Level crossings: The-state-of-the-art

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SUMMARY

This paper, which has been commissioned by the Rail Safety and Standards Board (RSSB), is the author's personal interpretation of what constitutes best practice from around the world in the management of risk at level crossings; or, to put it another way, the current state-of-the-art. As such the paper necessarily includes some consideration of data concerning safety at level crossings and also of wider road safety performance. But, the paper also relies extensively on qualitative material gathered by the author over many years.

HOW DO WE MEASURE LEVEL CROSSING SAFETY?

- A standardised approach is emerging in the European Community
- Differentiated approaches to addressing intentional deaths
- Strong case for use of risk models and risk ranking
- Important to understand risk in wider road and rail safety contexts

Simplistically the answer is different from jurisdiction to jurisdiction although the European Rail Agency is driving a standardisation of reporting and is retrospectively adjusting statistics as data quality improves within the European Community. National sources can differ widely as to what is included or not included within the data; for, example the way in which intentional death on level crossings is treated. While it is legitimate to exclude such deaths from consideration of accidental death, it is important that sight is not lost of these events, particularly when they involve road vehicles as the potential for a major accident involving the loss of lives of those travelling on the train striking the vehicle and also other members of the public.

The most significant variation in data found in the course of preparing this paper is internal to India data on the number of fatalities at level crossings. In the context of the International Level Crossing Awareness Day (ILCAD), an average of 182.50 fatalities per year is recorded for India. However, using the data recorded by India's National Crime Records Bureau, the average is some 13 times greater at 2361.40 fatalities per annum. Other factors that have the potential to distort figures is how unauthorised level crossings are treated and also how accidents at authorised private level crossings are treated. Also, in a number of cases changed reporting requirements can affect time series data, sometimes without earlier data having been re-based to fit the new reporting requirements.

Jurisdictions in which a risk model is in use to identify those crossings at which risk is likely to be the greatest are better equipped to determine where investment to eliminate or upgrade crossings is likely to provide the greatest safety benefit. The models having had a significant positive impact on the way in which level crossing risk is managed include those in use in Great Britain, Ireland and Portugal which intellectually have a common foundation and Australia where top slicing risk with the extra funding the federal Labor Government's economic stimulus programme provided. However, currently in Victoria there are examples where state-level political expediency ignores the risk ranked priority locations and invests elsewhere. Perhaps, this is best described as a "votes before safety" initiative.

A key component of each of the risk models is the use of the traffic moment (number of trains per day x road usage per day) to factor in the potential for conflict between trains and those using the highway. This

approach is valuable when comparing one crossing with another. Equally important is the increased understanding of risk factors particular to each level crossing as these have a material impact when seeking to identify the generic categories of crossing where there is a disproportionate concentration of risk. An example where this understanding has allowed level crossing risk at a system level to be reduced is in the Netherlands which a decade or more set out to and has achieved the wholesale elimination of active open crossings by upgrading them to an automatic half-barrier (AHB) configuration, often using stubby barriers. Having identified the same concentration of risk in Great Britain, it has taken a decade to identify that you don't always need to widen a road to allow a standard AHB installation and that stubby barriers are a transferable approach.

A structured programme with risk ranking to identify priorities is a feature of the jurisdictions where safety performance is particularly good.

SO WHAT IS GOOD SAFETY PERFORMANCE?

- Different ways of expressing what equates to good performance
- Need to use both rail and highway related data
- A country can be consistently good against all criteria
- A country can be strong on some indicators and weak on others
- Level crossing accidents are a small proportion of total highway accidents. This makes fully engaging the highways authorities a tough nut to crack

A variety of methods are available using publicly available data but each has limitations; for example, by looking at the accident rate per thousand level crossings. Another approach is to consider the harm arising at level crossings per million of population. Understanding the relationship between harm arising at level crossings and that arising more generally on a jurisdiction's roads is also useful. Before considering how such comparisons of performance might be used it is useful to look at the best in each category for a selection of 37 countries for which broadly comparable data[1] is available.

Best performing jurisdictions [2]				
	Crossing fatalities per million population	Highway fatalities per million population	Fatalities per thousand crossings	Crossing fatalities as a % of highway fatalities
1	United Kingdom [3] (0.16)	Netherlands (39.69)	Canada (0.62)	Italy (0.20)
2	Ireland (0.18)	Sweden (42.41)	Ireland (0.74)	South Africa (0.27)
3	Italy (0.19)	United Kingdom (42.70)	Sweden (0.90)	Ireland (0.28)
4	Norway (0.20)	Switzerland (46.63)	Switzerland (0.95)	United Kingdom (0.37)
5	Israel (0.27)	Norway (47.10)	Czech Republic (1.32)	Norway (0.43)
6	Spain (0.32)	Israel (50.28)	United States (1.43)	Bulgaria (0.50)
7	France (0.57)	Germany (54.23)	United Kingdom (1.48)	Greece (0.64)
8	Germany (0.61)	Denmark (58.59)	Australia (1.57)	United States (0.82)
9	Bulgaria (0.67)	Finland (60.11)	Italy (1.82)	France (0.82)
10	Canada (0.72) Denmark (0.72)	Ireland (64.07)	France (1.94)	Serbia (0.82)

[1] Data is missing in relation to Croatian highway fatalities and for Denmark the number of level crossings and hence the rate per thousand crossings.
[2] Data sources are explained in the appendices to this paper.
[3] United Kingdom comprises Great Britain and Northern Ireland

Interestingly, of the ten best performing countries reviewed against each of the indicators, only the United Kingdom and Ireland feature within the top ten for each of the four categories. However, there are counties, identified by green shading, which feature in the top ten on at least one criterion which also appear in the worst ten, again for at least one indicator. There is one country, Slovenia which features in all four categories against which the worst performing jurisdictions are identified.

