IRSE
Institution of Railway Signal Engineers

Back to basics: Level crossings

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In this, our latest, "back to basics" article we look at how signal and telecoms engineers have to consider more than just the movement of trains around the network. The article makes reference to factors which should be considered in the provision and operation of level crossings, although legal and cultural differences prevail in many countries which may override the generic principles set out in this article.

Why do we need level crossings?

In some countries the railway came before roads while in others the construction of the railway divided land and roads where other rights had been established. Either way, it created the need for road and rail to cross each other. Level crossings vary considerably in type, often on the same railway, but members of the public may not appreciate the differences in operation as they just require a place to cross the railway safely if a bridge or underpass cannot be provided.

Terminology

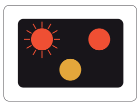
There are many different terms used to describe features of a level crossing around the world. Table 1 lists some terms associated with level crossings along with a description. Throughout this article we shall refer to 'level crossings', but they are also known as 'grade' crossings and 'rail' or 'railroad' crossings.

What is a level crossing?

So having determined the need to cross the railway on the level we can start to define this as a 'level' crossing. The form of this crossing may involve simply designating a place using signs, for example, where visibility is good to see trains approaching. Railways in many countries do not have continuous boundary fences, so it is important to designate safe places to cross the tracks. Although not usually part of the signal engineer's responsibility, the levelling up of the ground from the railway boundaries up to and in between the rails gives strength to the definition

Road crossing application and technology varies enormously around the world. This is one of several different types of half barrier crossing in the UK. Half barrier crossings are less expensive than full barrier crossings and prevent users being trapped inside the barriers. However there is a risk of crossing users 'weaving around' the closed half barriers.

Table 1 – UK signalling terminology.



Active warning	Warning or protection devices for road users which are activated by a train or railway staff.
Deck	The support and surface area of a crossing which carries users and/or their vehicles.
Full barrier crossing	A crossing fully fenced between road and railway when the road is closed. May use a single boom on each side or two half booms or equivalent equipment, e.g. gates.
Grounding	A vehicle stranded by coming into contact with the crossing surface/deck. Occurs when a long wheelbase vehicle traverses a crossing with a severe vertical curve or hump. This is often denoted by the sign on the left.
Half barrier	A crossing with a barrier closing the entrance lane(s) of each carriageway only.
Humped	The vertical profile of a crossing where it rises in the centre – see also 'grounding'.
Level Crossing	A designated place where the public can cross the railway safely on the level. May also be known as a grade crossing, rail crossing or railroad crossing. It may include a sign or other equipment to assist the user.
Passive crossing	A crossing where the user is responsible for assuring their own safety by checking for the approach of trains.
Protecting signal	A railway signal used to authorise train movements over a level crossing.
Saltire	St Andrews Cross or Crossbuck, commonly used to signify the presence of a railway crossing. This is shown to the left.
Wig-Wag or flashing light signal	A road traffic light signal with twin flashing red lights to warn road users of the approach of a train. May be used alone or in combination with barriers or gates.

"Some countries insist on measures to manage risk of collision with a train"

of 'level crossing'. By contrast many footpath crossings do not have a built-up deck, relying instead on users to step over the rails. Vehicle crossings mostly need a deck to reduce the risk of vehicles getting stranded. The design of the deck will be informed by the types of vehicle or traffic using it, especially the vertical curvature or hump which could lead to vehicles becoming stranded where the body of the vehicle between axles comes into contact with the crossing surface (that is, becomes grounded).

What does the law say?

Some countries insist on measures to manage risk of collision with a train, leaving the specific arrangements for the level crossing designer to decide based on risk. Others prescribe arrangements in detail; often a blend of these regulations will apply. In some countries it is the policy of the railway companies not to provide equipment unless required to do so by a government entity, as litigation may result where other similar crossings are not so equipped if there was an accident.

In some cases, the costs of provision and maintenance of a crossing fall on the railway authority, sometimes the government or other public body will require actions and fund those, in other cases costs may fall to the private user or be shared.

In some countries there are many different parts of law which can apply, especially where highways and road traffic is involved. Often different laws will apply for pedestrian crossings or for crossings between privately owned land such as farmers' fields or access to a single house.

Safety

Accident statistics demonstrate that level crossings are high risk sites for railway operators as well as contributing to large numbers of near-miss events. The reasons for this high level of risk should be obvious to railway professionals who are familiar with recognising hazards, but level crossing users come from a broad spectrum of society who may not be familiar with the characteristics of a train operations, where long stopping distances are normal, and trains are unable to deviate from the line of travel. Monitoring of crossing use is important as patterns of use (and therefore levels of risk) can change significantly over time. In recent years, for instance, there have been major changes of traffic pattern in some areas due to the use of satellite navigation devices and the popularity of home delivery courier services.

Selection of system

Where the law requires protection or warning systems to be provided, or the railway or other authority chooses to fund provision of equipment for their benefit or the benefit of the public, care should be taken in choosing the right combination of equipment to be safe and effective. Increasingly, convenience is being recognised as an important factor in system selection. Delaying users or trains has consequences, such as cost penalties either directly or in productivity loss and can lead to frustration which may result in users circumventing warnings.

