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Programme of Work – development of a road/rail interface strategy with recommendations

Assessment of safety at level crossings in UNECE member countries and other selected countries and strategic framework for improving safety at level crossings

Submitted by the Drafting Group of the Group of Experts on Improving Safety at Level Crossings

Summary

This document presents an assessment undertaken by the Group of Experts on Improving Safety at Level Crossings of safety at level crossings in UNECE member countries and other selected countries (Part one). It further presents a strategic framework prepared by the Group for enhancing safety at level crossings (Part two).

This document was finalized by the Drafting Group of the Group of Experts on Improving Safety at Level Crossings. It is submitted for consideration and endorsement by the Group of Experts at its ninth session.

Due to administrative reasons on length of documents accepted for translation, this document, in Part one contains only conclusions from the assessment of key factors contributing to unsafe condition at level crossings in UNECE member countries and other selected countries as well as recommendations resulting from these conclusions. The assessment of the key factors (chapters B to I of Part one) is provided in Annex III to this document (in chapters I to VIII) in English only.

Part one
Assessment of safety performance, conclusions from assessment of key factors contributing to unsafe condition at level crossings in UNECE member countries and other selected countries and recommendations

A. Safety performance at level crossings

1. The Group of Experts has not identified any source that contains data related to level crossings and their safety performance for all UNECE members. In the absence of such a source, the Group of Experts assessed the level crossing safety performance based on the following data:

- Data available for 29 UNECE members (i.e. all members of the European Union except Malta as well as Norway and Switzerland) contained in the database managed by the European Railway Agency (ERA)[1]. These countries are referred to in this chapter as “ERA countries”, and
- Data available for Canada[2] and United Sates of America[3] as well as data received from India, the Russian Federation and Turkey. These countries are referred as “other countries” in this chapter.

2. The assessment of safety performance is presented separately for “ERA countries” and for “other countries”. This is due to the fact that there is no certainty as to the uniformity of definitions and methods. As a result, the performance indicators may not be directly comparable between “ERA countries” and “other countries” and between any of the “other countries”.

3. The ERA database contains data for level crossings and safety at level crossings for 2006-2014. Not all the data are available for the entire period and for all “ERA countries”. The data on the number of level crossings and their type (active including breakdown of active level crossings and passive level crossings) are generally available for the period 2010-2014. The data on the number of significant accidents[4], killed or injured users are available as totals, whereas the disaggregation per type of level crossing is only available for several countries and only for 2014. Disaggregation per type of user of level crossing is

[1] Available at https://erail.era.europa.eu/safety-indicators.aspx
[2] Data available from http://www.tsb.gc.ca/eng/stats/rail/2014/sser-ssro-2014.asp#figure-12a.com
[3] Data available from http://safetydata.fra.dot.gov/OfficeofSafety/default.aspx
[4] Definition as per EU Commission Directive 2014/88/EU: Any accident involving at least one rail vehicle in motion, resulting in at least one killed or seriously injured person, or in significant damage to stock, track, other installations or environment, or extensive disruptions to traffic, excluding accidents in workshops, warehouses and depots