This dichotomy between countries featuring in both the best and worst performing cohort across the basket of indicators highlights the importance of understanding these differences and the implications they bring in relation to the quest to reduce risk arising at level crossings.

Worst performing jurisdictions [4]				
	Crossing fatalities per million population	Highway fatalities per million population	Fatalities per thousand crossings	Crossing fatalities as a % of highway fatalities
37	Croatia (6.00)	South Africa (276.51)	India (66.77)	Slovenia (3.24)
36	Slovenia (3.45)	Lithuania (160.41)	South Africa (31.96)	Austria (2.95)
35	Argentina (3.30)	Latvia (154.99)	Israel (20.83)	Hungary (2.91)
34	Hungary (2.96)	Greece (132.69)	Croatia (17.26)	Slovakia (2.88)
33	Slovakia (2.78)	Romania (129.56)	Portugal (13.60	Czech Republic (2.63)
32	Austria (2.31)	Poland (129.45)	Lithuania (12.45)	Finland (2.60)
31	Estonia (2.24)	United States (121.14)	Argentina (9.57)	Argentina (2.51)
30	Lithuania (1.99)	Estonia (117.82)	Estonia (9.09)	Australia (2.46)
29	India (1.93)	Slovenia (106.31)	Slovenia (7.51)	Netherlands (2.12)
28	Latvia (1.87)	Hungary (102.02)	Romania (7.33)	India (1.97)

Where a country has a low rate of level crossing fatalities per million population, societal intolerance of such accidents is likely to also be low with even non-fatal accidents generating substantial media coverage. This is clearly the case in both the United Kingdom and Ireland. Other counties where media coverage of non-fatal level crossing accidents is extensive include France, Spain, Italy and Germany. Although not in the top ten; the Netherlands is another country where media coverage of non-fatal accidents is extensive. In such countries, both the media and the wider community reaction to accident is likely to be couched in terms of there being a high expectation of further action being taken to reduce risk further. This can have an impact politically with government funded programmes driving a step change reduction in casualties as has been the case in France, Spain and Portugal.

A further example of a political response to events arising at the road-rail interface can be found in Great Britain following a vehicle incursion at Great Heck in 2001 that resulted in the death of ten people including both train crew and passengers. The response to this included involved both road and rail interests in the development of a shared approach to managing the risk of road vehicle incursions at other than level crossings. An important consideration was the need to avoid disproportionate expenditure.

The progress being made to reduce level crossing fatalities in France is part of a wider resolve to reduce road casualties in the round. Indeed, the various initiatives taken to improve road safety can be seen as leading to changed behaviours as, for example, the incidence of speeding and associated recklessness is reduced. This can be seen as a change in what is societally acceptable. Therefore, in seeking to understand the differences between jurisdictions it is necessary to consider the different attitudes of motorists to key precursors of road accidents relevant to those occurring at level crossings.

[4] Data sources are explained in the appendices to this paper.

The countries with a unitary highway and rail infrastructure authority – Finland and Sweden – judge the case for investment in rail and road infrastructure, and hence level crossings against the same criteria. This approach is wholly rational and defensible as it does not in itself drive a disproportionate investment in reducing risk arising at level crossings. To an extent it has proven possible to apply consistent treatment as the railway industry in Great Britain uses the same value of preventing a fatality (VPF) that is updated annually and published by the Department of Transport for the evaluation of highway investment schemes. The case for a jurisdiction accepting and applying the same decision criteria across transport modes is, to me, self-evident. Therefore, where this is not the case, it should be seen as an important issue to be addressed going forward.

The political and wider societal reaction to a high profile level crossing accident can deliver a significant increase in focus on reducing risk arising at level crossings. This is particularly the case when a large number of people are killed, particularly where those killed have been travelling on the train; and, where children are killed. In the past decade, level crossing safety performance in the United Kingdom has, by world standards, been consistently good. However the United Kingdom has experienced an accident with significant loss of life of those travelling by train at Ufton Nervet (2004). Also at Elsenham (2005) where two teenagers were killed on a footpath level crossing adjacent to the station and Halkirk (2009) where three elderly car occupants were killed. The Elsenham case in particular has through media coverage and activism on the part of the bereaved, significantly increased the commitment within Network Rail to reduce level crossing risk.

Universally level crossing fatalities are but a small percentage of the total number of road fatalities in a jurisdiction, the highest percentage of the countries reviewed being Slovenia at just 3.24%. On this indicator, the ten best performing countries record between 0.20% and 0.82%. This statistic alone explains why dialogue between rail and road authorities is often difficult as the highway infrastructure managers rightly say that they have other higher profile issues where they wish to focus their scarce resources. But, there are examples where substantive collaboration can be seen between rail and highways authorities, even where the ratio of level crossing fatalities to total road fatalities are particularly low. Great Britain, for example, has in recent years developed a significant number of partnerships at the local level with positive engagement between road and rail professionals.

Another manifestation of a low ratio between level crossing and total road fatalities can be a pulling back from a historically significant contribution to a national level crossing safety education programme. This issue is currently live in the United States where the rail industry is being expected to cover a higher proportion of Operation Lifesaver costs as the highway focused federal agency targets other issues with the funding available to it.

