SIGNALLING Level Crossings

Photo: ProRail

Protecting crossings with **ETCS Level 2**

The roll-outs of ETCS Level 2 in the Netherlands and Denmark are taking different approaches to the activation and protection of level crossings, while seeking to ensure that warning times for road users are more consistent regardless of the speed of approaching trains.

The large number of level crossing in the Netherlands poses a specific challenge for ERTMS implementation.

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Level crossing safety is a key priority for railways around the world. According to international statistics, level crossings remain one of the biggest contributors of external risk to the safety of railway operations. So it is not surprising that in recent years many railways have sought to eliminate as many crossings as possible, either by building replacement bridges or by closing the right of way.

Where this has not been possible, four quadrant barriers have become more common, often allied to the introduction of obstacle detection systems. Technical improvements include the use of aluminium or glass fibre barriers, LED 'traffic light' heads for road signals and electronic acoustic devices such as bells and warblers.

A new challenge for signalling engineers comes with the implementation of the European Rail Traffic Management System, and in particular how the operation of level crossings is integrated with ETCS Level 2 Baseline 3.

A project team in the Netherlands is currently developing specifications for the planned national roll-out of ERTMS. Given the number of level crossings in the country, their relationship to the signalling system is a major concern.

To inform our strategy, we have looked closely at the methods adopted for the Signalling Programme in Denmark (RG 10.17 p49), which is the largest comparable national roll-out of ETCS Level 2 using the Baseline 3 specifications. This found that the most significant factor affecting road closure times was not the type of signalling used but the underlying principles for activating a level crossing for the passage of a train.

Constant warning times

Reducing the variation in road closure times is an important objective, not only to minimise the economic impact of unnecessarily delaying road or rail traffic, but also because there are indications that large variations in closure times increase the risks caused by impatient road users. If the variance in

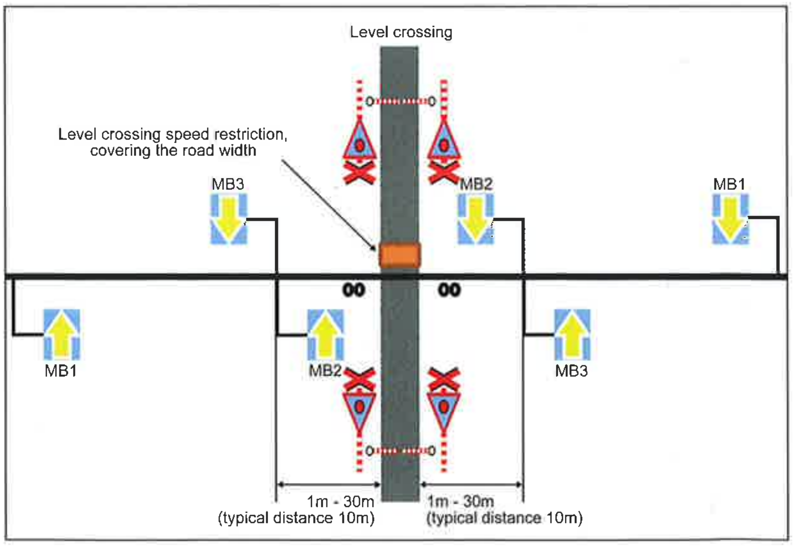

Fig 1. Simplest layout of a full-closure level crossing, showing the location of the ETCS Marker Boards that protect the route through the crossing.

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closure times is reduced, impatient road users are less inclined to ignore, or slalom around, the barriers.

While constant warning times may be the ideal, the ETCS level crossing activation principles could perhaps be better described as 'Predictable & Harmonised Warning Time and Minimised Waiting Time'. Although the Danish and Dutch approaches to level crossing activation using ECTS Level 2 Baseline 3 do not result in constant warning times, they do aim to reduce the amount of variation. However, our studies suggest that this may actually increase the average closure time.

In the societal cost-benefit analysis that informed the choice of ERTMS roll-out scenarios for the Netherlands, limiting road traffic delays appeared to be one of the biggest potential benefits.

Local variations

Level crossings in Europe are not covered by the interoperability directives, and are usually subject to national road and rail legislation. So the 'look and feel' for road users can vary from country to country, as can the interface with the signalling.

In some countries, a crossing will always be interlocked with a signal, which indicates to the train driver when the crossing is 'protected'. Denmark follows this convention, but with the special condition that road traffic has priority and the default state of the crossing is open.

The Netherlands, on the other hand, follows North American practice, with level crossings considered to be fully autonomous fail-safe systems. In this arrangement, the signalling system only checks that the activation logic has not been disabled, for example by reversing the running direction on a bidirectional line. If all is normal, the crossing is activated when the strike-in point is passed by a train and no further checks are applied to make sure the crossing is working properly.

Other countries, including the UK, follow a mix of these two approaches, where some crossings are interlocked with the signalling and others are fully autonomous.