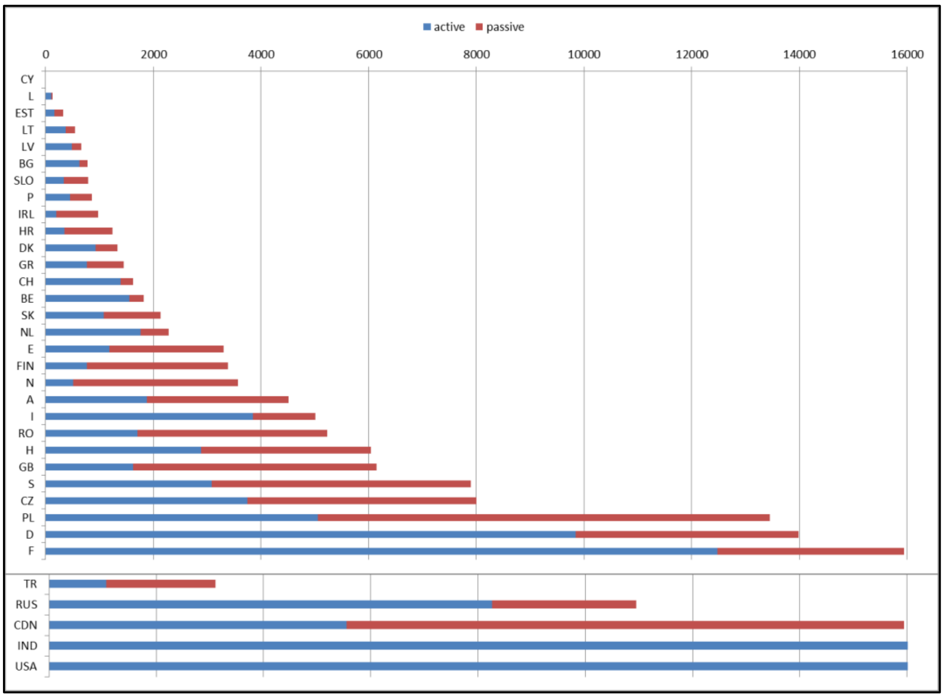
not available at all. The normalized data i.e. number of track kilometers[5], train kilometers[6] and line kilometers[7] are generally available.

4. For "other countries", data are available on the number of level crossings and breakdown of active and passive crossings. The data on the number of all or fatal accidents are also available, for Canada and the United States of America with disaggregation per type of level crossing and per type of user. The normalized data are also available.

5. In the "ERA countries", the number of level crossings varies between zero (no level crossings in Cyprus) and nearly 16,000 (France). For "other countries", there are between 3,100 level crossings (Turkey) to as many as nearly 210,000 (United States of America). The number of level crossings in individual countries usually depends on the size of the country and density of the rail and road networks (Figure 1).

Figure 1

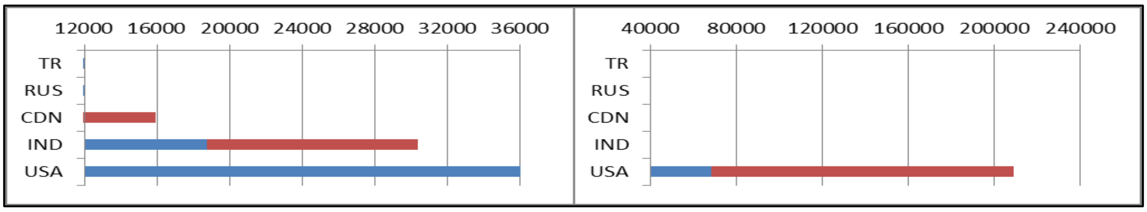
Number of level crossings, "ERA" and "other" countries, 2014



[5] Definition as per EU Commission Directive 2014/88/EU: The length measured in kilometres of the railway network. Each track of a multiple-track railway line is to be counted.

[6] Definition as per EU Commission Directive 2014/88/EU: The unit of measure representing the movement of a train over one kilometre. The distance used is the distance actually run, if available, otherwise the standard network distance between the origin and destination shall be used. Only the distance on the national territory of the reporting country shall be taken into account.

[7] Definition as per EU Commission Directive 2014/88/EU: The length measured in kilometres of the railway network. For multiple-track railway lines, only the distance between origin and destination is to be counted.