THE FIVE E APPROACH

- **E**nabling, **E**ducation, **E**ngineering, **E**nforcement and **E**valuation

The Operation Lifesaver [5] philosophy is that **E**ducation, **E**ngineering and **E**nforcement must be addressed in parallel. Many other countries have taken a similar stance without the use of Operation Lifesaver branding. In reality there are two unwritten Es that go hand in hand with those that are explicit in the Operation Lifesaver model – **E**nabling and **E**valuation. The balance of this paper seeks to draw out best practice and is structured to sequentially address the **E**nabling framework, **E**ngineering solutions, **E**ducation programmes, the case for **E**nforcement and the need for **E**valuation.

[5] Operation Lifesaver began in the United States in 1972 and has since been adopted in Canada, Mexico, Argentina and Estonia

ENABLING FRAMEWORKS

- Unified road and rail administrations level the playing field
- Voluntary road-rail partnerships
- Documented road-rail interface agreements add value
- Single cathartic events can change the approach quickly
- Specially funded national closure programmes
- Research, a good case for wider collaboration

Clearly, the Swedes and Finns have enabling frameworks that allow them to make rational decisions between investment in road and rail infrastructure, including level crossings, as they have unified the road and rail infrastructure authorities. The Swedes have also put in place an excellent tool, OLA [6], which allows diverse interests to focus on addressing the concentration of risk at particular level crossings. Indeed, the use of OLA for level crossings follows on from its use on other highway safety issues.

In Great Britain, the development of road-rail partnership groups under the auspices of national rail infrastructure manager, Network Rail, has put in place both national and local champions of change interacting with peers in the highways fraternity through road-rail partnership groups. However, what has now emerged under the current leadership of Network Rail, is an organisation that has with leadership from the highest level begun to demonstrate a serious resolve to address level crossing risk on a broad front.

From a standing start in 2002 when this series of conferences first visited the country, Australia has emerged as a country where level crossings have taken on a far higher priority in the national psyche with a well-established risk model, solid state-based risk reduction programmes underpinned by road-rail interface agreements that set out the roles of the road and rail infrastructure managers. This approach is to be commended, particularly as it is equally applicable to private level crossings where it is the authorised user who steps-up to the plate as the “road” party to an interface agreement.

The single cathartic event syndrome can be the catalyst that leads to a robust national programme to top slice level crossing risk by focussing on “bad actor” locations. This has been very evident in France since the collision with a school bus in the Haute Savoie on June 2, 2008 and in Victoria, Australia, following the Kerang collision of a truck with a passenger train in June 2007. In both of these jurisdictions a political will to act has been evident, albeit in Victoria tarnished since a change in government has seen a move away from the risk ranked priorities for grade separation.

Long-standing federal funding in the United States and Canada has acted as a catalyst for other partners including state, territory and local administrations to commit funding of their own. Spain, Portugal and France have similarly seen an injection of national level funding for a programme of crossing closures and grade separation schemes. For example in Spain, a five year programme to eliminate 1,931 essentially public level crossings is now starting to deliver a step change in safety performance as has been evidenced in Portugal. However, there are concerns that funding made available is not spent because the enabling infrastructure does not extend to the parties tasked with delivering a programme of works. For example, in India the Auditor General has found that Indian Railways is consistently returning allocated funding because land purchase issues cannot be resolved in a timely fashion and because of extensive delays in delivering the required engineered solutions. This is an issue that has to be speedily overcome if the admirable new political commitment to eliminate all unmanned level crossings in India is to be delivered in anything like the time envisaged by government.

[6] The English translation of OLA (Objektiva fakta, Lösningar och Agerande) is objective facts, solutions and action.

Railways in the private sector can and do fund substantial closure programmes with a particular focus on eliminating private level crossings as in the United States and Great Britain. However, these are a low-hanging fruit. When it comes down to eliminating public level crossings and taking forward highway-rail grade separation schemes public funding is essential. To maximise this, there needs to be a greater focus on the wider benefits that arise when a level crossing is eliminated. For example taking account of planning gain from developments made possible by a scheme, valuing time saved by motorists and reduced traffic congestion alongside the railway safety benefits and line-speed improvements that have often been used on a free-standing basis to justify the elimination of a level crossing. Indeed, given the cost of grade separation in an urban context this is essential.

An underpinning programme of research to address level crossing risk is valuable and can be seen to be an important part of national programmes to improve safety at level crossings. However, how ever good national programmes in Canada, the United States, Great Britain and Australia may be, there is a strong case for greater collaborative funding of research as the issues to be addressed are inherently very similar. This is a challenge for the industry going forward to, for example, take issues like flange-way gap fillers and find the solution to higher-speed operations and durability concerns. Simplistically, why invent the wheel more than once?

ENGINEERING

- Grade separation appropriate to use, don't over-engineer
- "Sealed" crossings an option sometimes ignored
- Driving down the cost of upgrades – wide variation today
- Train detection – think laterally
- Not a stand-alone panacea

That the best level crossing is one that has been eliminated is recognised universally. However, with the large number of level crossings in use today and the pressures in the developing world to increase the number of level crossings, the goal of zero level crossings is a long way off. Therefore, the imperative is to consider how the crossings that remain can be as safe as is reasonably practicable. Taken together, these positions demand that the cost of eliminating, grade separating, consolidating and upgrading level crossings are reduced in order that more can be achieved within finite funding limits.

