Technical Note

Project:	Rother Valley Railway
Subject:	This note responds to i-Transport's review (Ref: PH/JN/LC/LM/ITL14477-011).
Author:	[redacted] (Signalling Engineer)
Date:	28/05/2021
Project No.:	5165058

Document history

Revision	Purpose description	Originated	Checked	Reviewed	Authorised	Date
Rev 1.0	First Issue	[redacted]	[redacted]	[redacted]	[redacted]	15/07/2020
Rev 1.1	Minor update for further issue	[redacted]	[redacted]	[redacted]	[redacted]	28/05/2021
		[redacted]				
		[redacted]				

Client signoff

Client	Highways England
Project	Rother Valley Railway
Project No.	5165058
Client signature / date	

1. Introduction

This technical note aims to establish the typical road closure duration if a level crossing was installed across the A21 at Robertsbridge. Road closure time calculations are based on the understanding that RVR propose to install an Automatic Full Barrier Crossing Locally Monitored (AFBCL) level crossing, the track gradient at this location and of the approaches will be level and sighting will be not be restricted. Design requirements, standards and guidance documents for this crossing type are still to be produced to aid design development and layout of the crossing. An AFBCL is an enhanced form of Automatic Barrier Crossing Locally Monitored (ABCL), therefore in the absence of standards for an AFBCL crossing, Railway Group and Network Rail standards for ABCL crossings have been utilised with allowance for the addition of a Standing Person Obstacle Detector (SPOD) and exit road barriers.

2. Executive Summary

The 'i-Transport' review identified a number of differences (time penalties) between a typical Network Rail level crossing configuration and that which is proposed by RVR.

RVR have recognised that the original aspired road closure duration of 53 seconds was unrealistic. A revised time of 64 seconds has been proposed by RVR, with a potential reduction to 56 seconds for east bound trains if trains are permitted to accelerate over the crossing.

A typical Network Rail AFBCL level crossing configuration could be expected to have a road closure time of approximately 97 seconds based on Railway Group and Network Rail requirements, incorporating allowance for all rolling stock braking characteristics (both Passenger and Freight services) and an allowance for the application of older technology i.e. Route Relay Interlocking (RRI) type level crossing controller systems and traditional track circuit / treadle train detection methods.

Road closure calculations within this technical report make allowance for modern Computer Based Interlocking (CBI) level crossing systems, including further consideration of how existing AFBCLs currently operate on the network. The calculations have determined that a road closure time (72 seconds) may be possible by utilising modern technology and restricting the types of rolling stock that are permitted to operate over the level crossing. However, this may introduce greater level crossing risk and operational inflexibility. A potential further reduction in road closure time (65 seconds) could be possible for east bound trains if they are permitted to accelerate over the crossing. However, this practice is not recommended as the rear of the train would be technically speeding over the track section(s) in rear.

Whilst a typical Network Rail level crossing configuration road closure times may be undesirable, it is understood that i-Transport traffic modelling for RVR has shown that road closure timings using the Network Rail typical arrangement (circa 97 seconds) would be possible albeit with longer queues.

There is a balance between inconveniencing road traffic users and maintaining safe operation of the railway. Therefore, it is recommended that further consideration should be given to any highway and railway operational requirements before significantly reducing the road closure times. If determined that minimal timings (circa 72 seconds) are required, specific consideration must be given to increased level crossing risk and lower functionality.

3. Technical Review

The table below lists the differences between a typical AFBCL level crossing configuration and that which is proposed by RVR:

