train to pass a signal at danger by replacing one in error.
- 63 The signaller's last annual competence review was completed by his previous manager. The overall review comments state that he 'is a good signaller' and a valued member of staff with a positive attitude. There is no mention of any specific concern regarding his Cognisco results. The signaller's current line manager confirmed that he had no prior concerns regarding the signaller's competence.
- 64 The signaller was taking prescribed medication for a condition that was diagnosed in August 2005, and Network Rail arranged for him to attend regular occupational health reviews. The RAIB found no evidence that the medical professionals who saw him considered him unfit to carry out his duties.
- 65 Tests undertaken after the accident, in line with normal post-accident operating procedures, indicated that the signaller was not under the influence of drugs or alcohol.

Events preceding the accident

- 66 Saturday 16 January 2010 was the signaller's third day at work after being off duty for seven days. He had attended a safety briefing in Shrewsbury on Thursday, and had worked a standard 06:00-18:00 hrs shift in the signal box on Friday.
- 67 He booked on in the signal box at Moreton-on-Lugg at 05:43 hrs. He explained there was nothing out of the ordinary about the way he felt, and did not report that he felt fatigued. There were no issues with the shift handover or the first few hours of work.
- 68 Train 1V75 departed from Manchester Piccadilly at 08:31 hrs, one minute later than scheduled. It arrived at Crewe at 09:08 hrs, three minutes late, where a Cardiff-based driver boarded to take the train forward. The new driver described the onward journey to Leominster as uneventful. The train arrived there on time at 10:20 hrs, and was reported departing at 10:21 hrs.
- 69 The signaller was alone in the signal box at Moreton-on-Lugg.

Events during the accident⁹

- 70 Having been accepted by the signaller at Moreton-on-Lugg, train 1V75 passed the section signal at Leominster, LE27, at 10:22:31 hrs.
- 71 Just over a minute later, at 10:23:41 hrs, the signaller received a telephone call from Ox Pasture Farm No.1 user-worked crossing. The caller wanted to take sheep over the railway line. The signaller asked him how much time he required. The caller replied that he needed five or ten minutes. The signaller refused him permission, and he told him he would have to wait as a train from Leominster (train 1V75) was on its way. He asked the caller to call back after the train had gone past. The call ended at 10:24:08 hrs. The signaller then got the occurrence book for the user-worked crossing, he recalled that it had probably been on the lower shelf of the small desk (paragraph 32). When doing this, he noticed the three previous entries were all requests for 'sheep'. He repeated the ditto-marks under the last entry, and recorded '10:24' for the time of the call and when permission was refused, and five minutes for the 'time required for movement', figure 10. The signaller left the occurrence book open, so he could complete the entry when the caller had crossed, on a storage locker at the south end of the signal box, under the window overlooking the road and the level crossing (figure 7).

Appendix C
Ox Pasture Farm 1
Occurrence Book for 44M 38CH User Worked Level Crossing Network Rail

Date	Time	Nature of request	Time required for movement	Time permission refused	Time permission granted	Time reported clear	Time next train cautioned together with its reporting no.
23.11.09	11:22	Phone booked by patrolman					
23/11/09	11:51:10	Phone book by patrolman					
23/11/09	10:55	Phone booked by patrolman					
23/11/09	12:20	Phone booked by patrolman					
24.01.10	11:22	Phone booked by patrolman					
13-01-10	11:46	SHEEP	5	11:46	11:50	11:54	
	12:21	"	5	12:21	12:27	12:29	
	13:46	"	5		13:46	13:47	
16/1/2010	10:24	"	5	10:24	10:48	10:51	

Three previous requests for crossing sheep

Crossing request made on 16 January

Entries made after the accident

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Figure 10: Occurrence book for Ox Pasture Farm No.1 user-worked crossing

⁹ Times in this section of the report are from the RAIB's analysis of evidence listed in paragraph 91.

- 72 At 10:26:39 hrs, after passing through the down main tunnel at Dinmore, train 1V75 occupied track circuit B3, sounding the annunciator that prompts the signaller to lower the level crossing barriers at Moreton-on-Lugg and to clear the signals on the down main ahead of the train (paragraph 35). The data logger at Wellington level crossing recorded that the signaller cleared the distant signal (ML44) at 10:27:19 hrs.
- 73 A combination of evidence, from the train register books and railway telephone recordings, shows that very shortly afterwards the signaller accepted a train on the up main from Hereford (train 1W85) and set his up main block instrument to 'train on line'¹⁰. It also shows that he then offered the train on to Leominster who sent him 'line clear' on his block instrument, which would enable him to clear his section signal (ML6). From the same evidence, the RAIB has concluded that he started to record these actions in the train register book immediately after 10:27:30 hrs¹¹. However, the signaller can remember neither this nor when he operated his block bell and block instruments. He did not clear the signals on the up main.
- 74 Train 1V75 passed over Ox Pasture Farm No.1 user-worked crossing at 10:27:09 hrs, and at 10:27:30 hrs the caller called back. The signaller would have been making an entry in the train register book for 1W85 (or had just finished) when the call came through; he started the conversation at 10:27:36 hrs.
- 75 The caller told the signaller that train 1V75 had gone. However, because a train was now on its way from the Hereford direction (train 1W85), the signaller said he did not know if he could let him cross just now. He thought crossing in the requested five minutes would be tight. He asked the caller if he could cross quicker. The caller said he would try, and the signaller agreed he could go as long he could be as quick as possible. The caller then asked how long he had. When the signaller told him four minutes, the caller decided that he would wait. They both agreed that this was probably better and that there was a risk that the sheep could stray. The signaller told him he should be able to give him permission to cross after train 1W85 had passed, but he should call back to be sure. The call ended at 10:28:26 hrs, it lasted nearly a minute.
- 76 During this second call, the signaller was facing the TRUST computer (paragraph 32), accessing information about the progress of train 1W85, and using this to help decide whether there was enough time for the sheep to cross. He had noted that train 1W85 was reported delayed passing Tram Inn signal box (figure 2), the TRUST reporting point prior to Hereford, and it was not reported as having arrived in Hereford station yet.

¹⁰ There is an *intermediate block home signal* on the up main between Hereford and Moreton-on-Lugg. If this signal is cleared, regulations require the Hereford signaller to send 'train entering section' to Moreton-on-Lugg as soon as the train has passed the Hereford signal box. It is apparent from the Hereford train register book that this means signallers there regularly record the same time for both receiving 'line clear' and sending 'train entering section'.

¹¹ The entry made in the train register at Moreton-on-Lugg indicated that the signaller recorded accepting train 1W85 from Hereford at '10:28'. He also recorded receiving 'train entering section' (from Hereford) and 'line clear' (from Leominster) at '10:28'. All these entries were consistent with the times entered at Hereford and Leominster.

- 77 Immediately after putting the telephone down, the signaller recalled walking towards the occurrence book, which he had left at the south end of the box (paragraph 71). He has stated that his objective had been to check that he had completed it correctly. He did not recall if he actually got to the occurrence book (he made no entry for the second refusal). As he arrived at the south end of the box he noticed that the level crossing was still closed, and that cars were waiting. Assuming that he had left the barriers down in error, and that train 1V75 must have gone, he decided that he needed to open the crossing. He immediately began the task of replacing levers into the frame to allow this (paragraph 36). The data logger at Wellington level crossing shows ML44 reverted to caution at 10:28:42 hrs, 45 seconds after train 1V75 had passed it. ML43 reverted to danger at 10:28:44, shortly after the train had passed by (this was recorded by the rear CCTV¹² camera on train 1V75).
- 78 The driver of train 1V75 reported that ML42 had reverted to danger in front of his train. The RAIB estimates that this occurred at 10:28:46 hrs, around nine seconds before the train reached it. The driver immediately applied full service braking and, shortly after, sounded the horn.
- 79 The front CCTV camera on train 1V75 recorded the level crossing barriers starting to rise at 10:28:50 hrs, eight seconds after the signaller replaced ML44 to start the sequence of signalling tasks that permitted this. The camera shows the Volkswagen Touareg car on the east of the crossing starting to move forwards at approximately 10:28:53 hrs; the RAIB estimates that around this time the road traffic light signals would have extinguished, and that by 10:28:57 hrs the barriers were approaching vertical – the position they were in after the accident. By now the car driver had passed the road traffic light signals.
- 80 The signaller has stated that he realised his error when he saw train 1V75 out of the corner of his eye sometime after he pressed the ‘barriers raise’ push button. Given the near-vertical position the barriers were found in after the accident, the RAIB has concluded that this would not have been before 10:28:57 hrs (paragraph 79), around seven seconds after he pressed the push button and consistent with the signaller’s recollection that the cars had already started to move onto the crossing at this time. The signaller reported trying to recover from his mistake by pressing the ‘barriers lower’ push button. However, it takes around 14 seconds for the barriers to start lowering from vertical (table 1). There was therefore insufficient time to stop the cars going onto the railway line.
- 81 At 10:28:59 hrs, train 1V75 struck the offside of the Volkswagen Touareg at 58 mph (93 km/h). Around the same time, the Vauxhall Astra, which had been waiting on the west side, collided with the right-hand side of the train.