One characteristic of successfully eliminating significant numbers of level crossings is that multi-year programmes are in place and that where grade separation is necessary it is not approached on the basis that each level crossing has to be directly replaced with a bridge or underpass for all classes of traffic. The Spanish and Portuguese crossing closure and grade separation programmes are managed on the basis of an agreement with municipalities that identifies the crossings to be closed and the nature of the replacement routes across the railway. It is good practice to consider the replacement routes for pedestrians and cyclists separately from the requirements for vehicular traffic as the latter is more able to accept diversion over a longer distance. Therefore, a level crossing with significant pedestrian / cyclist usage may be directly replaced, vehicular traffic may either be consolidated over an existing alternative route or a group of crossings for vehicular traffic concentrated over a new bridge or via a new underpass and a short length of new highway that may allow traffic to be diverted away from an historic town or city centre. India is also a good example of a jurisdiction in which limited use grade separations are provided with all or most vehicular traffic diverted as in the Spanish and Portuguese examples. Ireland too has established a tradition of building replacement structures appropriate to the user, particularly where farm crossings are being eliminated. The fact that a private level crossing is wide enough to allow the largest farm machinery to pass does not mean that the replacement structure always needs to replicate this. Why build for a combine harvester when all that is needed is a cattle creep which can be provided for a fraction of the cost of a new over-bridge?

The costs of upgrading level crossings from passive to active status are high and often a barrier to large scale progress. Therefore, where passive crossings have to remain, ensuring that they are signed on the approach to and at the crossing to a high standard, visibility of approaching trains is good and that the approaches to and roadway across the railway are maintained to a high standard. Simple to say but when there are thousands of these crossings, still something that can come with a hefty price tag. In terms of signage adding retro-reflectivity can be as simple as adding a vertical strip to the poles on which signs are mounted or adding this as a border to existing signs rather than replacing them completely. Ensuring that users of passive level crossings know how to contact the railway in an emergency as required in the United States constitutes good practice.

Train detection by track circuits is particularly expensive if this has to be provided from scratch for a new active crossing. Predictor technology overlaying the railway signalling system drives down costs but is not suitable in all contexts. Therefore if a significantly larger number of crossings are to be equipped with active controls, lower cost and high integrity alternatives need to be available. Detecting the presence of trains using GPS technology has a significant potential although it will require all locomotives and fixed formation trains to be equipped before the cut over to this technology would be possible. This may be achievable on a self-contained short line or urban system but is significantly more difficult on a large system with thousands of locomotives, including some from other railway systems, working over it. This suggests that a “universal” standard is needed. But why reinvent the wheel as modern train protection systems such as ERTMS already provide the means of accurately and continually detecting the position of trains?

The safety performance of active open level crossings means that there is an inherently poor case for providing these crossings and therefore the upgrade route should be straight to a level crossing system with lights, audible alarms and barriers. So what is state of the art today? Costs of equipment supplied on a modular “plug and Play” basis is key in constraining cost and is increasingly the norm in many jurisdictions as is the use of standard components. However, the cost of hardware can be dwarfed by other project costs. This is the area where identifying best practice approaches and following them is of critical importance. This applies equally when upgrading from an active open configuration to one with barriers also.

Examples of efficient practice include the use of time-limited economic stimulus funding provided by the Australian federal government where a lot was quickly achieved for the funds provided. The way in which some of the Swiss secondary railway systems have set about upgrading their level crossing inventory at lower cost than was historically the case is also to be commended. The costs of upgrading level crossings in Australia, Canada and the United States are markedly lower than is too often the case in Europe. The reasons for significant cost variations were considered in a RSSB study [7] and this study can now be seen as helping to shift attitudes and improve the efficiency of level crossing projects in Great Britain.

Going beyond the standard automatic half-barrier level crossing to better control risk is widespread with quad-gates and full barriers taking on a greater prominence as obstacle detection to prove that a vehicle and, in some cases, pedestrians are not trapped on the level crossing. Both optical and radar systems are in use to good effect. For example, in Great Britain radar detection is allowing the automation of significant numbers of presently staffed crossings with CCTV available in the signalling centre to allow interventions to be made when the radar identifies an obstruction. Active advance warning signs are also appropriate and featured in the schemes taken forward with stimulus funding in Australia.

The case for higher-speed rail services is being made worldwide. Where new lines are constructed it is standard practice that no level crossings are permitted. However, when upgrading an existing line, grade separation of all level crossings may not prove economically justified. Therefore, high-integrity crossing systems may be an attractive incremental step. Going beyond quad gates and obstacle detection by channelling road traffic using kerbing and median strips is one option to further reduce the risk of a vehicle

[7] T364 – The Cost of Level Crossings - an international benchmarking exercise, June 2006.

incursion. Indeed, such treatments are used to good effect in the United States, often with quad-barriers, to allow quiet zones in which locomotive horns are no longer routinely sounded. However, in some jurisdictions the median strip has not been progressed because they are seen as novel and not covered by highway standards. Systems to physically prevent a vehicle incursion exist – the rising step in Russia and the Energy Absorption Systems [Quixote] StopGate™ system [8] in the United States. The rising step may protect the railway but does so in a way that may well harm road vehicle occupants while the StopGate system will retard rather than stop a heavy truck travelling at speed.

While the jury is out on the benefits of rumble strips on the approach to level crossings, enhanced pavement markings are used to good effect in wider road safety management and have the potential to be used to good effect at level crossings. A number of in-pavement lighting systems are in use, including on rail based transit systems and ought to be transferable to the heavy rail context. However, such novel treatments are slow to take hold as the benefits are not widely understood. Indeed, in some cases, those promoting novel engineered solutions are naïve in believing that no formal evaluation is needed and that a cost – benefit equation is irrelevant. However, it is important that infrastructure authorities have a process to evaluate such ideas in an expeditious way.