Constant Warning Time crossing control systems are not new, being derived from the track-circuit based 'grade crossing predictors' developed in the USA. They are used predominantly on non-electrified lines, but attempts to use adapted versions in Europe have not been very successful. Some use axle counter technology with counter heads that can sense the passing axle speeds as well as the direction of travel. Studies in the Netherlands confirmed that the CWT principle was viable, but it was not pursued, because covering all of the

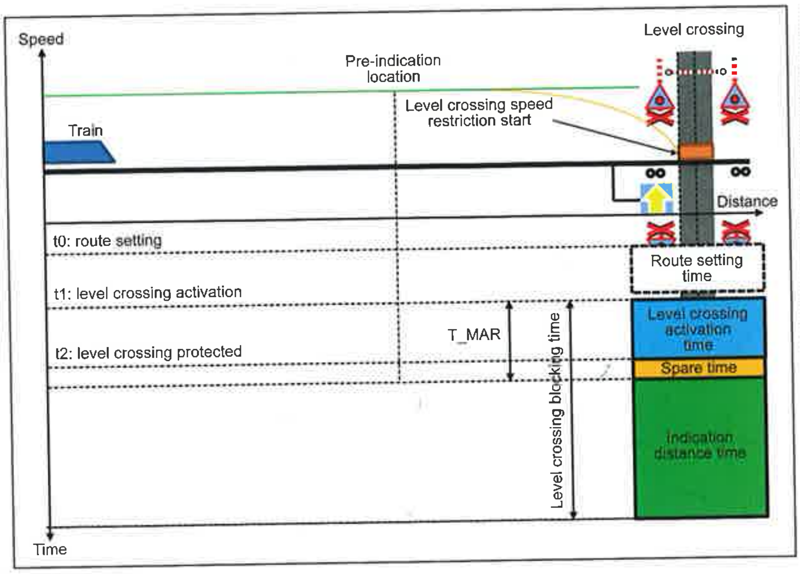

Fig 2. Elementary timing for the passage of a train through a level crossing.

conceivable scenarios was judged to add too much complexity.

Activation principles

In the Danish Signalling Project, the transmission-based activation system aims to minimise delays by optimising the timing of the activation of warning signals and barriers and efficient deactivation after the train has passed. Crossing operation is initiated and overseen by the national Traffic Management System in line with the constantly-updated timetable, known as the Online Production Plan (RG 12.16 p37).

The Banedanmark specifications stipulate that a level crossing shall be activated, starting to close the crossing to road traffic, when a route is locked across the crossing, at a time where the approaching train is in such a position that it can receive the 'crossing protected' status indication without having to brake, but not earlier than 15 sec before the train reaches the 'pre-indication' point associated with the End of Authority (for at least 99% of activations). This should apply under normal operating conditions, whether the train is running under an ETCS Full Supervision or On-Sight movement authority.

In line with Danish traffic legislation, the level crossing must default to the 'deactivated' and 'not protected' status. Crossings may be kept closed to facilitate trains passing each other, but there is a maximum restriction time, after which the crossing should be opened to road traffic. Crossings must also provide a minimum open time for road users. However, a control centre operator can override the closure and opening commands as necessary.

In ERTMS terms, level crossings are treated as intelligent Interlocking Field Equipment. Activation and de-activation commands are issued by the interlocking to the local controller, which operates the barriers, lights and acoustic warning devices. The level crossing controller then reports its status back to the interlocking using the fixed transmission network.

Traffic management

Under ETCS, every level crossing is protected by a Marker Board located up to 30 m on each side of the crossing area (Fig 1). Each MB is an end or start point for a route. Activation of the crossing is initiated by the interlocking, and deactivation is done automatically as the train clears the crossing track section, unless inhibited by the TMS.

For each timetabled train, the TMS sets a booked time for calling the route through the crossing into its daily production plan, with a margin for transmission and processing delays and a pre-configured margin for each type of crossing. When the intended train approaches and all routes are set up to MB2, the TMS issues a route command to the interlocking for MB2 – MB3. When the route is cleared and locked, the RBC will extend the Movement Authority to at least MB3 and send this to the train, including the status information that the level crossing is not yet protected.

Based on this, the train's On-Board Unit will start to supervise the train speed using the beginning of the level crossing as the Supervised Location, rather than the End of Authority supplied with the MA. When the train approaches its calculated pre-indication point, the OBU sends a request to the RBC that the level crossing be protected in time for it to receive an updated status before it has to start braking to stop at MB2. The MA request is forwarded to the TMS, which checks the route status and requests the interlocking to activate the crossing.

Optimisation of crossing warning

25 sec

MINIMUM WARNING AND CLOSURE TIME FOR MOTORISTS AT LEVEL CROSSINGS IN THE NETHERLANDS

Fig 3. A braking curve will be indicated on the DMI if a train passes the pre-indication point and the level crossing has not yet been protected.

and closure times is ensured by the TMS determining when to request activation, based on the crossing characteristics and the difference between Actual Train Speed and Warning Ceiling Speed at the time the OBU issues the MA request.

When the interlocking receives the activation request from the TMS, it sends the protection command to the level crossing controller, which then activates the barriers, road signals and acoustic warning devices. After the level crossing is 'fully protected', with the barriers detected in the lowered position and road signals activated, this information is transmitted by the level crossing controller to the interlocking, which informs the RBC. At this point the RBC can update the status information in the MA.