Events following the accident

- 82 At 10:29 hrs, the signaller made an immediate 999 call to the emergency services operator, requesting ambulance, fire and police – ambulance being the priority.
- 83 Independently, at 10:30 hrs, the driver of train 1V75 made an emergency call to Network Rail control at Swindon on his *national radio network* (NRN) radio. They told him railway staff would be on their way.

¹² Because of the attitude of the front CCTV camera on train 1V75, the indications of signals the train was closely approaching were not in its field of view.

- 84 At 10:33 hrs the signaller informed the Network Rail control office in Cardiff. He confirmed that he had called the emergency services, and that all lines were blocked. Around the same time, the front CCTV on train 1V75 showed train 1W85 arriving on the up main, and stopping short of the accident site.
- 85 Ambulance crews were reported to be on site by 10:38 hrs, with the air ambulance arriving at 10:50 hrs. Prior to this, others, including members of public on the train and the driver of the Vauxhall Astra, had responded and administered first aid to the occupants of the Volkswagen Touareg.
- 86 The passenger in the Volkswagen Touareg was in a critical condition and was airlifted to Hereford hospital, where she unfortunately later died. The driver, her husband, was also admitted to hospital, and was detained for three days. The occupants of the Vauxhall Astra had no obvious physical injuries, but attended hospital as a precaution.
- 87 Train 1V75 sustained damage, mainly to its front end, bogies and underframe equipment. With critical components damaged in the accident repaired or replaced, standard post-incident tests revealed nothing untoward with key safety equipment: brake system, speedometer, windscreen, wipers and washers, headlights and warning horns. Furthermore, there was no evidence from the *on train data recorder* (OTDR) to indicate a brake system malfunction.
- 88 Although there was negligible damage to the railway infrastructure as a result of the accident, Network Rail closed the railway to normal operation while it completed standard testing of the signalling equipment at the level crossing. Network Rail was satisfied that the equipment could be restored to service, and it re-opened the line at 03:34 hrs on 18 January 2010.

Previous level crossing incidents at Moreton-on-Lugg

- 89 Network Rail's fault records showed evidence of one technical fault at Moreton-on-Lugg level crossing since the new barrier equipment was installed (paragraph 27). This was on 18 November 2009. The barriers failed to lower, but the crossing remained protected as the railway signals could not be cleared. A technical team repaired the fault within five hours. Prior to the new barriers, there had been an average of more than five equipment failures per year.
- 90 Between February 2005 and October 2009, there were 37 recorded cases of misuse at the crossing. Nearly all involved car drivers violating the road traffic light signals. The RAIB found no previous accounts of the barriers being raised at the level crossing while a train was approaching.

The Investigation

Sources of evidence

- 91 The RAIB used the following key sources of evidence in its investigation:
- from its activities on site:
 - photographic records of the accident site, including the signal box and its controls;
 - survey of the railway and the final position of the train; and
 - copies of documents from the signal box.
 - OTDR data and external CCTV recordings from train 1V75;
 - recordings of railway telephone calls;
 - signalling data recorded by computer equipment at Wellington level crossing and in the south Manchester area (through which the train 1V75 had earlier passed);
 - witness testimony;
 - personnel and training records;
 - records relating to the design, maintenance and renewal of signalling equipment at Moreton-on-Lugg;
 - post-accident testing of the signalling and level crossing equipment at Moreton-on-Lugg;
 - risk assessment work carried out in support of Network Rail's level crossing risk management process;
 - a *human factors* study commissioned by the RAIB;
 - records kept by the RSSB regarding level crossing accidents and incidents with similar characteristics; and
 - other information and documents provided by Network Rail and Arriva Trains Wales.

Key facts and analysis

Identification of the immediate cause¹³

- 92 **The signaller raised the barriers at Moreton-on-Lugg level crossing when train 1V75 was closely approaching the protecting signal and unable to stop before reaching the crossing. This permitted the waiting cars to move onto the railway and into the path of the train.**
- 93 The following evidence supports this:
- The signaller thought that the barriers needed to be raised, and did so (paragraph 77).
 - The limited warning the driver of train 1V75 had of the need to stop. As the train approached the crossing, signals ML44 and ML43 were clear, and ML42, the protecting signal, reverted to a danger indication when train 1V75 was only nine seconds away¹⁴ (paragraphs 77 and 78).
 - The absence of approach locking made it possible for the signaller to raise the barriers after replacing ML42 with a train approaching it (paragraph 46).
- 94 The driver of the Volkswagen Touareg car waited for the barriers to rise before driving onto the crossing (paragraph 79).

Identification of causal¹⁵, contributory¹⁶ and underlying factors¹⁷

- 95 The causal factors relate to:
- an unrecoverable human error that resulted in the barriers being raised; and
 - the lack of an engineered safeguard, such as approach locking, to prevent an error by the signaller causing the barriers to rise when a train is closely approaching the crossing.

Unrecovered human error

- 96 **The signaller failed to re-orientate to the original task of monitoring the passage of train 1V75 after being interrupted by a telephone call. Then, mistakenly thinking that the train had passed over the crossing at Moreton-on-Lugg, he raised the barriers. When he realised his mistake, he was unable to recover the situation. This was causal to the accident.**
- 97 The task of signalling a train on the down main at Moreton-on-Lugg requires the signaller to monitor the train's passage so that he can operate signals and level crossing equipment in a safe and timely manner.

¹³ The condition, event or behaviour that directly resulted in the occurrence.

¹⁴ See paragraph 155 for issues to do with the way the train was driven.

¹⁵ Any condition, event or behaviour that was necessary for the occurrence. Avoiding or eliminating any one of these factors would have prevented it happening.

¹⁶ Any condition, event or behaviour that affected or sustained the occurrence, or exacerbated the outcome. Eliminating one or more of these factors would not have prevented the occurrence but their presence made it more likely, or changed the outcome.

¹⁷ Any factors associated with the overall management systems, organisational arrangements or the regulatory structure.

- 98 Signallers at Moreton-on-Lugg use different indications to monitor the passage of trains, including the lamps showing track circuit occupation on the signal box diagram and visual cues from outside the windows (paragraph 31). However, the RAIB concluded that, on 16 January 2010, the signaller was interrupted by the second telephone call from Ox Pasture Farm No.1 user-worked crossing, stopped monitoring the passage of train 1V75 and did not return to it afterwards.
- 99 In practice, an interruption¹⁸ can be considered to have occurred when:
- a second task is involved (dealing with the telephone call) that leads to the suspension of the original task (monitoring the passage of train 1V75);
 - the second task captures the attention of the individual and involves decision-making; and
 - the individual needs to retain information about the original task so that he can return to it after disengaging from the second task (re-orientate to the original task).

Figure 11 is a simplified diagram of the interruption caused by the second call from Ox Pasture Farm No.1 user-worked crossing.