For so long as level crossings remain, engineering alone will not reduce risk so far as is reasonably practicable. Therefore, it must go hand in hand with measures to change behaviours of road users.

Education

- Branded national programmes
- Lifesaver model & Australasian foundation approaches are good
- Publicly funded programmes can often get free public service announcements where privately funded campaigns are required to pay for broadcast media air-time.
- ILCAD is achieving great things already as do national safety weeks
- Social media
- Distraction is an issue that cannot be ignored

In creating a national enabling framework, it is vital that this extends to the means by which education of road users both vehicular and pedestrian is to be achieved. Branded national programmes are well established with many characterised by partnership between rail and other authorities, including the police and in the Operation Lifesaver model the use of community based volunteers, some of which are railway staff. In Canada, the principal partners in Operation Lifesaver are Transport Canada and the Rail Association of Canada with Transport Canada conducting a quinquennial review to validate that the programme is continuing to deliver good value and therefore worthy of continued public funding. This constitutes good practice.

Where it is perceived that public and not for profit organisational funding is in place, free access to public service announcement slots on television and radio can often be achieved. However, where it is seen as a commercial organisation seeking such coverage, it leads to commercial advertising charges being applied. This is an argument for structuring the public education programme in a manner analogous to Operation Lifesaver, the Chris Cairns Foundation in New Zealand and the TrackSafe Foundation, newly launched in Australia. The wider benefits of these approaches are that they are seen as non-partisan and inclusive of interests beyond those that might in practice fund the bulk of activity. However, failure to secure long-term funding from a principal partner can de-stabilise the initiative.

While there is a continuing place for the conventional face-to-face delivery of safety messages and public service announcements on broadcast media; it is essential that new media is utilised to the full as the young are increasingly dependent on this. Also, it is important that education initiatives evolve to tackle emerging

[8] http://www.energyabsorption.com/products/products_stopgate_rail.asp

and more prevalent risky behaviours, particularly those that can distract a crossing user from the task in hand. So, as distraction is a factor in about 20% of traffic accidents, recognising and addressing this factor is essential but still not a factor in some national educational strategies.

The number of high-consequence accidents involving professional drivers of buses and other large vehicles is an issue around the world and one that has to be addressed through the targeted education of these professionals. Indeed, employers of these drivers have a large part to play in ensuring that those they employ act safely at level crossings. However, as a first step, those that regulate the bus and truck industry and the professional drivers they employ need to play a part in the initiatives to reduce risk arising at the road-rail interface. For example, in the United States, the Federal Motor Carrier Safety Administration is an active participant.

Commitment to ensuring that every child receives railway safety education is a commendable goal that is being realised in Estonia, for example, where a particularly vibrant education programme has been put in place. But, this can prove costly if repeated as children become independent users of level crossings and again when they are learning to drive. Canada has an excellent on-line resource that allows learner drivers to test their knowledge, receive a certificate and thus demonstrate to their instructor that they understand the theory of using level crossings safely.

There is one new dimension that is particularly noteworthy, the annual International Level Crossing Awareness Day (ILCAD) sponsored by the International Union of Railways and the European Level Crossing Forum. This year, on June 7, 42 countries participated using the same messages with delivery tailored to local circumstance. This approach has direct benefits in that it makes the case for safe behaviour but also because it demonstrates that the issue is of world-wide concern. That the same resource is made available in a multiplicity of languages is a unifying point that has wider potential. For example, Estonia generates a Christmas seasonal campaign resource which can be, and is, overlaid with text in the local language and the logos participating in delivery of the message.

Similarly, unified national weeks of action can and do generate an incremental level of commitment within the partnerships driving rail safety education and cost-effectively achieve a high-level of awareness of the issue. Australia and New Zealand together and Canada are leading proponents of this approach which more locally can be found at state level in the United States where, for example, California has a month when activity is particularly noticeable down to Wisconsin where the Governor declares a state-wide awareness day.

ENFORCEMENT

- Joint initiatives work best – Officer on the Train for example
- Photo enforcement is an opportunity that too many jurisdictions are missing
- Punishment to fit the crime requires distinction between accidental and wilful misuse

If education is the carrot then enforcement is the stick to be used in parallel. Across the United States the major rail operators, their police departments and those operating in the community locally jointly mount initiatives to identify and sanction those found to be misusing level crossings. The “Officer on the Train” approach where the on-train officer identifies misuse and radios essential information to allow other officers deployed near the targeted crossing(s) to stop the offending party, is particularly effective in generating media coverage to include the number of citations issued. Also, it can provide an opportunity for media to ride along and learn more of the issue of high risk behaviours from the train driver perspective. Similar targeted operations are mounted in other jurisdictions to varying effect.

Photo-enforcement is an increasingly used technique. For example France deploys fixed cameras at hot-spot crossings to target both excessive speed and red light running. Supplementing fixed cameras, Network Rail in the United Kingdom has provided British Transport Police with a fleet of state-of-the-art camera vans. These are netting large numbers of red light runners and at the same time generating significant media

coverage. In some jurisdictions such equipment cannot be used at level crossings. This needs to be rectified as enforcement cameras, properly integrated within wider road safety programmes deliver improved behaviours at the targeted crossings

Sanctions applicable to wilful misuse of level crossing vary greatly with a milestone case in South Africa where a court has convicted a taxi driver of multiple counts of murder in respect of the children killed when he overtook a line of traffic already stopped at a half-barrier equipped level crossing and drove into the path of a train with catastrophic consequences. At the other end of the scale, dangerous driving may only lead to imposition of perhaps 25% of the penalty points needed to lose a driving licence and a fine that is bordering on the trivial. Campaigning for an international consensus on the sanctions appropriate to the wilful misuse of level crossings would be appropriate and could be something that ILCAD might organise.