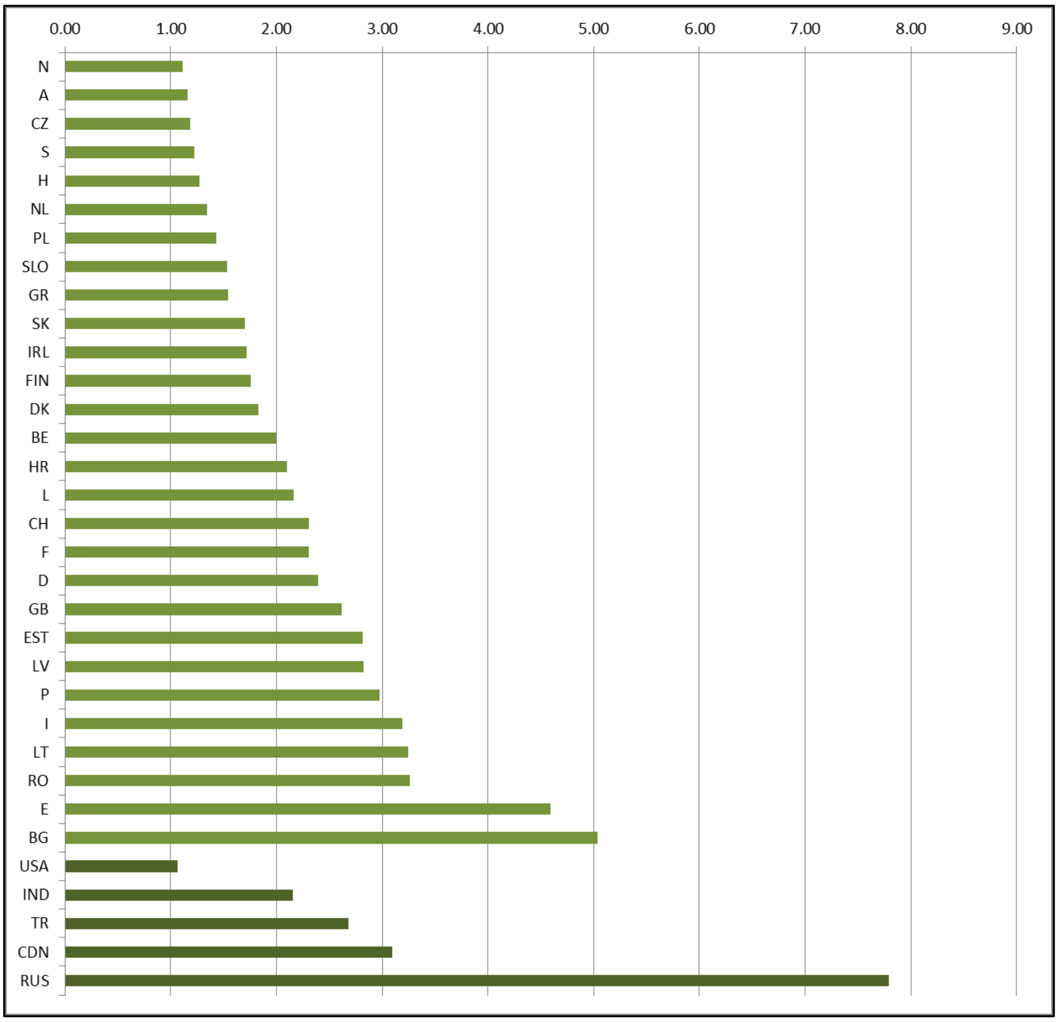
Source: ERA database, Canadian and US databases, data submitted to UNECE, UNECE secretariat calculations.

Note: Country codes based on the 1949 or 1968 Conventions on Road Traffic. They are: CY – Cyprus, L – Luxembourg, EST – Estonia, LT – Lithuania, LV – Latvia, BG – Bulgaria, SLO – Slovenia, P – Portugal, IRL – Ireland, HR – Croatia, DK – Denmark, GR – Greece, CH- Switzerland, BE – Belgium, SK – Slovakia, NL – Netherlands, E – Spain, FIN – Finland, N – Norway, A – Austria, I – Italy, RO – Romania, H – Hungary, GB- United Kingdom of Great Britain and Northern Ireland, S- Sweden, CZ –Czech Republic, PL – Poland, D- Germany, F – France, TR – Turkey, RUS – Russian Federation, CDN – Canada, IND – India, USA – United States of America.

6. The distribution of active (with its various types) and passive level crossings is different from country to country and it depends on many factors which are not subject of this assessment. On average, level crossings are located between every one (Norway, USA) to nearly eight (Russian Federation) rail line kilometres (Figure 2).