<table>
<tr><th colspan="2">AFBCL Configuration Differences</th><th>Typical AFBCL Durations on Network Rail Infrastructure (Seconds)</th><th>RVR Proposed Durations, as detailed in #2.2.13 (Seconds)</th><th>Atkins Commentary</th></tr>
<tr><td colspan="2">Allowance for system response times (RRI based level crossing controller systems and traditional track circuit / treadle train detection methods).
[#2.2.4]</td><td>2</td><td>0</td><td>System response times cannot be avoided. Therefore, reducing the system response tomes to zero (2 second time saving) will be impractical. It is considered that a 1 second saving (>0) may be achievable with modern CBI and axle counter type systems. Note: allowance for system response time when calculating road closure time is only applied for the train striking-out. The strike-in system response time does not affect road closure time.</td></tr>
<tr><td colspan="2">Reduction in the permissible line speed on approach to the Strike-in-Point
[#2.2.5 & #2.2.6]</td><td>25</td><td>Time Not Quoted</td><td>The proposed approach speeds (10mph or 25mph) have no influence on the barrier down time, as the Strike-in-Point (SiP) is positioned to provide a constant approach time i.e. the SiP is positioned to enable the Drivers White Light (DWL) to illuminate before the train reaches the Special Speed Restriction Board (SSRB) - see Section 4.2</td></tr>
<tr><td colspan="2">Train can accelerate towards 25mph when the front of the train is immediately beyond the crossing (~5m).
[#2.2.7 & #2.2.11]</td><td>Not Allowed</td><td>0 East Bound
7 West Bound</td><td>Network Rail require the rear of a train to clear a speed restriction before accelerating.
Early acceleration has no influence on the barrier down time for west bound trains, as they will remain travelling at 10mph. However, early accelerations would reduce road closure times by circa 7 seconds for East bound trains.</td></tr>
<tr><td rowspan="3">Barrier machine operation
[No Ref.]</td><td>Lowering entrance barriers</td><td>8-10</td><td>$8</td><td rowspan="3">As above, system response times cannot be avoided; therefore a 4-6 second time saving will be impractical. Based on existing AFBCL installations, a duration of 8 seconds for lowering each set of barriers and 6 seconds for raising all barriers would be a more realistic minimum achievable value. Note: the SPOD scans the crossing as the entrance barriers lower. Therefore, no additional time is required in the barrier lowering sequence to complete the scan.</td></tr>
<tr><td>Lowering exit barriers</td><td>8-10</td><td>4</td></tr>
<tr><td>Raising all barriers</td><td>6-8</td><td>4</td></tr>
<tr><td colspan="2">Reduce DCI system response time (Establish DWL)</td><td>2</td><td>1</td><td>Agreed, system response time to establish DWL reduced to 1 second, subject to the provision of a modern CBI based level crossing controller system (as per minimum recommended system response time above).</td></tr>
<tr><td colspan="2">Reduce distance/time between the SSRB & DCI (S_B)</td><td>19 (82m)</td><td>8 (35m)</td><td>It is only possible to reduce this value once it is confirmed that <u>all</u> operational rolling stock can come to a stand within the proposed distance (including drivers reaction time etc.). A typical Network Rail road closure duration would be based on the assumed stopping distance for passenger & freight services on a level gradient (88m). The calculation assumes the RVR proposed distance of 35m is sufficient. Note: any proposed level crossing designs will be subject to a level crossing signal overrun risk assessment (SORAT-LX) or equivalent.</td></tr>
</table>

 # - references contained in i-Transport's review (PH/JN/LC/LM/ITL14477-011)
$ - time penalty constrained by SPOD operation

The differences between a typical AFBCL level crossing configuration and that which is proposed by RVR time penalty can be grouped into two categories, those which can be realised by technology improvements and those which are affected by rolling stock characteristics:

- Technology Improvements
  Introduction of Computer Based Interlocking (CBI) type level crossing controllers and electronic train detection systems to reduce level crossing operation times. Note: as per the current preferred methods of train detection (Track Circuits & Treadles or Axle Counters), the proposed train detection system will also need to be capable of determining the direction of travel to enable the correct sequential operation of the crossing on a bi-directional line. For further details and considerations refer to Section 2.2.4.

- Rolling Stock Characteristics
  Provision of accurate braking and acceleration capabilities, to enable consideration of any effect from gradient profiles on either approach to the crossing. Also considering the application of last-wheel-replacement to detect a train of any length clearing the crossing reduce level crossing operation times.