Distinguishing between wilful and accidental misuse of level crossings is important as the latter can be an indicator that a crossing and the warnings on the approach to it are in need of remedial action to address human factors induced errors. For example, a speed derestriction sign at the exit from a village coming immediately before the advanced warning for the level crossing.

EVALUATION

- A generally neglected area
- Crossing or small number of crossings specific for engineered solutions
- Wider purview when considering effectiveness of most education initiatives
- Demonstrating value-for-money is key to future funding

This can be an area that is neglected and therefore the relative value of interventions cannot be determined. This can lead to funding being squandered on less effective initiatives and thus the safety benefit achieved is sub-optimal.

For evaluation to be effective it needs to have two complementary dimensions, the first looking at the benefits of actions taken at individual or small group of level crossings in the same locality. This will allow the value of an enhanced crossing configuration, a local enforcement drive or whether education is changing behaviours locally to be established. The second dimension must look at broader initiatives, for example a nation-wide awareness programme where before and after understanding of the key messages can be tested. But, importantly, the intelligence gained through local evaluation has to be aggregated and made available at system and national levels as it informs the wider programme evaluation.

Evaluating the effectiveness of awareness raising campaigns as opposed to the value of investment in enhanced crossing configuration is legitimate. Sometimes those tasked with the awareness raising believe that they should operate in a ring-fenced environment where all that has to be demonstrated is that awareness of the crossing safety issue has been generated. This stance is unfortunate as the balance between education, engineering and enforcement needs to change to reflect the combination of measures to optimise risk control at level crossings.

At all times it is prudent to remember that demonstrating value-for-money is the key to unlocking further funding and support for further multi-agency activity to reduce the risk arising at level crossings

SO WHERE IS THE STATE-OF-THE-ART TO BE FOUND?

- Elements of best practice are widely distributed
- Mix and match what is working elsewhere
- Avoid not invented here syndrome
- Action taken after an accident is important, but it is better to have addressed the risk appropriately before the cathartic catastrophic accident occurs
- Reduce risk only so far as is reasonably practicable (SFAIRP)

This cannot be answered on the basis that it is found in one country or on a particular railway system. For me, the ideal can be described as:

- Managing level crossing risk in a country with the best levels of road safety – The Netherlands, Sweden and United Kingdom.
- Having an enabling framework within which the rail sector is prepared to take the lead in building the partnerships needed to address the spectrum of level crossing risk reduction – Australia is doing a pretty good job at the moment.
- A quality research programme – Australia, Canada, the United States and Great Britain spring to mind.
- Having access to a risk model to support decision making – The United Kingdom, Australia, Ireland and Portugal, for example.
- Access to truly lower cost level crossing systems capable of speedy deployment – This is critical if level crossing risk management is to be cost effective.
- Strong government support and funding to allow grade separation and elimination of significant numbers of level crossings – in the developed world Spain, Portugal, the United States stand out but are a step behind Sweden and Finland where the road and rail infrastructure authorities are a single entity able to look at the wider economic benefit on a bi-modal basis. In the developing world the recent Government commitment to eliminate unmanned level crossings by upgrading them if closure is not possible is noteworthy.
- A problem solving toolkit – The OLA approach from Sweden is very good and works well in solving location specific issues. I would back this up with the interface agreements being used in Australia and local road-rail partnership group as facilitated by Network Rail in Great Britain.
- A national public education initiative that is committed to using new media and targeting particular risks as they emerge; for example tackling the growing issue of distraction – The commitment and enthusiasm of Chris Cairns and the foundation he launched in New Zealand, the similar foundation approach from Australia with the best of Operation Lifesaver practice from the United States, Canada and Estonia would be a good mix.
- Enforcement systems that make full use of photo enforcement and a judiciary prepared to impose heavy sanctions on those that wilfully misuse level crossings – The United Kingdom and South Africa respectively.
- Evaluation – Support from a body such as the Rail Safety and Standards Board.

In addition my ideal is a regulatory environment that is equally effective in targeting highways authorities as it is a rail infrastructure provider and an independent accident investigation regime in which the capability to look at all aspects of an accident without disproportionately focusing on the railway contribution to an accident.

I also want the enthusiasm and commitment generated through international co-operation as exemplified through ILCAD, the Operation Lifesaver family and the European Level Crossing Forum which was established as a result of this series of symposia being held in Sheffield, England, in 2004.

What I don't want are further humbling experiences of seeing the rail industry publically criticised for failing to manage risk at level crossings where the case for remedial action should and could have been clear before rather than as a result of an accident. However, this does not mean that safety at any price is the answer as where rational decisions using nationally recognised criteria have been made not to upgrade a particular crossing the infrastructure providers must stand-up for their decisions with support from their regulators and also the sponsoring government department.

Finally, jurisdictions applying the so far as is reasonably practicable (SFAIRP) approach to reducing risk at level crossings and elsewhere in that jurisdictions transport system have an in-built advantage in ensuring that expenditure to reduce risk arising is not disproportionate. Even so, come the next accident the media will challenge and the government and its safety regulator may forget the importance of standing by the SFAIRP principle.