Figure 2

Average distance between level crossings, "ERA" and "other" countries, line kilometers, 2014



Source: ERA database, Canadian and US databases, data submitted to UNECE, UNECE secretariat calculations.

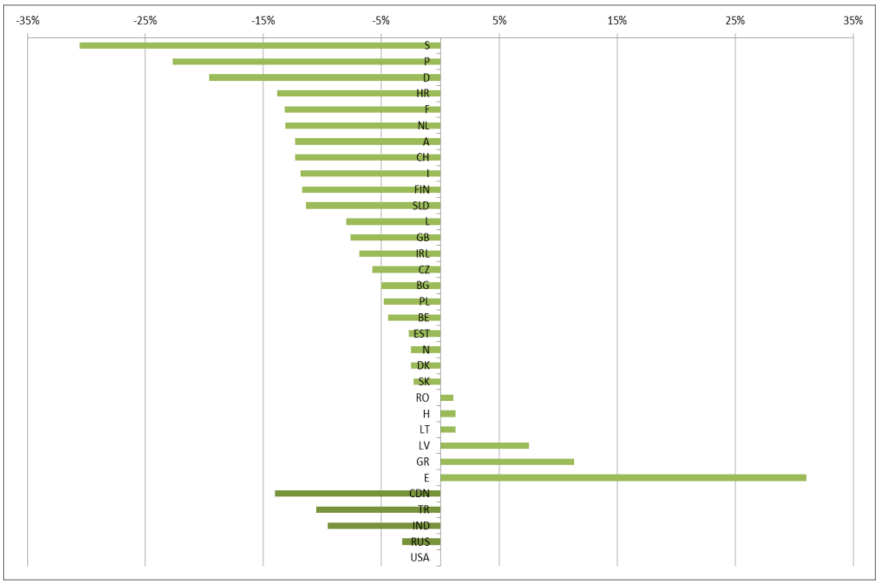
Note: High speed lines (with dedicated no "level crossing tracks") are included.

7. In recent years, the number of level crossings decreased in the majority of "ERA countries" (Figure 3). The decrease ranged from as high as 30 per cent (Sweden) to two per cent (Denmark, Slovakia). In five "ERA countries" the number of level crossings increased from between one per cent (Hungary and Latvia) to 14 per cent (Greece) to more than 20 per cent (Bulgaria and Spain).

8. In "other countries", the number of level crossing decreased or remained unchanged (United States of America).

Figure 3

Percentage change in the number of level crossings, “ERA” and “other” countries, 2010-2014



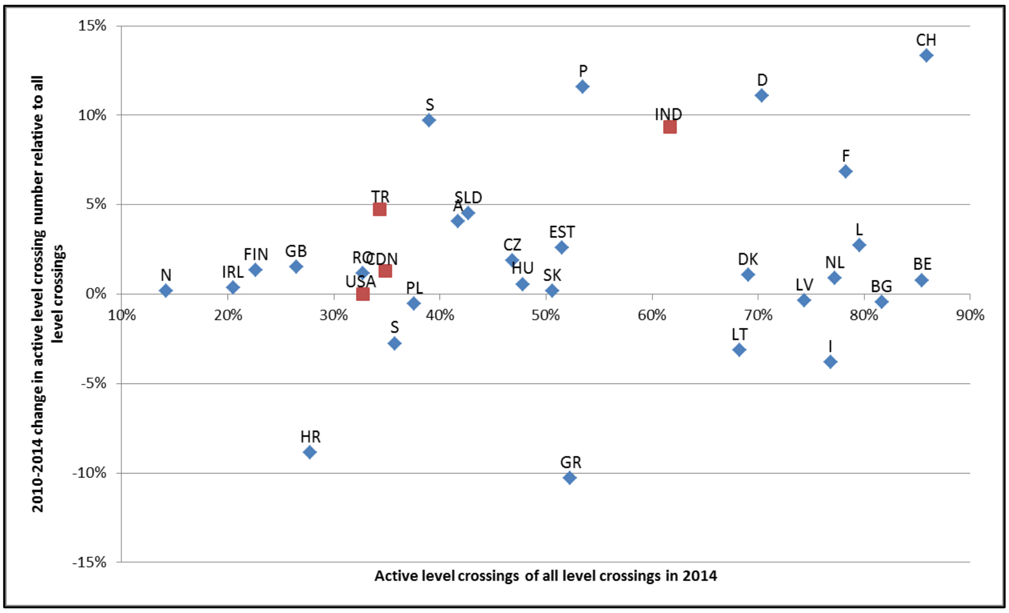
Source: ERA database, Canadian and US databases, data submitted to UNECE, UNECE secretariat calculations.