Road closure calculations for a typical Network Rail AFBCL level crossing configuration would be based on Railway Group and Network Rail requirements, incorporating additional allowance for system response times, based on Route Relay Interlocking (RRI) technology, with track circuit / treadle train detection. Rolling stock braking characteristics would be based on level gradients for both Passenger and Freight services. Also, worst case timings for level crossing sequences would be assumed.

It is acknowledged that time saving will be realised in regard to technology improvements. However, the magnitude of some of the savings suggested would be a challenge. For example, the timings for the crossing sequences will still need to incorporate an element of system response time. Also, the proposed reduction in time for lowering the exit barriers from 8-10 to 4 seconds could be regarded as questionable and would need to be proven, particularly considering that other AFBCL installations typically lower the exit barriers in approximately 8 seconds.

It is also recognised that time savings may be accomplished if the crossing is designed to actual RVR rolling stock characteristics. However, there are implications that need to be considered in doing so, including:

- Confirmation of all operational train types, including their formations and performance data would need to be provided to ensure their characteristics are incorporated into the level crossing design.
- All future alterations to rolling stock would need to be assessed against the design parameters of the level crossing before being permitted to use the crossing.

Reducing the distance (S_B) between the ‘Special Speed Restriction Board’ (SSRB) and ‘Drivers Crossing Indicator’ (DCI) will reduce the time the train drivers have to observe and react to the DCI, and thus increase the risk of a train passing the indicator when showing a red light. Therefore, the level crossing designer will need to fully understand the risks and the pressure placed on drivers to undertake their duties at the specific location without distraction. It is recommended that a level crossing risk workshop (or equivalent) is undertaken to assess the risk of a DCI being passed at ‘Red’ and the train encroaching on the crossing with the barrier(s) raised.

The passenger and composite braking distance tables in Railway Safety and Standards Board (RSSB) Railway Group Standard ‘GK/RT0075 - Issue 5’ have been utilised to determine the distance S_B. For a typical Network Rail crossing appraisal, ‘Appendix A - Composite Minimum Signalling Braking Distance (MSBD) Data for All Trains’ (worst case braking distances) would be applied. However, further consideration should be given to applying ‘Appendix B - Composite MSBD Data for Passenger Trains’ (reduced braking distance), subject to confirmation that all intended rolling stock meets the necessary ‘Passenger Train’ braking characteristics. It will be necessary for RVR to confirm all operational train formations and their performance data to ensure these characteristics are incorporated into the level crossing design. Any potential reductions in crossing closure time cannot be verified until this activity has been undertaken. Additionally, a robust process may be required to ensure all future services operate within the parameters of the level crossing design or to provide assurance that the crossing is suitably modified prior to their introduction.

The RVR proposal incorporates a system of train detection loops. This form of train detection is less common on stand-alone level crossings in the UK (e.g. ABCLs & AFBCLs). It is unclear if the proposed method is a typical ‘Axle Counter’ type system or similar to the examples found on the Chiltern lines, where additional equipment is required to be installed on the rolling stock.

Additionally, the RVR proposal implies that a ‘Barrier Up Loop’ / Strike-out-Point (SoP) will be positioned 120m beyond the crossing, with the barriers raising after the front of the train reaches that point. However, the typical operation of a level crossing requires the barriers to raise immediately after the rear of the train passes the level crossing. This method is operationally less restrictive and reduces the level crossing risk. For further details refer to Section 4.4.

In summary, the level crossing closure time can be reduced below the typical Network Rail road closure timings. However, the calculated timings will require further review following confirmation of the RVR train performance details, with any aspirations of further reductions to consider the potential increase in level crossing overrun risk and operational inflexibility.

4. Calculations & Considerations

Indicative level crossing calculations have been produced below to establish a recommended minimum achievable road closure timing. Where specific data is unavailable, recommended values (*) have been applied in the calculations which are subject to confirmation from RVR.