APPENDIX 1: FATALITIES BY JURISDICTION AND LEVEL CROSSING FATALITIES AS A PERCENTAGE OF TOTAL ROAD CASUALTIES

Country	Rail [i] Road [ii]	2006	2007	2008	2009	2010	2011	5 year average [iii]	LX as % of road fatalities
Argentina	Rail	-	120	155	126	132		133.25	2.51
	Road	4,995	5,428	5,759	5,219	5,094		5,299.00	
Australia	Rail	-	-	-	-	-		37.00 [iv]	2.46
	Road	1,602	1,603	1,466	1,488	1,352		1,502.20	
Austria	Rail	22	33	17	12	13		19.40	2.95
	Road	730	691	679	633	552		657.00	
Belgium	Rail	9	19	10	8	9		11.00	1.09
	Road	1,069	1,067	944	944	-		1006.00	
Bulgaria	Rail	4	5	4	4	8		5.00	0.50
	Road	1,043	1,006	1,061	901	-		1002.75	
Canada	Rail [v]	28	26	26	19	24		24.60	0.96
	Road	2,895	2,769	2,371	2,207	-		2560.50	
Croatia	Rail	-	12	9	15	7		10.75	-
Czech Republic	Rail	31	23	24	21	34		26.60	2.63
	Road	1,063	1,221	1,076	901	802		1012.60	
Denmark	Rail	5	5	3	3	4		4.00	1.19
	Road	306	406	406	303	255		335.20	
Estonia	Rail	-	6	1	3	2		3.00	1.90
	Road	204	196	132	100	-		158.00	
Finland	Rail	5	10	8	11	8		8.40	2.60
	Road	336	380	344	279	272		322.20	
France	Rail	38	38	38	36	29		35.80	0.82
	Road	4,709	4,620	4,275	4,273	3,992		4373.80	
Germany	Rail	50	67	50	41	44		50.40	1.13
	Road	5,091	4,949	4,477	4,152	3,648		4463.40	
Greece	Rail	12	5	6	13	12		9.60	0.64
	Road	1,657	1,612	1,553	1,456	1,258		1,507.20	
Hungary	Rail	22	26	42	28	30		29.60	2.91
	Road	1,303	1,232	996	822	740		1018.60	
India	Rail (ILCAD)	-	275	147	177	131		182.50	0.15
	Rail [vi] (NCRB)	2,353	2,369	2,222	1,516	3,347		2361.40	1.97
	Road (NCRB)	105,725	114,590	118,239	126,896	133,938		119,877.60	
Ireland	Rail	0	1	1	0	2		0.80	0.28
	Road	365	338	279	238	212		286.40	
Israel	Rail	-	0	0	1	7		2.00	0.54
	Road	405	382	412	352	314		373.00	

Country	Rail [i] Road [ii]	2006	2007	2008	2009	2010	2011	5 year average [iii]	LX as % of road fatalities
Italy	Rail Road	19 5,669	16 5,131	6 4,731	5 4,237	11 4,090		11.40 4,771.60	0.24
Japan	Road	7,272	6,639	6,023	5,772	5,745		6290.20	-
Latvia	Rail Road	4 407	4 419	6 316	2 254	5 -		4.20 349.00	1.20
Lithuania	Rail Road	8 759	6 739	6 499	8 370	5 299		6.6 533.2	1.24
Luxembourg	Rail Road	- 36	- 46	- 35	1 47	0 32		0.5 39.20	1.28
Netherlands	Rail Road	12 730	19 709	18 677	13 644	8 537		14.00 659.40	2.12
New Zealand	Rail Road	- 393	8 421	6 366	5 384	1 375		5.00 387.80	1.29
Norway	Rail Road	0 242	0 233	0 255	2 212	3 208		1.00 230.00	0.43
Poland	Rail Road	32 5,243	81 5,583	39 5,437	72 4,572	54 3,907		55.60 4948.40	1.12
Portugal	Rail Road	18 969	20 974	15 885	17 929	11 937		16.20 938.80	1.73
Romania	Rail Road	22 2,478	55 2,800	38 3,061	40 2,796	35 -		38.00 2783.75	1.37
Serbia	Rail Road	- -	11 -	15 -	8 810	15 660		12.25 735.00	0.82
Slovakia	Rail Road	16 579	15 627	11 558	25 347	9 -		15.20 527.75	2.88
Slovenia	Rail Road	9 263	9 293	4 214	7 171	6 138		7.00 215.80	3.24
South Africa	Rail [vii] Road [viii]	- -	- -	34 -	34 13,923	44 13,802		37.33 13,862.50	0.27
Spain	Rail Road	14 4,104	19 3,823	15 3,100	16 2,714	9 2,478		14.60 3243.80	0.45
Sweden	Rail Road	9 445	9 471	4 397	6 358	7 266		7.00 397.80	1.76
Switzerland	Rail Road	- 370	6 384	5 357	7 349	3 327		5.25 357.40	1.47
United Kingdom	Rail Road	5 3,298	13 3,059	14 2,645	13 2,337	4 1,905	6 [ix]	9.8 2,648.80	0.37
United States	Rail [x] Road	376 42,708	344 41,259	298 37,261	261 33,883	271 32,885	248	310.00 37,599.20	0.82