In order for the train to receive the updated MA before reaching the pre-indication point, the margin in the MA request has to be equal to, or greater than, the delays in message transmission (Fig 2).

The minimum closure time for a full-barrier crossing is longer than that required for other types of crossings such as half-barrier or warning lights, so the road closure time for such crossings could be longer than necessary. This can be mitigated by configuring a type-specific delay in issuing the activation command within the TMS.

If a train reaches its pre-indication point before receiving the 'level crossing protected' status indication, an audible warning is issued by the Driver Machine Interface, and the brake curve supervision will be initiated as indicated on the DMI (Fig 3).

Obviously there are many variations to this simple algorithm, for instance where level crossings have two or more tracks, are located in or near station areas, or are connected to road traffic lights to prevent queuing over the crossing area.

However, two important issues are evident. Firstly, for even in the simplest variant, the process is quite complex, involving many subsystems. As such it is likely to be susceptible to timing variations or disturbances. At the moment, the system is in the very early stage of testing and it remains to be seen how robust it will prove in practice.

Secondly, the methodology requires all trains to be entered in the online production plan with the correct data. Trains operating in degraded mode that have no movement authority will have to stop before reaching the crossing and then proceed under the driver's responsibility.

Speed-dependent activation

Such an interlocked process would cause significant problems in the Netherlands, where level crossing activation is typically designed to provide a minimum warning and closure time for motorists of just 25 sec. In most cases this implies a strike-in point much closer to the crossing than the braking distance. Today, the barriers need to be closed at least 4 sec before the train reaches the crossing, whereas in the Danish application the barriers must be closed and proven before the train reaches the pre-indication point. Adopting this approach would increase closure times significantly.

Dutch level crossing control relies on the inherent fail-safe nature of the protection equipment, combined with the fact that rail has priority over road. It is assumed that a crossing which is activated will always lower its barriers and present the visible and audible warnings to road users. Strike-in is at nominal warning time (plus margins) at maximum line speed, considering the 'worst case fastest train'. This approach gives short closure and warning times, but it is subject to variations due to individual train performance.

To counter any increase in closure times following the introduction of ERTMS, we envisage a strategy of 'controlled deferral', where crossing activation is based on a train's position reports, actual speed and acceleration. Suppliers bidding for the contracts will have to detail their proposed implementation method, but the aim is to achieve a speed-dependent activation which can be continuously optimised for actual train speed and acceleration.

The process begins by calculating the earliest possible arrival time of a train based on its current location, speed and potential acceleration. The system then calculates the optimum activation time for the level crossing using the required announcement time, with the process being repeated for each subsequent position report. In each cycle, the activation time is set to allow the earliest possible arrival. If a train could reach the crossing too soon, the system delays the issuing of the movement authority.

This process relies on the confidence interval 'maximum safe front end' included in a train's position report. The timestamp of the position report and a safe synchronisation of train and trackside/RBC times are used to eliminate the impact of transmission delays.

Using the actual train information, including maximum allowed speed, actual speed and train position, minimises deviations in the level crossing closing time, helping to achieve the constant warning time objective. The reduction in closing time would be most noticeable in situations where train speed is below the line speed, such as a freight train, or when a train is departing from a station.

The use of ETCS train position information reduces the requirement for additional trackside train detection equipment to activate and protect the level crossing. It also eliminates the risk of late crossing activation due to detection problems such as loss-of-shunt. ■

The authors would like to thank Alstom for permission to use its description of the activation algorithm, as well as some of the diagrams used in this article.

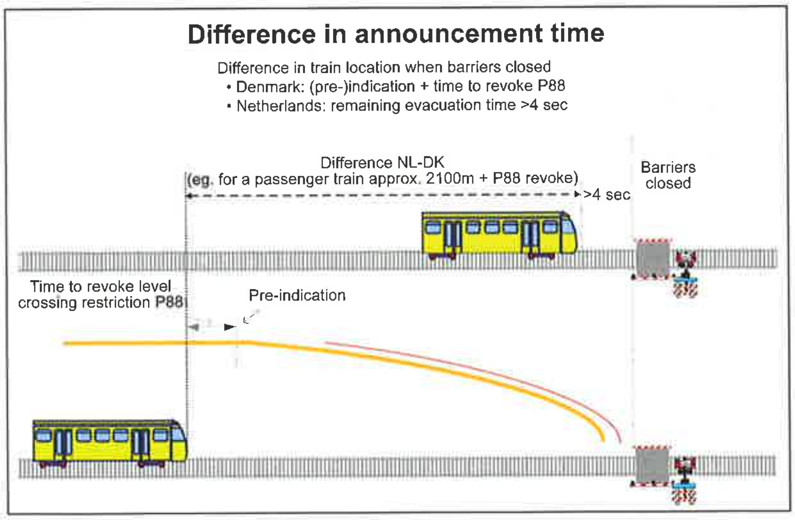

Fig 4. Comparison of the anticipated crossing closure times in the ETCS approaches for Denmark and the Netherlands.