For the purpose of the following calculations, please refer to the Level Crossing Sketch in 'Appendix A'

4.1. SiP to CIP (System Response)

Although it is proposed that a modern CBI type level crossing controller and train detection system will be implemented, allowance will still need to be considered for the associated system response times; i.e. the time between a train arriving at the SiP and the amber RTL's illuminating. This point at when the amber RTL's illuminate is identified as the Crossing Initiation Point (CIP).

The system response time includes CPU input/output clock cycles for determining the detection/direction of trains, proving of RTL's and detection of barriers down etc. As details of the proposed level crossing system(s) are not available, for the purpose of this exercise the system response time is assumed to be a maximum of 1 second.

When calculating the location of level crossing SiPs, suitable distance needs to be added to make allowance for the system response time. The following calculations provide the necessary distances for both 10mph & 25mph line speeds on approach to the crossing:

<u>Option 1 - 10mph Permissible Line Speed (Approach Speed)</u>

Time (T_{R1}) = 1s*

Distance (S_{R1}) = 1s* @ 10mph = 4.47m/s = **5m**

<u>Option 2 - 25mph Permissible Line Speed (Approach Speed)</u>

Time (T_{R2}) = 1s*

Distance (S_{R2}) = 1s* @ 25mph = 11.18m/s = **12m**

Note: the system response time (T_{A1} or T_{A2}) does not affect the road closure time and is not included in the road closure time calculations in Section 2.2.6.

4.2. CIP to SSRB (Level Crossing Initiation)

The 'Drivers White Light' (DWL) on the 'Drivers Crossing Indicator' (DCI) is required to be illuminated before the train reaches the 'Special Speed Restriction Board' (SSRB). To enable this requirement to be achieved, allowance needs to be made for the following crossing sequence and associated timings to complete:

- Amber 3s
- Red 5s
- Entrance Barriers Down & Simultaneous SPOD Scan 8s*
- Exit Barriers Down 8s*
- Establish DWL 1s*

<u>Option 1 - 10mph Permissible Line Speed (Approach Speed)</u>

Time (T_{A1}) = 3s + 5s + 8s* + 8s* + 1s* = **25s**

Distance (S_{A1}) = 25s @ 10mph

= 25 x 4.47m/s

= 111.75m

= **112m**

<u>Option 2 - 25mph Permissible Line Speed (Approach Speed)</u>

Time (T_{A2}) = 3s + 5s + 8s* + 8s* + 1s* = **25s**

Distance (S_{A2}) = 25s @ 25mph, Including Braking to 10mph @ 9%g*

= (17.4s @ 25mph) + (7.6s Braking to 10mph @ 9%g*)

= (17.4s x 4.47m/s) + (7.6s @ 6%g)

= 77.78m + 59.44m

= 137.22m

= **138m**

Note: both distances (S_{A1}) and (S_{A2}) have the same timings (25 seconds). i.e. barrier down time is the same regardless of the approach speed, be it 10mph, 25mph or even 55mph.

4.3. SSRB to DCI (Level Crossing Failure Mitigation)

In the event of a crossing failure, sufficient distance must be provided to enable the train to come to a stand beyond the point where the DWL is usually established and the edge of the crossing i.e. between the SSRB and the DCI.

For the purpose of this exercise, it is assumed that 35m will suffice, based on RVR's proposal. However, this distance will need to be confirmed, including consideration for driver's reaction time and train performance figures i.e. braking capability of all train types/configurations, taking the gradients into consideration.

Crossing Speed (V_B) = 10mph (4.47m/s)

Braking Distance at Crossing Speed (S_B) = 10mph to 0mph = 35m*

Time (T_B) = Time taken to travel 35m* @ 10mph

= 35m / 4.47m/s

= 7.82s

= **8s**

Note: regardless of the permissible line speed on approach (25mph or 10mph), it is still recommended to provide the SSRB and its associated Advance Warning Board (AWB). These boards are critical to remind the driver to be prepared to stop in advance of the approaching level crossing.