APPENDIX 2: NUMBER OF LEVEL CROSSINGS, ACCIDENTS PER THOUSAND LEVEL CROSSINGS AND PER MILLION LEVEL CROSSINGS

Country	2007	2008	2009	2010	Fatalities (5 year average)	Fatality per 1,000 LX	Population millions	LX fatals per million
Argentina			13,912	13,912	133.25	9.57	40.412	3.30
Australia			23,500	23,500	37.00	1.57	22.268	1.66
Austria	7,310	7,116	6,939	5,430	19.40	3.57	8.394	2.31
Belgium			1,913	1,902	11.00	5.75	10.712	1.03
Bulgaria			820		5.00	6.10	7.494	0.67
Canada			40,000	37,000	24.60	0.62	34.017	0.72
Croatia	1,566	1,561	1,541	1,515	26.60	17.26	4.403	6.04
Czech Republic	8,362	8,296	8,274	8,161	10.75	1.32	10.493	1.02
Denmark					4.00		5.550	0.72
Estonia			330		3.00	9.09	1.341	2.24
Finland			4,218	3,172	8.40	1.99	5.365	1.57
France			18,459	18,364	35.80	1.94	62.787	0.57
Germany			20,385		50.40	2.47	82.302	0.61
Greece			1,829		9.60	5.25	11.359	0.85
Hungary			5,819	5,819	29.60	5.09	9.984	2.96
India			35,363	32,694	182.50 2361.40	5.16 66.77	 1,224.614	1.93
Ireland			1,074	1,054	0.80	0.74	4.470	0.18
Israel			96	88	2.00	20.83	7.418	0.27
Italy			6,269	6,003	11.40	1.82	60.551	0.19
Latvia			666	557	4.2	6.31	2.252	1.87
Lithuania			530	536	6.6	12.45	3.324	1.99
Luxembourg			142	138	0.5	3.52	0.507	0.99
Netherlands	2,720	2,696	2,659	2,587	14.00	5.27	16.613	0.84
New Zealand			1,400	1,400	5.00	3.57	4.368	1.14
Norway					1.00		4.883	0.20
Poland			16,485	12,977	55.60	3.37	38.277	1.45
Portugal	1,266	1,229	1,191	1,107	16.20	13.60	10.676	1.52
Romania			5,181	5,181	38.00	7.33	21.486	1.77
Serbia			2,354		12.25	5.20	9.856	1.24
Slovakia			2,265	2,219	15.20	6.71	5.462	2.78
Slovenia			932		7.00	7.51	2.030	3.45
South Africa				1,168	37.33	31.96	50.133	0.74

Spain	2,811	2,699	2,613	2,512	14.60	5.59	46.077	0.32
Sweden	8,151	8,054	7,793	7,652	7.00	0.90	9.380	0.75
Switzerland			5,510	4,934	5.25	0.95	7.664	0.69
United Kingdom			6,600	6,452	9.8	1.48	62.036	0.16
United States				217,269	310.00	1.43	310.384	1.00

APPENDIX 3: ROAD FATALITIES PER MILLION POPULATION

Country	Population millions	Road fatalities (5yr average)	Road fatalities per million population
Argentina	40.412	5,299.00	131.12
Australia	22.268	1,502.20	67.46
Austria	8.394	657.00	78.27
Belgium	10.712	1,006.00	93.91
Bulgaria	7.494	1,002.75	133.81
Canada	34.017	2,560.50	75.27
Czech Republic	10.493	1,012.60	96.50
Denmark	5.550	335.20	58.59
Estonia	1.341	158.00	117.82
Finland	5.365	322.20	60.11
France	62.787	4,373.80	69.66
Germany	82.302	4,463.40	54.23
Greece	11.359	1,507.20	132.69
Hungary	9.984	1,018.60	102.02
India	1,224.614	119,877.60	97.89
Ireland	4.470	286.40	64.07
Israel	7.418	373.00	50.28
Italy	60.551	4,771.60	73.85
Latvia	2.252	349.00	154.97
Lithuania	3.324	533.2	160.41
Luxembourg	0.507	39.20	77.32
Netherlands	16.613	659.40	39.69
New Zealand	4.368	387.80	88.78
Norway	4.883	230.00	47.10
Poland	38.277	4,948.40	129.45
Portugal	10.676	938.80	87.94
Romania	21.486	2,783.75	129.56
Serbia	9.856	735.00	74.57

Slovakia	5.462	527.75	96.62
Slovenia	2.030	215.80	106.31
South Africa	50.133	13,862.50	276.51
Spain	46.077	3,243.80	70.40
Sweden	9.380	397.80	42.41
Switzerland	7.664	357.40	46.63
United Kingdom	62.036	2,648.80	42.70
United States	310.384	37,599.20	121.14

Footnotes to Appendix 1, similarly relevant to appendices 2 and 3

[i] Rail safety data is drawn from International level Crossing Awareness Day website and European Rail Agency safety reports except where otherwise specified.
[ii] Road safety data drawn from Eurostat and International Traffic Safety Data & Analysis Group reports except where otherwise specified.
[iii] The Average is calculated over lesser periods where less than five years statistics are available. Where shown, 2011 data is excluded from the analysis.
[iv] Average as reported in National Level Crossing Strategy 2010.
[v] Operation Lifesaver data.
[vi] Data from National Crime Records Bureau reports
[vii] Data from Railway Safety Regulator, covers a reporting year ending March 31 of the year later than shown in table.
[viii] Data from Arrive Alive, covers a reporting year ending March 31 of the year later than shown in table.
[ix] RSSB data only, excludes Northern Ireland and minor railways.
[x] Uses Federal Railroad Administration includes non-validated Federal Transit Agency data, except 2011 which is FRA data only.