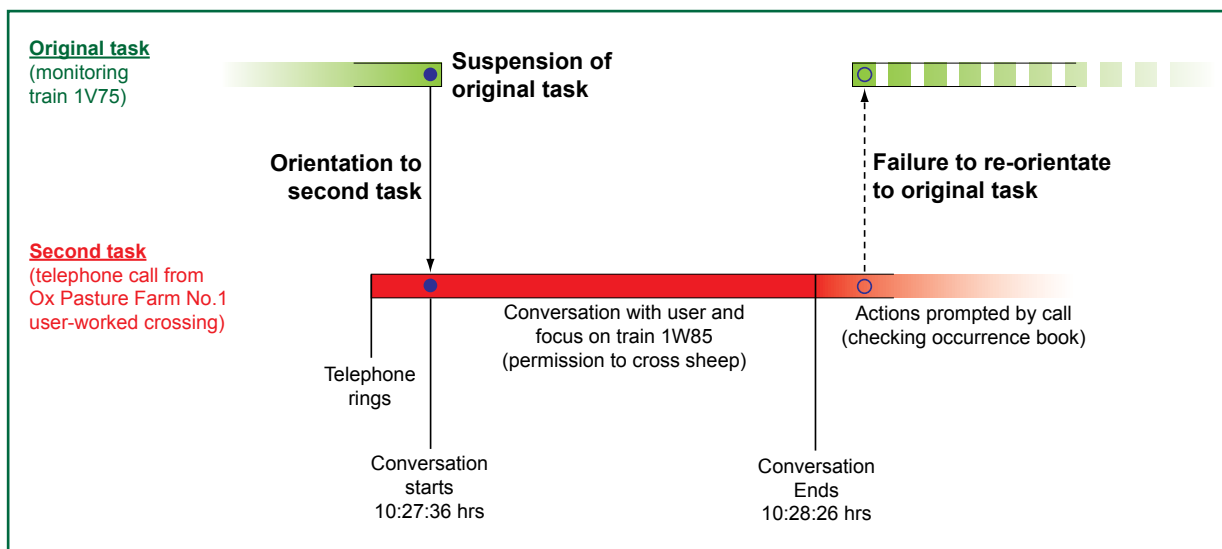


Figure 11: Interruption resulting from the second call from Ox Pasture Farm No.1 user-worked crossing

- 100 Factors leading to an interruption differ for each individual and also each specific circumstance. However, there is a variety of evidence (discussed further in paragraphs 103 to 117) that, together, helps explain why the second call on 16 January 2010 interrupted the signaller and caused him to completely suspend monitoring the passage of train 1V75:
- It captured his attention: to the signaller, the request was unusual and unanticipated, and the conversation focused his attention on another train, 1W85.

¹⁸ Human factors researchers consider interruptions to be distinctly different from the everyday distractions a signaller would be able to cope with at work. They describe them as when, because of a second task, the stream of work associated with an original task is suspended, before that task is complete, and where there was an intention to resume that stream of work and complete the original task.

- It required memory recall: regulations apply to a signaller's handling of calls from user-worked crossings, and these vary according to the type of request. The signaller had to think about how to apply the regulations in this specific situation, and also how he needed to record the call in the occurrence book.
 - It demanded decision-making: he had to assess if the caller had enough time to cross.
- 101 The following factors have been identified which help explain why, afterwards, the signaller did not re-orientate to the original task of monitoring the passage of train 1V75, but went on to raise the barriers at the crossing:
- the loss of normal cues, because the signaller was away from his usual place, which could have helped him re-orientate to the task of monitoring train 1V75;
 - the belief the signaller had that train 1V75 had already passed the signal box; and
 - the signaller feeling under pressure to open the crossing to road traffic.
- 102 Human errors resulting from interruptions are not unusual. This, coupled with the above factors, explains how it is credible that the signaller went on to make the final mistake of starting the familiar sequence for raising the barriers. The relatively short time that the signaller took to go through this (around eight seconds, see paragraph 79) shows that he was likely to be solely focused on the task in hand: getting the level crossing open to road traffic. At the time, he would have mistakenly believed that this was the right course of action.

Suspension of original task - attention capture

- 103 The signaller stated he had maybe only once before had a request to cross animals at Ox Pasture Farm No.1 user-worked crossing in his 19 years of working at Moreton-on-Lugg. In fact, he stated it is possible that he had never had a request to cross sheep before. It was also unusual to get any requests from this crossing in the winter; most are received during harvest time. Other witness evidence supported this.
- 104 The RAIB examined all the level crossing occurrence book sheets in the signal box at Moreton-on-Lugg. They held records going back to 27 January 2009. Prior to the accident, the signaller's last recorded call from a user-worked crossing was on 5 September 2009 from Dolmeadow. He dealt with eight crossing requests that day, all for farm vehicles and plant. His last recorded call from Ox Pasture Farm No.1 was on 29 August 2009, also for farm vehicles. None of his calls involved sheep or other animals. In fact, the only recorded requests for sheep were the three the signaller noticed when he went to record the first call he had on 16 January 2010 (paragraph 71 and figure 10); all three were handled by another signaller.
- 105 In the second call, the conversation was focused on the time available before the arrival of train 1W85, the train that was now on its way to Ox Pasture Farm No.1 user-worked crossing. It led the signaller to concentrate on the passage of this train rather than train 1V75.

106 The signaller was able to deal effectively with the first call from the user-worked crossing. He knew immediately there was insufficient time for the sheep to cross, and was able to promptly dismiss the caller's request without it becoming an interruption (paragraph 71). However, the second call led him to consider the time that was available and to work out the location of train 1W85. The fact that the request captured his attention and focused his concentration on another train probably caused him to suspend his monitoring of the passage of train 1V75.

Suspension of original task - memory recall

107 Signaller's instructions for user-worked crossings¹⁹ require the signaller to instruct the caller to either cross immediately, if there is time, or to wait and call back later. However, if the request concerns 'animals or large, low or slow-moving vehicles', and there is time to cross, the signaller has to go through a more restrictive process. This involves signal protection and the need to ask the caller to call back to confirm he has safely crossed and is clear of the railway.

108 There is evidence suggesting that the signaller had to give more thought to deciding what rule or instruction applied in this situation than he normally had to:

- He had not received a request to cross animals in recent time, and possibly never before (paragraphs 103 and 104). Because of this, he stated he needed to think very carefully about whether there were special instructions additional to those for the usual requests to cross with farm vehicles.
- He stated that he believed that at some time in the past signalling protection was required for crossing requests at user-worked crossings, and that the current regulations, which meant that this protection was not always needed, had changed this established requirement. However, the RAIB has found no relevant change to the regulations for over six years.
- He recalled attending a safety briefing a year or so before, and believed that this may have mentioned a change of rule or instruction for user-worked crossings. The RAIB found a record of the signaller attending a briefing on user-worked crossings in January 2009, but this briefing primarily related to guidance on what constituted a 'slow-moving vehicle', and, beyond following the signaller's instructions (paragraph 107), made no reference to requests for crossing animals. The signaller stated that the briefing he remembered could have been earlier than this.

109 The other concern the signaller had was over the correct way to record calls in the occurrence book. This is evidenced by the checks he stated he wanted to make immediately after the second call (paragraph 77). He was aware that Network Rail reviews the occurrence book as part of routine signal box audits, and he would have wanted to make sure it was right. The RAIB noted that the proforma Network Rail uses in the book has only one column to enter 'time permission refused'. It found that signallers use a variety of methods for recording a second refusal. The signaller cited the single column as a possible concern, and he may have been trying to remember how he needed to record this second refusal. In the end, he made no entry (figure 10).

110 Having to think about the rules and processes to be used for handling the request from Ox Pasture Farm No.1 crossing possibly contributed to the signaller suspending his monitoring of the passage of train 1V75.

¹⁹ Railway Group standard GE/RT8000/TS9 'Rule Book, Level crossings – signallers' instructions', Regulation 7 Occupation and accommodation (including bridleway) level crossings.