Note: Calculations for Belgium for 2007-2014, Bulgaria: 2010-2014, Croatia: 2010-2014, Estonia: 2007-2014, Luxembourg: 2009-2014, Norway: 2010-2014, Romania: 2007-2014, Spain: 2008-2014, and Switzerland: 2009-2014.

9. The relative share of active level crossings to all level crossings increased between 2010 and 2014 in the majority of “ERA countries” and all “other countries” except the United States of America where it remained unchanged (Figure 4). This was achieved by upgrading passive level crossings to active ones and by eliminating passive level crossings. The shares increased from less than one per cent (Belgium, Hungary, Ireland, Netherlands, Norway and Slovakia) to as high as 13 per cent (Switzerland). The ratios decreased in several “ERA countries”, most prominently in Croatia and Greece (9-10 per cent).

Figure 4

Change in the relative share of active level crossings to all level crossings, "ERA" and "other" countries, 2010-2014

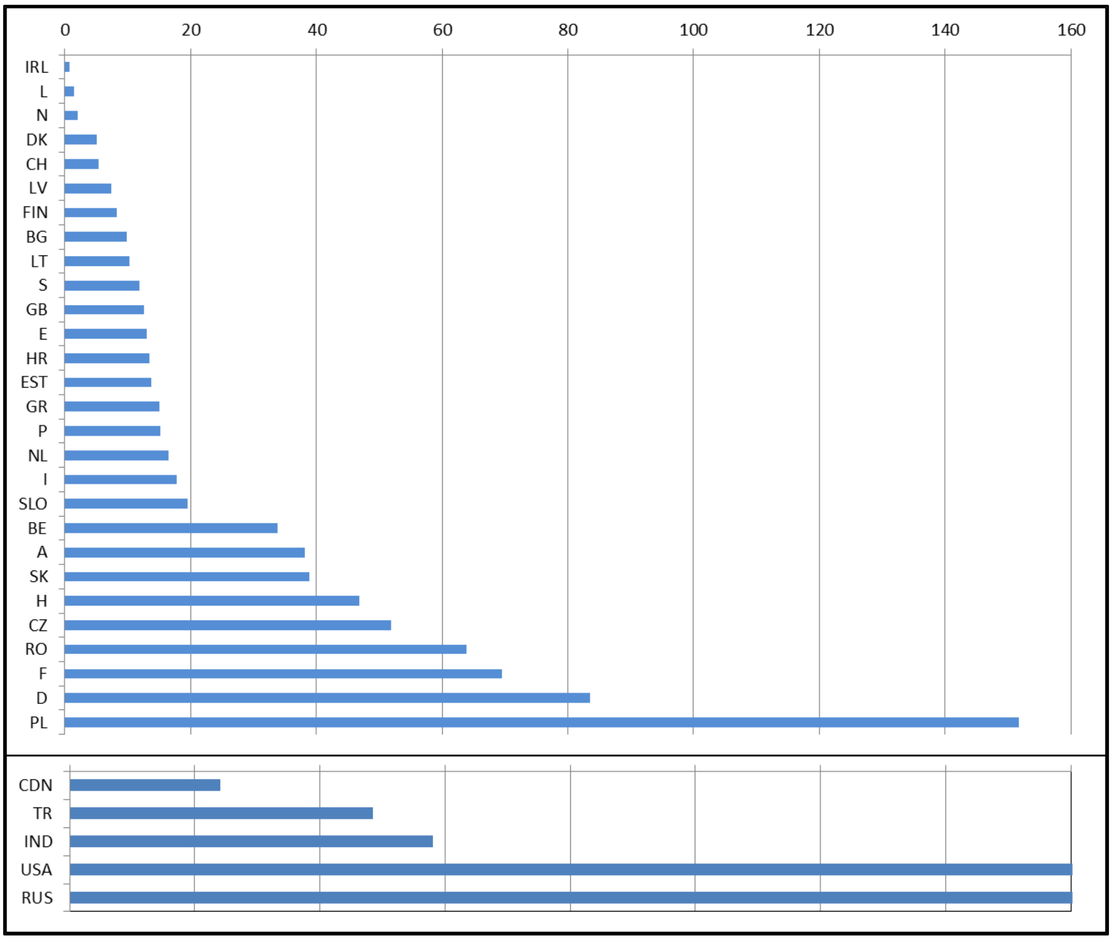


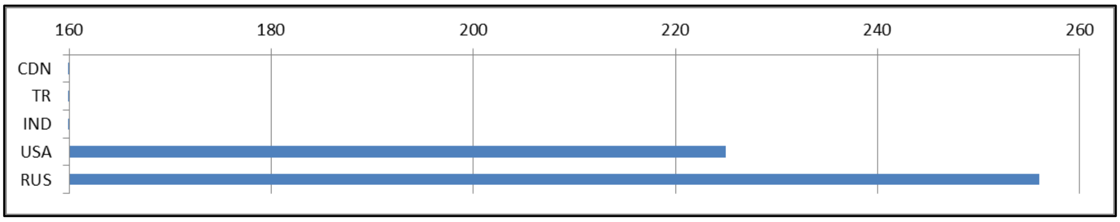
Source: ERA database, Canadian and US databases, data submitted to UNECE, UNECE secretariat calculations.

Note: Calculation for Denmark for 2013-2014 and for Slovakia for 2011-2014.

10. The average annual number of significant accidents at level crossings varies considerably. In "ERA countries" in 2006-14, it ranged from the annual average of one significant accident (Ireland) to as many as 152 in Poland (Figure 5). For "other countries", level crossing accidents resulting in fatalities and/or other severe consequences range from annual average of 24 accidents (Canada) to over 250 accidents (Russian Federation).

Figure 5
Number of significant accidents, "ERA" and "other" countries, annual 2006-2014 average