Some railways have risk modelling tools to help choose equipment configurations that give the most effective risk reduction. Such tools also help to support a financial case for investment

An unprotected crossing in Chile. The safety of road user and the railway is very much dependent on the signs being obeyed.

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in risk reduction and may include benefits to society through a reduction in lives lost or injuries incurred.

A key input to the selection process is understanding the use of a crossing both by the railway and by users. A census of use taken over several days is helpful to identify all of the different types and numbers of users, and their characteristics. It is important to understand how long they take to traverse the crossing and whether users can pass safely if they meet on the crossing. What are the approaches like, can vehicles stop easily? Do vehicles approach at speed, or is there a likelihood of becoming stranded on the railway?

On the railway how many tracks are there? Do all trains pass through at line speed or are there some trains passing at slower speeds? Is there a station or junction nearby which affects speeds? Do trains pass in the area or closely follow each other and therefore keep the crossing closed for long periods? Can visibility of approaching trains and therefore warning time be improved by removal of lineside vegetation?

Pedestrian user characteristics may include mobility, hearing or sight impaired people; people with luggage, pushing cycles, or children/young adults or those with cognitive impairment who are less risk aware. Distraction factors such as mobile devices or moving in groups should also be considered.

When level crossings are renewed these factors may have changed considerably so it is vital that a thorough assessment is made whenever a change is proposed to a crossing.

Historically many crossings were operated by railway staff. Automation is now common on some railways which makes crossings cheaper to operate and manage but this relies on increased knowledge and discipline on the part of users. Understanding human behaviour factors and the interpretation of warnings is a necessary part of selecting the best combination of equipment to assist users.

Some railways have dedicated level crossings specialists while in others it is a general signal engineering responsibility. Level crossing management extends to engaging with users to educate them how to use level crossings safely, especially when changes are proposed or implemented. This may be through school visits, media campaigns or local meetings with individuals or groups.

Proposals to change a crossing or sometimes to renew it, may require consultation with stakeholders who have an interest. Typically, people representing interested groups such as the traffic authority, disability groups, the emergency services, planning authorities, or political representatives may contribute to these consultations and expect their views to be taken into account. Consultees may express views about safety, convenience, appearance, noise, lighting, accessibility, disruption during work, to list just some of the factors.

Technical protection or warning systems

The level crossings engineer has a lot of equipment available which can be configured to provide an appropriate solution. At the simpler end there are warning signs, or instructional signs. At the complex end there are complete barrier installations with sophisticated obstruction detection devices, which can identify people or objects on the crossing. These should have a high reliability and assurance of safe operation which allows them to automatically confirm the crossing is clear.

Crossings may have gates or barriers. These are operated either by the railway or by the road user. The road may have lights, usually twin flashing red, which are accepted as an absolute stop signal, even by emergency services. Sounders may be provided to reinforce a warning and to assist vision-impaired users. The use of surface markings on a road or path to identify the safe place to stop is another feature along with signs and other carriageway markings to help the user navigate a crossing. Where railway signals are provided, they may be controlled to only allow trains to proceed when the crossing is closed and clear; they may also be interlocked to prevent the crossing being opened for road users once a train has been signalled until it has passed through or safely stopped.

In some countries telephones are provided at some types of crossings to enable members of the public to seek permission to use a crossing. These are normally provided where the warning time obtained by visual means is less than the time needed to cross safely, and no other active protection or visible warning is provided. The telephones need to be protected from water ingress, vandal damage and located in a position of safety and with clear instructions on their use to cross safely. The telephones are normally 'direct lines' to the controlling signaller. The signaller must only be able to talk to one crossing at any one time, and the crossing name must be displayed to the signaller throughout the call. There must be no overhearing, so that one crossing user cannot hear instructions intended for another crossing and the voice quality must provide clear communication. The identity and location of the crossing from which the call is being made must be clearly and accurately displayed to the signaller.

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There are number of problems with telephone crossings. The signaller may not have an accurate knowledge of where trains are in relation to the crossing. This can lead to misunderstanding of messages and increases the workload for the signaller. Signallers are trained to use 'safety critical communications' protocols but communicating with the public requires an additional skill set. The crossing user may not bother to use the telephone or may misunderstand the message being given and cross with a train approaching. With signal control areas getting larger and potentially more telephone crossings per signaller the risks become even greater.

At some types of automatic crossing telephones are provided for users to alert the signaller if the crossing becomes occupied with a failed road vehicle. In such situations the telephone is the only way of protecting the crossing from an approaching train, assuming there is a protecting signal in the right place, or an emergency radio call can be made to the approaching train with time to stop. Such telephones must operate at all times and self-reporting fault monitoring can be provided to check the telephone is working.

Where a crossing is supervised the signaller may confirm the crossing is safe to allow trains to proceed by direct observation from the signal box or Closed-Circuit Television (CCTV) from a remote location. A crossing attendant may be employed to operate barriers or gates; this person would be provided with an indicator or other information to advise when a train is expected.