Suspension of original task - decision-making

- 111 When dealing with a request to cross animals at user-worked crossings, signallers have to make sure that the caller has enough time to cross and that trains are not delayed. To do this, they need to determine the location of approaching trains and how much time is available before they arrive. The signaller recalled he started dealing with this task on receiving the second call from Ox Pasture Farm No.1 user-worked crossing.
- 112 He took the call, and, rather than turning and looking at the block instruments behind him to determine the status of approaching trains, he consulted the TRUST computer that is directly adjacent to the telephone concentrator (figure 8). It seems it was then that he became conscious of the significance of train 1W85, and that, because it was not far away, there might not be enough time for the sheep to cross. TRUST information at the time showed that train 1W85 was delayed passing Tram Inn, and had not yet arrived at Hereford. He thought that there could be enough time if the caller could cross quicker than his estimate (he was aware that the occurrence book showed that three previous requests for crossing sheep had been achieved in less than five minutes, figure 10). However, he was also mindful that the TRUST information might not be accurate, and wasn't certain if 1W85 had, by now, arrived at Hereford.
- 113 While focused on the TRUST information, the signaller appears to have overlooked that he had already accepted train 1W85 from the signal box at Hereford, acknowledged 'train on line', set his up main block instrument to 'train on line' and recorded this in the train register book. Had he recalled this, or had noticed the indication showing on his up main block instrument, he is likely to have realised that train 1W85 would be at Moreton-on-Lugg in four to five minutes.
- 114 It is apparent that it was these factors (the signaller considering the time that he had available before the arrival of train 1W85 and the time previously taken to cross sheep) that drew the signaller into an absorbing conversation with the caller (paragraph 75). It almost became a negotiation, as the signaller tried to decide if he could allow the sheep to cross.
- 115 The decision making process that the signaller became involved with as he tried to determine if there was enough time for the caller to cross was probably causal to him suspending his monitoring of the passage of train 1V75.
- 116 Train 1W85 was much closer to Moreton-on-Lugg than the TRUST computer indicated. At Tram Inn and Hereford signal boxes, the reporting points either side of where the train was shown to be, TRUST information is input manually. As signallers do not immediately input the actual time for train arrival, departure or passing, the TRUST computer does not always give the most accurate indication of train location. This is relevant to the reporting of train 1W85. The RAIB has concluded that at the time the signaller was interrogating the TRUST computer, arrival and departure information had yet to be input at Hereford signal box. The final TRUST report for train 1W85, shows that it caught up two minutes of the delay reported at Tram Inn and had arrived in Hereford at 10:26 hrs, nearly two minutes before the start of the second telephone call. It was reported leaving Hereford on time at 10:28 hrs, the same time that the signaller recorded that he had acknowledged 'train entering section' for train 1W85 just before he took the second call (paragraph 113).

117 Information on the block instruments (and in the train register book) provides a more reliable indication than TRUST of the status of approaching trains. However, the signaller was apparently drawn into consulting the TRUST computer and did not recall that he had just set his block instrument for train 1W85. There were cues that could have prompted the signaller to realise that the TRUST computer had diverted his concentration from train 1V75:

- If he had turned away from the computer he may have noticed that his block instrument was showing 'train on line' for train 1V75, reminding him that it had not yet passed his signal box.
- Similarly, he could have observed that, during the call, the indication lamps on the diagram started to show train 1V75 occupying track circuits as it approached his signal box.
- Alternatively, he could have consulted the train register book, which showed his entries for train 1V75.

It seems that these cues were not effective in directing the signaller's attention back to monitoring the passage of train 1V75.

Failure to re-orientate to the original task, and then raising the barriers

118 Having completed the second call, the signaller could have re-orientated to the original task of monitoring train 1V75. The RAIB found evidence that indicates both why this did not happen and why he then made the mistake of raising the barriers at the level crossing.

Loss of normal cues

119 Witness evidence indicates that the signaller would normally stand facing the lever frame when monitoring the passage of a train, checking the track circuit indication lamps on the signal box panel, looking out of the window, and replacing signals as the train passes. The RAIB observed that other signallers at Moreton-on-Lugg stand in a similar location.

120 The signaller was away from this location when he went to the south end of the signal box after the second call from Ox Pasture Farm No.1 crossing (paragraph 77). He was therefore deprived of his normal cues. It is possible that this contributed to him not re-orientating to the original task of monitoring train 1V75.

Believing that the train had gone past the signal box

121 The signaller recalled that it was when he approached the south end of the signal box, and saw that the crossing was closed and cars were waiting, that he started to think that train 1V75 must have already gone past and that he had left the barriers down in error (paragraph 77).

122 A number of other factors could have contributed to this belief:

- The second call from Ox Pasture Farm No.1 crossing was conversational and relatively long (approximately one minute, paragraph 75); it is credible that the signaller could have lost track of time, making it seem possible that train 1V75 had gone past in the meanwhile.
- At the start of the second call, the caller stated 'he's gone' (meaning train 1V75 had passed by Ox Pasture Farm No.1 crossing). The rest of the conversation concerned train 1W85. It is possible that the lack of further reference to train 1V75 added to the signaller's misconception that train 1V75 had been dealt with, and now train 1W85 was the priority.
- The signaller reported that he thought he heard the cars revving while they were waiting at the crossing. While the driver of the Volkswagen Touareg did not recall doing this (or that he was in any particular hurry), the signaller's perception made him believe that the car drivers must have seen train 1V75 go by, and now they wanted to get on their way.

123 The signaller's interrogation of the TRUST computer during the second call may also have added to the picture. At the time of the accident there was no dedicated reporting screen for trains passing Moreton-on-Lugg. As a result, signallers used the screens for adjacent reporting points at Leominster, Shelwick Junction and Hereford. Although the RAIB has been unable to confirm, it is very possible that the signaller was using the reporting screen for Leominster, regularly refreshing it to get the latest information for train 1W85. If this was the case, train 1V75 would have been deleted from the list of approaching trains when Leominster signal box entered that it had departed the station there at 10:21 hrs (paragraph 68). This would have further added to the signaller's misconception that he had dealt with train 1V75, and now train 1W85 (which would now have been at the top of the list) was the priority.

124 The signaller's belief that train 1V75 had gone past the signal box, after he had suspended monitoring its passage, was the fundamental human error that caused him to raise the barriers.

Pressure to open the crossing

125 The signaller would have been aware of the need to open the level crossing to road traffic as soon as was possible. Instructions concerning full-barrier level crossings worked by the signaller²⁰ state that 'the normal position of barriers is raised'.

126 The signaller also explained that it is not unusual for road vehicle drivers to get impatient at the crossing, revving engines, tooting horns and using verbal abuse, causing him to feel pressure to open the crossing.

127 The pressure that the signaller felt under to open the crossing possibly contributed to him raising the barriers.

²⁰ Railway Group standard GE/RT8000/TS9 'Rule Book, Level crossings - signallers' instructions', Instruction 3 Level crossings with full barriers worked by the signaller.

Engineered safeguards

128 Although an engineered safeguard was provided in the form of interlocked signals, this was not sufficient to prevent a signaller mistakenly replacing the protecting signal and then raising the barriers when a train was closely approaching. Approach locking, an engineered safeguard that would have provided this protection, was not fitted when the crossing was converted to manual barrier operation in the mid-1970s. Network Rail has neither subsequently fitted it, nor undertaken a formal risk assessment to quantify the safety benefit. Without approach locking, or an equivalent engineered safeguard, there was nothing to prevent the signaller raising the barriers in error. The lack of this engineered safeguard was therefore causal to the accident.

- 129 The RAIB found no evidence of a regulatory requirement for British Rail to fit approach locking to the signals protecting the level crossing at Moreton-on-Lugg when the crossing was converted to manual barrier operation in 1975. Neither the level crossing requirements issued by the Secretary of State for the Environment demanded it, nor did the 1975 Level Crossing Order (paragraph 43). However, there is evidence that at around this time British Rail had documented internal requirements for approach locking at this type of barrier crossing (paragraph 45).
- 130 The RAIB has not investigated how British Rail interpreted its internal standards for approach locking or how it applied them, either to the conversion of level crossings or to other signalling alterations.
- 131 An examination of records, and testing by the RAIB, has confirmed that approach locking has not been fitted since the crossing was converted (paragraph 46).
- 132 There have been a number of alterations to the signalling at Moreton-on-Lugg since the crossing conversion. These include signalling renewal work associated with:
- the removal of the signal box at Shelwick Junction in 1984;
 - the installation of *train protection and warning system* (TPWS) equipment at ML5 and ML43 signals in 2003; and
 - the renewal of the barrier equipment at Moreton-on-Lugg in 2009 (paragraph 27).
- 133 Signalling renewals and alterations, particularly those associated with modifications of level crossings, present an opportunity for bringing existing signalling protection arrangements into compliance with modern standards (paragraph 45). With this in mind, the RAIB investigated the work carried out in support of the most recent alteration, the 2009 barrier renewal. The RAIB focused on this because it would deliver the most relevant safety learning.
- 134 Similarly, the RAIB also investigated work undertaken in support of Network Rail's level crossing risk management process (paragraph 51). However, it found that neither piece of supporting work ultimately resulted in plans to fit approach locking, and neither included a formal assessment of the benefits.