4.4. DCI to Strike-out Point (SoP)

Although RVR have proposed to position the SoP at 120m beyond the crossing, it is considered this would be operationally restrictive for running shorter and/or longer train formations. Also, potentially increasing risk to the level crossing users and train passengers e.g. barriers raising when the rear of a longer train (>120m) is still on the crossing. Therefore, for the purpose of this exercise the typical method of proving the crossing is clear recommended i.e. providing a train detection section over the crossing (Island Track) and positioning the SoP immediately beyond the crossing (~5m beyond). This typical method would provide a last-wheel-replacement type arrangement to detect the passing and direction of the train, typically achieved using Track Circuits & Treadles or Axle Counters. A suitable mitigation measure would be required for any proposal not to follow this recommendation.

Distance (S_C) = DCI to Crossing + Crossing Length + Distance to SoP

= 10m + 10m + 5m

= **25m**

Time (T_C) = Time Taken to Travel 25m @ 10mph

= 25m / 4.47m/s

= 5.59s

= **6s**

4.5. SoP to Barriers Raised (Level Crossing Clear)

Although RVR have proposed the driver will accelerate to 25mph when the front of the train is immediately beyond the crossing (~5m beyond), this would imply the rear of the train is technically speeding over section(s) in rear i.e. the rear of the train will be travelling faster than the 10mph ‘Crossing Speed’ (V_B). This proposal is a non-standard driving technique, as drivers should not typically accelerate until the rear of the train has passed the speed restriction. Also, this would require the track section(s) in rear to be categorised and maintained for the higher line speed (25mph).

For the purpose of this exercise, the necessary calculations for RVR proposal / operational instructions have been applied. Therefore, the time taken for the entire length of a 115m train to pass over the SoP and accelerate steadily towards 25mph is calculated as follows:

Distance (S_D) = Train Length = **115m**

- Time taken to accelerate slowly from 10mph towards 25mph for 115m @ 2%g* = 18.34s = 19s
- Maximum speed achieved after accelerating for 115m = 18mph

Once the rear of the train has passed over the SoP the following crossing sequence and associated timings are required before the RTL’s are extinguished and the highway is open to traffic:

- System Response Time 1s*
- Barriers Raise & RTL’s extinguish 6s*

Time (T_D) = 19s + 1s + 6s = **26s**

Note: if the driver does not accelerate immediately beyond the crossing and maintains speed at 10mph for 115m, the time will be increased by 7 seconds i.e. Time (T_{D1}) = 33s

4.6. Road Closure Times

Based the information available and the calculations above, the following indicative durations are considered the lowest achievable road closure times.

4.6.1. Scenario ‘A’ (Not Recommended)

Road Closure Times for trains accelerating to 25mph before the rear of the train clears the crossing:

- Option 1 - 10mph Permissible Line Speed (Approach Speed)

  Time (T_{A1}) + Time (T_B) + Time (T_C) + Time (T_D) = 25 + 8 + 6 + 26 = **65s (1 Minute 5 Seconds)**
- Option 2 - 25mph Permissible Line Speed (Approach Speed)

  Time (T_{A2}) + Time (T_B) + Time (T_C) + Time (T_D) = 25 + 8 + 6 + 26 = **65s (1 Minute 5 Seconds)**

4.6.2. Scenario ‘B’

Road Closure Times for trains remaining at 10mph before the rear of the train clears the crossing:

- Option 1 - 10mph Permissible Line Speed (Approach Speed)

  Time (T_{A1}) + Time (T_B) + Time (T_C) + Time (T_{D1}) = 25 + 8 + 6 + 33 = **72s (1 Minute 12 Seconds)**
- Option 2 - 25mph Permissible Line Speed (Approach Speed)

  Time (T_{A2}) + Time (T_B) + Time (T_C) + Time (T_{D1}) = 25 + 8 + 6 + 33 = **72s (1 Minute 12 Seconds)**

Note: all road closure times are indicative and subject to change following RVR confirmation of the operational requirements, rolling stock performance data, gradient profile information, proposed level crossing equipment types and associated system response times etc.

Appendix A. Level Crossing Sketch