Source: ERA database, Canadian and US databases, data submitted to UNECE, UNECE secretariat calculations.

Note: Calculations for Croatia for 2010-2014, Estonia: 2007-2014, Luxembourg: 2009-2014, and Switzerland: 2009-2014; Canada, India, Turkey and United States of America: 2009-2014 and Russian Federation 2010-2014.

Definition of a significant accident as per EU Commission Directive 2014/88/EU: Any accident involving at least one rail vehicle in motion, resulting in at least one killed or seriously injured person, or in significant damage to stock, track, other installations or environment, or extensive disruptions to traffic, excluding accidents in workshops, warehouses and depots.

11. The number of significant accidents has followed a decreasing trend in the majority of "ERA countries" as well as "other countries" except Canada and the Russian Federation

(Figure 6). The negative slope of the trend line is high in several cases, especially for those "ERA countries" with a high number of significant accidents (France, Germany and Poland). At the same time, the value of the correlation coefficient is high and thus it confirms the trend for the majority of "ERA countries" (Figure 7). The few "ERA countries", whose trends are flat or negative and insignificant at the same time, are those with a rather good absolute safety performance of level crossings (Denmark, Ireland, Netherlands, Sweden and United Kingdom). Two "ERA countries" (Bulgaria and Norway) have flat or positive trends (indicating an increasing trend in the number of significant accidents over time) but they have a good absolute safety performance at level crossings. From "other counties" the negative slope of the trend line is high only in Turkey.