Signalling renewal works

135 Railway Group standard GK/RT0063 'Approach Locking & Train Operated Route Release' mandates approach locking for new signalling installations (paragraph 42). It was current when Network Rail actively started to consider replacing the barrier equipment at Moreton-on-Lugg in around 2005. In clause 4.1 it states:

'Approach locking shall prevent, until it is safe to do so, the changing of a route ahead of a signal/indicator once the driver has had the opportunity to observe a proceed aspect at the signal or an aspect at a previous signal that would indicate that the signal had displayed a proceed aspect.'

and also:

'"Change of route"...includes the opening of level crossings to road traffic where the level crossing...is interlocked with the signalling...'

136 Railway Group standard GI/RT7012 'Requirements for Level Crossings' (August 2004) was also current at this time. Although it does not specifically mandate approach locking, its use at new 'crossings worked by signallers' is implied. In clause E6.1²¹ it states:

'It shall not be possible to open the crossing to road users unless the protecting signals are at danger and free of approach locking'.

137 Renewal work and alterations are an opportunity to bring existing signalling into line with the standards for new installations. Compliance statements detail how each of the standards should apply:

- In GK/RT0063 it states that 'Railtrack (the owner of the infrastructure at the time) shall consider the need to adopt the requirements of this standard on a signalling scheme where an alteration to the approved signalling scheme plan is made after 7th April 1997'.
- In GI/RT7012 it states that compliance is necessary, but only in relation to the specific equipment being renewed, and then only if there is a 'reasonable opportunity' to improve the safety performance of that piece of equipment.

138 The last significant signalling renewal at Moreton-on-Lugg was the replacement of the original barrier equipment in 2009 (paragraph 27). When Network Rail was developing signalling designs against the initial remit for the renewal, there was discussion over the need to comply with these standards. In addition to other work, the initial remit called for new barrier control panels that meant a change to the signalling plan; hence consideration was given to GK/RT0063. As a result, there was an early proposal to fit approach locking. However, it was eventually decided that the design should be developed without this. A risk assessment was to be done to support the decision, and a note was added to the draft signalling plan recording this.

²¹ Clause E6.3 also requires that the barriers are maintained locked in their lowered position when the track section between the protecting signal and the crossing is occupied. This is the type of locking referred to in paragraph 47.

- 139 However, around this time Network Rail confirmed that it became increasingly concerned about the cost of the design being developed, and had similar concerns about a number of other barrier renewal projects. It decided to look for an alternative, more cost-effective, approach. The draft signalling plan was put aside and design work done against the initial remit stopped; the risk assessment was not carried out.
- 140 Network Rail termed the alternative approach it developed the 'partial renewal'. This enabled the Western Region barrier units (these were suffering from reliability issues (paragraph 27), and new ones were no longer available) to be replaced with standard BR 843 units without the need for new barrier control circuitry. The partial renewal of a crossing in Truro in 2008 verified this approach.
- 141 Renewal of the barriers at Moreton-on-Lugg in 2009 was done as a partial renewal, undertaken against a revised remit. Choosing this way forward allowed Network Rail to renew a greater number of problematic barrier units than it could by the original approach.
- 142 There was a wider and more general discussion in Network Rail regarding level crossing renewals at this time. As part of this, a flowchart (figure 12) was produced for discussion that directly supported the partial renewal philosophy as a strategy for improving level crossing renewal efficiency. Network Rail tabled this, in October 2007, at a meeting it had with the Office of Rail Regulation. Network Rail's records of the meeting do not indicate that the Office of Rail Regulation raised any objections. The document detailing the revised remit recorded that the flowchart influenced the decision to renew the barriers at Moreton-on-Lugg as a partial renewal.
- 143 By adopting the partial renewal strategy, GK/RT0063 did not require that formal consideration be given to fitting approach locking. The flowchart reinforced this, because the level crossing control circuits were not being renewed.
- 144 Alterations to existing signalling installations can be costly. Therefore, even if Network Rail had formally considered fitting approach locking at Moreton-on-Lugg, it may ultimately have decided there was no investment justification, and rejected it. However, coming to this investment decision would have required Network Rail to quantify the safety benefit that approach locking would bring. The RAIB found no evidence of a formal risk assessment to support this, nor an industry requirement for one.
- 145 The decision to carry out a partial renewal, as a strategy to improve value for money, limited the signalling renewal work at Moreton-on-Lugg to 'like-for-like' equipment replacement. This contributed to there being no industry requirement to do a risk assessment to consider the safety benefit of an upgrade to bring the wider signalling system into compliance with current engineering standards.

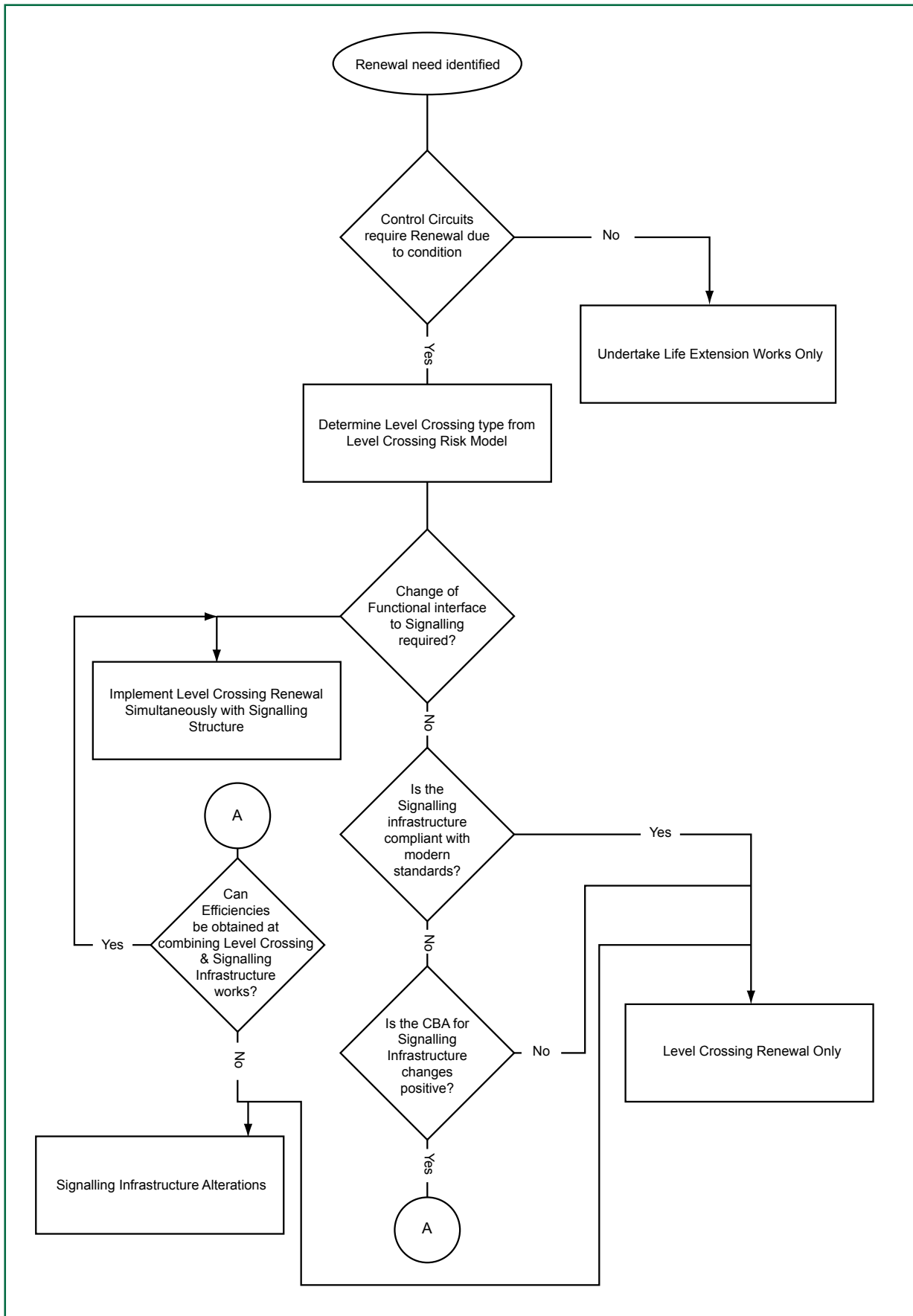


Figure 12: Level Crossing renewal flowchart produced by Network Rail for discussion in 2007 (note: the term 'life extension works' is used instead of partial renewal)

Network Rail's level crossing risk management process

146 Network Rail's level crossing risk management process, NR/L2/OPS/100, requires the use of ALCRM, supported by additional risk assessments where appropriate (paragraph 51). In clause 5.2.4, it states:

'The All Level Crossing Risk Model (ALCRM) shall be used to assess the risk (of existing level crossings), to be supported as necessary by expert judgement or additional risk assessment processes where appropriate.'