Automatic crossings may not have signals interlocked with the crossing and instead rely on highly dependable safety features to ensure the crossing operates for each train. It is important that when a crossing operates there is not too much time before a train arrives, or an inconsistent time between the arrival of trains, which might otherwise encourage poor discipline by users who may attempt to circumvent the protection or ignore the warning.

Automatic crossings are activated by the approach of a train and rely on train detection equipment; treadle, track circuit, axle counter or prediction device placed an appropriate distance from the crossing to guarantee timely operation. A crossing control device may be configured to deal with trains approaching from more than one direction.

Quad barrier crossing in the USA.

Above, open crossing with lights in New Zealand.

Right, a pedestrian crossing in Melbourne, Australia.

Sometimes automatic crossings are provided with an escape route or clear exit to avoid users being trapped if the crossing operates when they are part way across. Unfortunately this leaves an opportunity for malicious or unsuspecting users to enter the crossing from the opposite direction when a train is approaching.

"On some lines it can be useful for train crew to operate a crossing"

On some lines it can be useful for train crew to operate a crossing, typically where line speed is low and only infrequent and less time-critical services operate. This introduces additional hazards, similar to where a signaller has to push gates across a road; this is really only suitable where road speeds are low and traffic infrequent. Train drivers may also be required to observe a crossing is clear after it has activated automatically but before passing over it. This is only practical where train speed is low and there is good visibility approaching the crossing, allowing them time to stop short if there is an obstruction.

In-cab signalling

Systems such as the European Train Control System (ETCS) in-cab signalling presents both opportunities and challenges for the operation and management of level crossings.

Initially ETCS was only planned for high-speed lines where level crossings do not exist. As the use of ETCS has become more widespread, lines which have quite high populations of level crossings have been fitted. One feature of level crossing operation is the critical timing required. As ETCS transmits a movement authority to the train and the train reports its position there can be a small delay or even a loss of transmission in a message.

While this can be accommodated in the course of normal train movement it becomes important where reporting the position of a moving train in relation to a crossing is concerned. A slight delay in triggering an automatic crossing could result in the crossing not being closed for sufficient time before the arrival of the train.

Restrictions of speed can be embedded in the permitted speed profile to ensure that where users need a given number of seconds clear sight of an approaching train in order to cross safely this can be enforced precisely and cost effectively without additional line-side infrastructure.

A lightly used, yet fully equipped, crossing in Switzerland.

"Any prediction of the future will almost certainly prove to be wrong"

Automatic train operation

Automatic train operation is commonly associated with metros and other high density urban railways which do not have level crossings. Some heavy haul freight railways now use automatic operation of their trains over long distances. With remote management of the operation and driverless trains it is important that level crossing use does not impact the safety of the rail operation. Automatic operation of the level crossings is preferred. This is achieved, in some railways, through the use of predictor technology which allows for adequate warning times for road users and also ensures that the level crossing is open long enough for road users to clear the crossing once they have committed to crossing it. Obstacle detection equipment is used to identify any problem with the level crossing and in particular where road and rail intersect, which informs the train control system and revokes the movement authority through an emergency brake application. Where braking distances may be 2km or more advance notice of any problem is essential to manage the train to avoid a conflict. The ability to stop a train before a level crossing needs to occur outside the minimum stopping distance. Anything less than that is a situation that raises the likelihood of a collision.

Future opportunities

Any prediction of the future will almost certainly prove to be wrong. However, there are a few foreseeable developments which will impact the future of level crossings. The introduction of Future Railway Communications System (FRMCS) may allow more use of wireless technology in the control and operation of crossings, with 5G likely to be used both for FRMCS and autonomous vehicle operation. Artificial Intelligence (AI) could be harnessed to allow learning from current operations and to improve our understanding of user behaviours. The use of AI derived solutions could prove challenging to safety validate. Self-driving autonomous vehicles may have a significant impact on safety improvement where messages transmitted from the crossing may give advance notice to the road vehicle of the imminent operation of a crossing, possibly enforcing a controlled brake application. Radio communications could also be used to alert an approaching train if the crossing is occupied. These developments could reduce or eliminate human error or misunderstanding which contributes to many level crossing incidents.

About the author ...

Ed is a Chartered Engineer and Fellow of the IRSE with a MSc in Railway Systems Engineering and Integration from the University of Birmingham. His career began in 1977 as a signal and telecommunications trainee and he held various roles in British Rail Signal and Telecoms department including maintenance, design, and project support.

In 1993 he joined Railtrack as part of a team preparing for privatisation before becoming signal engineer for the Midlands Zone on its inauguration as the infrastructure owner.

His involvement with level crossings began in 1985 undertaking scheme development for signalling and level crossings projects.

Ed held the post of professional head of signalling and technical lead for level crossings engineering with Network Rail, the GB main line railways infrastructure owner. Today he runs a company providing signalling and level crossing systems engineering consultancy. He also edits IRSE News Presidential Papers.