Figure 6

Coefficient of linear trend for number of significant accidents, "ERA" and "other" countries, 2006-2014

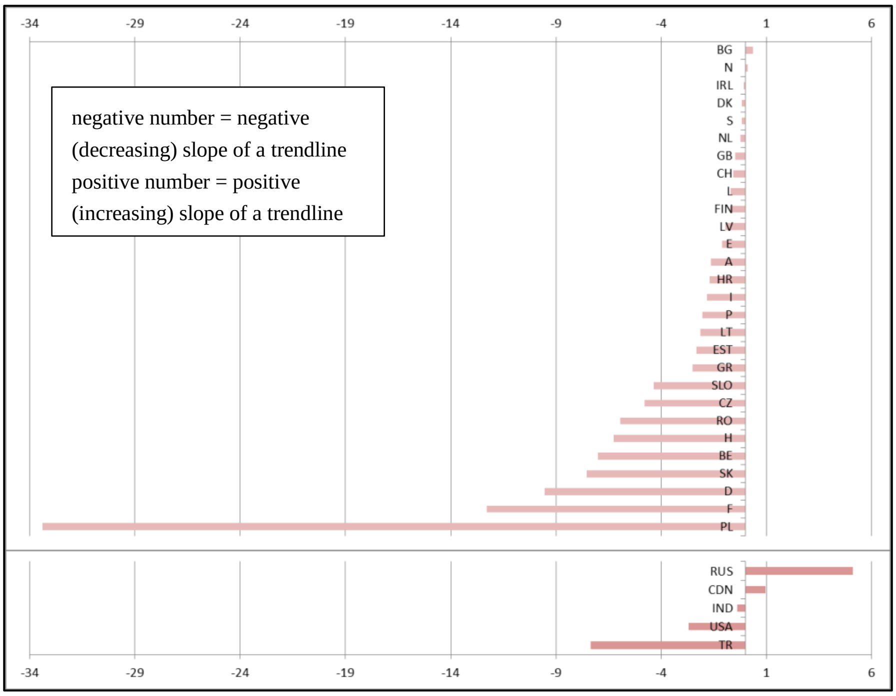


Figure 7

Correlation coefficient of the linear trend

Source: ERA database, Canadian and US databases, data submitted to UNECE, UNECE secretariat calculations.

Note: Calculations for Croatia for 2010-2014, Estonia 2007-2014, Luxembourg 2009-2014, Switzerland 2009-2014; India, Turkey and United States of America: 2009-2014 and Russian Federation 2010-2014.

Correlation coefficient of "-1" means perfect correlation with a negative (decreasing) slope, of "0" means no correlation, and of "+1" means perfect correlation with a positive (increasing) slope.

12. The assessment of safety performance at level crossings in relative terms shows different results. "ERA countries" and "other countries" with a high absolute number of accidents (France, Germany, Poland and the United States) and with a high number of level crossings achieve relatively good results in terms of accidents per number of level crossings than "ERA" or "other" countries with fewer accidents and fewer level crossings (e.g.

Bulgaria and Estonia) (Figure 8). Similarly, both "ERA countries" and "other countries" with a high absolute number of accidents and many train kilometres driven annually (e.g. Germany, India and Russian Federation) achieve better performance in terms of average distance driven by trains per accident to occur than "ERA" or "other" countries with fewer accidents but a relatively low number of train kilometres driven (Greece) (Figure 9).

Figure 8
Number of significant accidents per 1,000 level crossings, "ERA" and "other" countries, 2014