Network Rail's local operational risk teams are responsible for this work.

- 147 The last periodic risk assessment for Moreton-on-Lugg was carried out on 10 February 2009, as required by a supporting procedure in Network Rail's operations manual, NR/L3/OCS/041. This did not find that the crossing had a particularly high risk level (paragraphs 50 to 53).
- 148 Network Rail explained that the risk team is focused on the operational interface between the railway and public road users. For MCB-type crossings, the biggest issue is road vehicle drivers violating the road traffic light signals (the incident record for Moreton-on-Lugg supports this, see paragraph 90). ALCRM uses a generic risk profile for each crossing type. This has been developed from historic data, and is adjusted using variables that relate to local risk factors for the individual crossing considered.
- 149 Appendix C lists the ALCRM input parameters used to vary the local risk factors for MCB-type crossings. They all relate to environmental factors to do with the road-rail interface, road and railway usage and the likelihood of deliberate misuse by road vehicle users. None of the parameters relate to the signalling arrangements at the level crossing, or the risk of signaller error. Network Rail's briefing material for ALCRM confirms that signalling-related risks, specifically those due to trains passing protecting signals at danger, are excluded from the model.
- 150 Although there are some exceptions²², NR/LS/OPS/100 generally infers that the burden of responsibility lies with Network Rail's operations function, in practice the local operational risk team.
- 151 It is significant that Network Rail's level crossing risk management process did not require that the team, responsible for the risk assessment, was aware of how the engineered safeguards at a crossing compare with those required by modern standards. Furthermore, although the team sometimes liaises with signalling engineers if they identify a particular issue with the road-rail interface (like the need for new barrier timings), there is no regular forum between the two functions. This could explain why the RAIB found no evidence of a risk assessment, resulting from work done in support of Network Rail's level crossing risk management process, which additionally considered the signalling system risks at Moreton-on-Lugg.

²² For instance, the property function has a role when it identifies relevant planning applications.

- 152 In summary, no explicit requirement was found in Network Rail's level crossing risk management process to consider signalling design²³ and operation issues. This contributed to there being no industry requirement to undertake a risk assessment to formally consider the safety benefit of fitting approach locking, or an equivalent engineered safeguard.
- 153 The lack of regular liaison between the operational risk team and signalling engineers made it less likely that the risk associated with signaller error, and the potential mitigation, would be considered. This was possibly an underlying factor. Such liaison could have enabled the sharing of information and expertise that would have been necessary to establish a comprehensive understanding of the risks at Moreton-on-Lugg level crossing.
- 154 Network Rail company standard NR/L2/OPS/100 was introduced in December 2006; it covers 'all level crossings on Network Rail Managed Infrastructure'. The scope of the company's previous standard, NR/CS/OPS/061 'Management of Risk at Level Crossings', did not include MCB-type crossings. At the time, these crossings were assessed by checking against the appropriate Level Crossing Order. The Order for Moreton-on-Lugg does not require approach locking (paragraph 43).

Driving of the train

- 155 The driver of train 1V75 immediately applied full service braking when signal ML42 reverted to danger. He explained that he did not initially perceive this as an emergency situation, and thought that the signaller wanted to bring him to stop because of an obstruction further down the line. Shortly after this he sounded his horn. He kept looking at the signal box expecting a visual warning like a red flag or a request for him to call the signaller on the telephone. As events developed, he applied his emergency brake and sounded his horn again. Because of the proximity of the train to the crossing when ML42 reverted, the RAIB found that immediately applying the emergency brake is unlikely to have prevented a collision on the crossing or significantly reduced the speed of the train as it approached. The driving of the train was therefore neither a causal nor a contributory factor.

Occurrences of a similar character

- 156 The RAIB has investigated incidents at two level crossings that involved human operational error: Crofton Old Station No.1 level crossing near Wakefield and Poplar Farm level crossing near Attleborough, Norfolk. Both involved gated-type crossings operated by *level crossing keepers*.
- 157 At Crofton Old Station two incidents were investigated, the first on 1 May 2006, and the other on 18 May 2006. In both cases trains passed over the crossing while at least one of the gates was open to the road, and involved staff omitting steps in the procedure for the method of working. In the second incident, the signaller in the controlling signal box was distracted by attending to a personal telephone call.

²³ Clause 6.1.1 of NR/SP/OPS/100 requires Network Rail's engineering function to have a risk assessment process in place to determine the most suitable form of protection at a level crossing, but only for when equipment renewal work is planned. The RAIB has described in paragraphs 135 to 145 why such renewal work did not result in an assessment that considered the benefits of fitting approach locking at Moreton-on-Lugg.

- 158 The crossing was not fitted with any interlocking between the manually operated gates and the protecting signal. The RAIB recommended that Network Rail fit this. The Office of Rail Regulation²⁴ has advised the RAIB that Network Rail has since fitted gate locks, ahead of installing interlocking as part of a planned resignalling scheme.
- 159 The incident at Poplar Farm was on 1 July 2008, and involved a mobility scooter that had been driven onto the crossing when the gates were open to the road and a train was approaching. The train was unable to stop, but the mobility scooter was able to move clear before it arrived. There were no injuries or damage.
- 160 The crossing keeper opened the gates on the crossing because he mistakenly thought that the indication he had for a 'train in section' was for a train that had already passed by. The RAIB recommended that Network Rail review its operating procedures for the crossing, notably with respect to mistaking the location of trains. The Office of Rail Regulation has advised the RAIB that Network Rail has undertaken a review, and as a result:
- briefed affected staff on the need to check indications; and
 - cleared vegetation that was partly obscuring approaching trains.
- 161 At about 14:51 hrs on 24 November 2010, an incident occurred at Foxton MCB level crossing, Cambridgeshire. At this crossing there are, in addition to the full barriers across the carriageway, *wicket gates* across the footways alongside the road. This foot crossing forms part of the route for pedestrians between the platforms of the adjacent station. The crossing is operated by a crossing keeper from a former signal box building nearby.
- 162 A pedestrian approached the level crossing from the north (down) side, while the road barriers were closed. After he had waited at the down side wicket gate for about one minute, a down train passed at line speed (90 mph (145 km/h)). The pedestrian then opened the wicket gate and walked onto the crossing. As he did so, an up train approached, also travelling at 90 mph. This train sounded its horn. The pedestrian broke into a run and crossed in front of the train, which passed very close behind him, and may have struck him, although he continued on his way. The incident was captured on CCTV cameras.
- 163 The driver of the train, who thought that he had hit the pedestrian, stopped the train and reported the incident to the controlling signal box. Network Rail subsequently tested the controls of the wicket gates, and no fault was found. The RAIB carried out a preliminary examination of the incident.
- 164 The wicket gates can be locked by the crossing keeper using buttons on the control panel in the former signal box. However, there is no engineered safeguard ensuring the wicket gates are locked, and remain locked, when a train is approaching.
- 165 From data provided by the RSSB for MCB and gated crossings, the RAIB has identified 12 other level crossing incidents involving signaller or level crossing keeper error over the last 10 years. All were at gated-type crossings, and mainly involved staff either forgetting about the approaching train or believing that it had passed by.

²⁴ The Office of Rail Regulation is the organisation responsible for ensuring that RAIB recommendations made to Network Rail are duly considered and, where appropriate, acted upon.

166 The RSSB has recently concluded that just over 8% of the total accident risk at level crossings on the national rail network is within the direct control of the rail industry, and that most of this arises from workforce error²⁵. Given that they are manually operated, there is more scope for workforce-related accidents from MCB and gated crossing types than from level crossings that are automatically operated, such as the AHB type.

Observations²⁶

167 Run-by controls were not fitted at Moreton-on-Lugg (paragraph 49). The RAIB found no evidence of plans to fit them, or a formal assessment of the benefit of fitting them at Moreton-on-Lugg.

168 The driver of the Volkswagen Touareg would have been in a position that meant he probably would not have seen the road traffic lights had they changed to red when train 1V75 passed the protecting signal, ML42. It is therefore unlikely that run-by controls would have prevented the accident on 16 January 2010. However, in slightly different circumstances these controls could have been beneficial.

²⁵ 'Rail-road interface special topic report 2010', Railway Safety and Standards Board.

²⁶ 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.

Summary of Conclusions

Immediate cause

169 The immediate cause of the accident was that the signaller raised the barriers at Moreton-on-Lugg level crossing when train 1V75 was closely approaching the protecting signal and unable to stop before reaching the crossing. This permitted the waiting cars to move onto the railway and into the path of the train (**paragraph 92**).

Causal and contributory factors

170 A causal factor was that the signaller failed to re-orientate to the original task of monitoring the passage of train 1V75 after being interrupted by a telephone call. Then, mistakenly thinking that the train had passed over the crossing at Moreton-on-Lugg, he raised the barriers. When he realised his mistake, he was unable to recover the situation (**paragraphs 96 and 124, Recommendations 2 and 4**).

171 The above human errors were a result of the signaller first suspending his monitoring the passage of train 1V75, probably caused by a combination of the following:

- a) the call from Ox Pasture Farm No.1 user-worked crossing, in that it captured his attention and focused his concentration on another train (**paragraph 106, Recommendation 2**); and
- b) the decision-making process that the signaller became involved in as he tried to determine if there was enough time to cross sheep at Ox Pasture Farm No.1 user-worked crossing (**paragraph 115, Recommendations 2 and 4**).

172 Having to think about the rules and process for handling the call from Ox Pasture Farm No.1 user-worked crossing possibly contributed to the signaller suspending his monitoring the passage of train 1V75 (**paragraph 110, Recommendation 2**).

173 The following possibly contributed to the signaller not subsequently re-orientating to the original task of monitoring the passage of train 1V75, and then raising the barriers:

- a) The loss of normal cues, because the signaller was not in his usual location (**paragraph 120, Recommendation 2**).
- b) The pressure that the signaller felt under to open the crossing (**paragraph 127, Recommendation 2**).

174 A further causal factor was that although an engineered safeguard was provided in the form of interlocked signals, this was not sufficient to prevent a signaller mistakenly replacing the protecting signal and then raising the barriers when a train was closely approaching. Approach locking, an engineered safeguard that would have provided this protection, was not fitted when the crossing was converted to manual barrier operation in the mid-1970s. Although there have been a number of other incidents involving errors made by signallers and level crossing keepers in recent years, Network Rail has neither subsequently fitted it nor undertaken a formal risk assessment to quantify the safety benefit (**paragraphs 128 and 165, Recommendation 1**).

175 There was no industry requirement that mandated a risk assessment to formally consider the safety benefit of fitting approach locking. The following contributed to this:

- a) The decision to limit signalling renewal work at Moreton-on-Lugg to like-for-like equipment replacement, as a strategy for improving value for money. As a consequence, there was no need to formally consider the benefits of an upgrade to bring the wider signalling system into compliance with current engineering standards (**paragraph 145 Recommendation 3**).
- b) The absence of any mandated requirement to consider signalling design and operation issues as part of Network Rail's level crossing risk management process (**paragraph 152, Recommendation 2**).

Underlying factors

176 A possible underlying factor was the lack of regular liaison between Network Rail's operational risk team and signalling engineers. This made it less likely that the risk associated with signaller error, and the potential mitigation, would be considered (**paragraph 153, Recommendation 2**).

Additional observations

177 Although not linked to the accident on 16 January 2010, the RAIB observes that run-by controls were not fitted at Moreton-on-Lugg. There was no evidence of plans to fit them, nor a formal assessment of their benefit (**paragraph 167, Recommendation 1**).

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

- 178 Network Rail are planning to action two recommendations from the Formal Investigation it has led into the accident at Moreton-on-Lugg (paragraph 10):
- a review of improvements to interlocking arrangements to mitigate the risk of operator error at MCB level crossings in semaphore signal areas; and
 - a review of the effectiveness of the follow up of employees who score low on confidence in Cognisco tests.
- 179 A working group has been set up to implement the first recommendation, and work has been undertaken to determine the status of engineering safeguards fitted to other level crossings. The review has been expanded to cover all level crossings with interlocked protecting signals (not only in semaphore signal areas). It has identified that, including Moreton-on-Lugg, there are 54 MCB-type level crossings without approach locking, or with only partial protection.
- 180 Network Rail has reported that it has established a means of prioritising the risk at the identified level crossings. A programme of site visits is being planned to review the implementation of potential engineering and operational control measures.
- 181 Network Rail has also reported that it is undertaking a review of its level crossing risk management process, which will include how the risk of signaller error should be taken into consideration.

Recommendations

182 The following recommendations are made:²⁷

- 1 *The intention of this recommendation is, where necessary, to implement engineered safeguards at level crossings similar to Moreton-on-Lugg. The objective is to reduce the risk of signallers opening the crossing to road users when a train is approaching, particularly as a result of interruptions or other out-of-course events.*

Network Rail should identify level crossings operated by railway staff where a single human error could result in the road being opened to the railway when a train is approaching. At each such crossing, Network Rail should consider and, where appropriate, implement engineered safeguards. Safeguards for consideration should include additional reminder appliances, alarms to warn of the approach of trains, approach locking, locking of the route, run-by controls, and local interlocking of train detection and signalling systems with level crossing controls (paragraphs 174 and 177).

- 2 *The intention of this recommendation is that implementation of Network Rail's level crossing risk management process will identify and assess the risks from all aspects of the design, operation and maintenance of equipment and systems, including signalling, so that mitigation measures can be identified and implemented.*

Network Rail should enhance its level crossing risk management process to include identification, assessment and management of the risk associated with:

- human error by signallers and crossing keepers;
- operational arrangements, in particular with regard to the ability of operators to cope with interruptions, such as telephone calls, and other out-of-course events;
- equipment design, in particular where it is not compliant with latest design standards; and

continued

²⁷ 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.

- maintenance and inspection arrangements, particularly where these are used to identify and remedy any equipment functional and performance deficiency.

The process should allow for sufficient liaison between the relevant engineering and operational departments.

When addressing risks identified by the implementation of the revised process, Network Rail should prioritise the implementation of required mitigation measures to level crossings where consequences of operator error are severe and not protected by engineered safeguards (paragraphs 170, 171a, 171b, 172, 173a, 173b, 175b and 176).

- 3 *The intention of this recommendation is to ensure that whenever signalling renewal or major maintenance work is planned, those responsible understand when it is necessary to formally evaluate the opportunity to improve compliance with the latest engineering standards.*

Network Rail should develop and implement (paragraph 175a):

- criteria for when it is necessary to formally assess the need to bring existing signalling and level crossing assets in line with latest design standards; and
- a process to record the findings of such assessments.

- 4 *The intention of this recommendation is for Network Rail to understand the risk posed by the use of non-critical information systems in signal boxes and implement practical mitigation measures.*

Network Rail should assess the risk associated with the use of TRUST, and similar information systems, by signallers when undertaking safety critical activities, and implement appropriate mitigation measures. This assessment should include a review of the extent to which signallers may be distracted or misled, and the influence of factors such as the location and orientation of any associated equipment (paragraphs 170 and 171b).

Appendices

Appendix A - Glossary of abbreviations and acronyms

AHB	Automatic half barrier
ALCRM	All level crossing risk model
LED	Light emitting diode
MCB	Manually controlled barrier
NRN	National radio network
OTDR	On train data recorder
RSSB	Rail Safety and Standards Board
TPWS	Train protection and warning system

Appendix B - Glossary of terms

All definitions marked with an asterisk, thus (*), have been taken from Ellis's British Railway Engineering Encyclopaedia © Iain Ellis. www.iainellis.com.

Absolute block principles	A signalling principle that permits only one train in a block section at any time. The regulations concerning this method of signalling are defined in GE/RT8000/TS3 <i>Rule Book, Absolute block regulations</i> .
Accept	The action of giving permission for a train to enter a block section in absolute block signalled areas.
All level crossing risk model	A computer model used by Network Rail to calculate the risk at level crossings and to evaluate reasonably practicable improvements to reduce the risk.
Automatic half barrier	An automatically-operated level crossing fitted with half barriers.
Bell code	A means of communication between adjacent signal boxes, in absolute block areas, using a Morse-type key and single-stroke bell.
Block instrument	An item of signal box equipment used for controlling entry to, and indicating the state of, a block section.
Block section	The section of the line between the section signal of one signal box and the home signal of the next signal box ahead.
BR 843 Mk 2 barrier unit	A type of barrier unit (the piece of equipment that raises and lowers a level crossing barrier) designed to requirements originally specified by British Rail.
Caution	A signal indication or aspect meaning that the driver must be prepared to stop at the next signal that can be put to danger.
Clear	For a track circuit or block section, it means a train is not present. For a signal, it is an indication or aspect that means that a driver can proceed. It is also the action of showing this indication or aspect.
Colour light signal	A railway signal which conveys its message by means of coloured lights.
Danger	A signal indication or aspect meaning that the driver must stop.
Distant signal	A signal used to tell a driver whether he needs to be prepared to stop at the next signal. It cannot show a stop indication or aspect.
Down	In the direction of Newport (on this railway).
Fault control	An office to which all railway infrastructure faults and failures in area are reported to enable a response to be made.

Formal investigation	A formally structured investigation of an accident or incident carried out by industry representatives in accordance with Railway Group standard GO/RT3119.
Home signal	A signal capable of showing a stop aspect on the approach to a signal box using the absolute block system of signalling.
Human factors	The environmental, organisational and job factors, and human and individual characteristics which influence behaviour at work.
Interlocking	A general term applied to equipment that controls the setting and releasing of signals, points and other apparatus to prevent an unsafe condition of the signalling system arising during the passage of trains.
Intermediate block home signal	In an absolute block signalled area, a signal that controls entry to a block section from an intermediate block section (an additional block section between two signal boxes).
Level crossing keeper	A person (other than a signaller) who operates a level crossing from a position near the crossing.
Level Crossing Order	A legal document describing in detail the method of operation and control to be employed at a particular level crossing.
Lever frame	An assembly of two or more levers and an interlocking system, arranged to control the points and signals in an area.*
Light emitting diode	A semi-conductor light source.
Manually controlled barrier	A type of level crossing with full barriers that is manually operated from a control point nearby (for instance a signal box).
National Radio Network	A dedicated nationwide radio system operated and maintained by Network Rail that allows direct communication between train drivers and the control office.
Occupied	The state of a block section, or track circuit, when a train is present.
Occurrence book	A document used by signallers to record events (for instance requests to cross) at level crossings that they are responsible for.
Offer	The process by which a signaller in an absolute block area asks permission from the signaller beyond to allow a train into the next block section.*
On train data recorder	A data recorder fitted to trains that is used to collect information about its operation and performance.
Permanent speed restriction	A speed restriction applied permanently to a length of track.
Points	A piece of track equipment used to change the route of a train.

Rail Safety and Standards Board	Organisation responsible for railway standards and co-ordinating research relating to railway safety.
Replace (or replacing)	The action of returning a signal (or its lever) to its most restrictive position following the passage of a train.
Reverted	The action of a signal returning to its most restrictive indication.
Section signal	A stop signal that controls the entrance to a block section or intermediate block section ahead.
Signalling inspector	A person involved in the audit, checking and approval of signalling operations.
Signalling plan	A diagram that describes the layout of the signalling system in an area using a standard convention and symbols.
Stop signal	A signal capable of showing a danger indication or aspect.
T2 possession	A section of line that is blocked, according to defined rules, so that engineering work can be carried out on the railway.
Telephone concentrator	A device used to collect many telephone circuits together onto one terminal, avoiding the need to provide a separate telephone instrument for each circuit.*
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.*
Track circuit block principles	A method of signalling trains on sections of line fitted with continuous track circuits and colour-light signals. The regulations concerning this method of signalling are defined in GE/RT8000/TS2 'Rule Book, Track circuit block regulations'.
Train protection and warning system	<p>The primary purpose of the Train Protection and Warning System (TPWS) is to minimise the consequence of a train passing a TPWS-fitted signal at danger and a train over-speeding at certain other locations on Network Rail controlled infrastructure.</p> <p>The Train Protection and Warning System is designed to be compliant with the train protection requirements of the Railway Safety Regulations 1999.</p>
Train register book	A book kept in signal boxes for recording the passage of trains, and other events.
TRUST	A computer system that processes reports of train operation and compares it with the scheduled timetable.
Up	In the direction of Shrewsbury (on this railway).
User-worked crossing	A level crossing where the user operates the barriers or gates. There is sometimes a telephone nearby so the user can contact the signaller.

Western Region	Regional division of British Rail, mainly covering south-west England, south Wales and the mainline to London.
Western Region barrier unit	A type of barrier unit (the piece of equipment that raises and lowers a level crossing barrier) that was originally designed and manufactured by and for the Western Region. These units were also fitted on other parts of British Rail-owned infrastructure.
Wicket gate	A type of pedestrian-operated gate used at level crossings.

Appendix C - ALCRM input parameters for MCB-type level crossings

List of ALCRM input parameters when Network Rail last assessed Moreton-on-Lugg level crossing before the accident on 16 January 2010

Crossing Basics	Crossing name
	Crossing type
	Alternative name
	Engineers line reference
	Crossing ID
	Name of nearest stations/ Junction up
	Name of nearest stations/ Junction down
	Is the crossing at or near a station
	Crossing status
	Value map
	Crossing Location
Crossing OS grid reference	
Engineers line reference	
Strategic route	
Highway authority	
Controlling signal box	
Location on the rail	
Location on the road	
Crossing layout	Number of tracks crossing traverses
	Orientation of road/path across the crossing from the north
	Orientation of railway from the north
	Describe the horizon looking from the crossing
Taker info	Assessment title
	Collector's name
	Collector's phone number
	Collector's email
Photographic record	Photos taken of downside crossing approach
	Photos taken of downside looking across crossing
	Photos taken of downside crossing approach
	Photos taken of downside looking across crossing
	Signs/lights/crossing equipment
	Photograph notes
Environment general details	Is power to the line supplied by conductor rail
	Is power to the line supplied by conductor rail

Environment in up (and down) direction	Distance to set of points
	Distance to cutting
	Distance to another crossing
	Distance on right (and left) to a building within 20 metres of the track
	Distance on right (and left) to a platform within 20 metres of the track
	Distance on right (and left) to a tunnel within 20 metres of the track
	Distance on right (and left) to a steep drop within 20 metres of the track
	Distance on right (and left) to an underbridge within 20 metres of the track
	Distance on right (and left) to water within 20 metres of the track
	Distance on right (and left) to a platform within 2 metres of the track
	Distance on right (and left) to a tunnel within 2 metres of the track
	Are there any other hazards
	Notes about the crossing environment
Census: General info	Date
	Taker
	Type
	Start
	Duration
	Notes
	Duration of time that trains run
	Proportion of year that census applies to
	Census proportion notes
Census: Environment	Is there a high number of irregular users
	Irregular user notes
	Is there a higher than usual number of vulnerable people
	Vulnerable people notes
Census Usage	Pedestrians
	Car count
	Vans/small lorries
	Buses
	HGVs
	Pedal/motor cycles
	Tractors/farm vehicles
General train info	Group (1, 2 and 3) train
	Group (1, 2 and 3) trains per day
	Group (1, 2 and 3) max speed
	Group (1, 2 and 3) length (m)
Train sighting	Group (1,2 and 3) normal strike-time(s)
	Average time taken to close the gates/barriers
	For what proportion of crossing activations does more than one train pass the crossing

Approach (road)	At what speed do (road) vehicles approach the crossing
	At this approach speed the visibility of the signs and crossing equipment
	Are there any other known visibility problems at the crossing at certain times of the year (eg fog or foliage)
	Describe the road
	Is ice, mud, loose material or flood water a known problem at certain times
	Notes on temporary adhesion issues
	Is the approach road long and straight
	Are there features on the crossing or on the distant side of the crossing (eg roundabout, road junction) that could distract a driver approaching the crossing
	Notes
Approach notes	Has there been or is there planned or apparent any development near the crossing which may lead to a change or increase in use such as a housing estate or a change in farming practice
	Notes on new developments
	Crossing approach notes
	Notes on traffic utilisation
Deliberate misuse	The chance of a vehicle user deliberately abusing the crossing is estimated to be (with reasons)
Mitigation	Reasons for mitigation
	Car reduction
	Van/small lorry reduction
	Bus reduction
	HGV reduction
	Cycle reduction
	Pedestrian reduction
	Tractor reduction
	Train passenger reduction
	Train staff reduction
	All users reduction

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