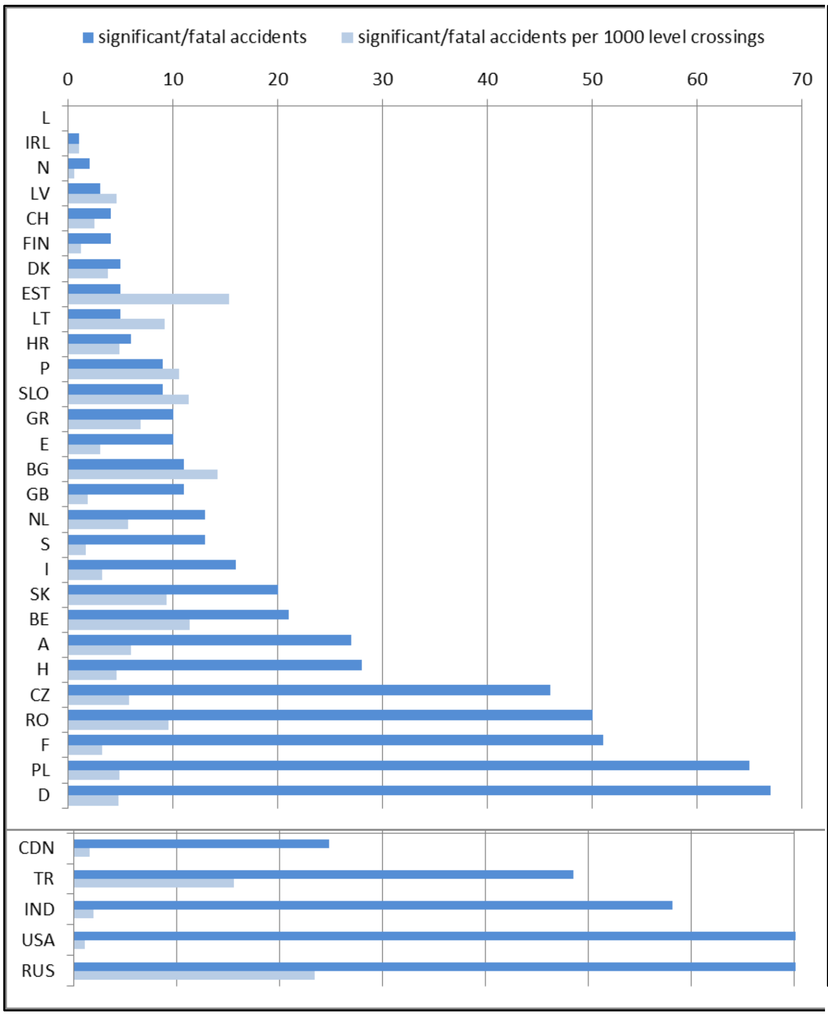
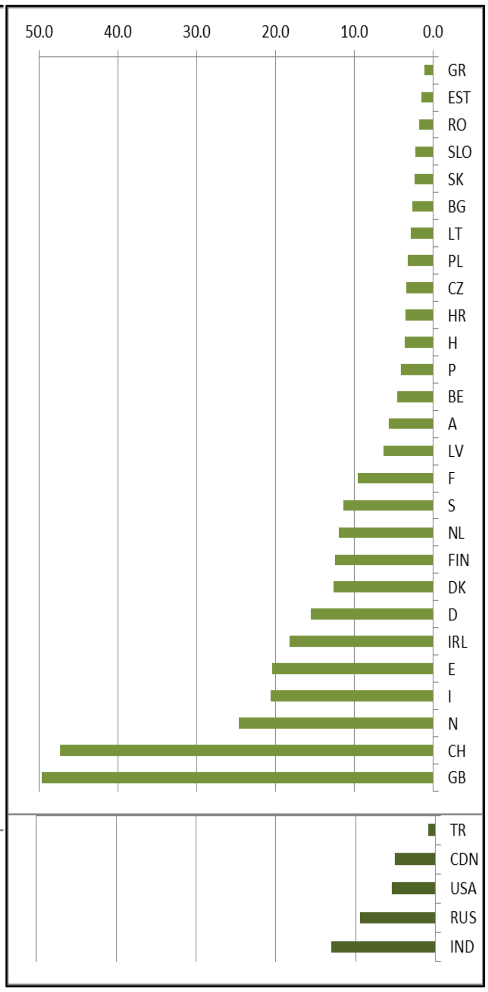


Figure 9
Million train kilometers driven per accident, "ERA" and "other" countries, 2014

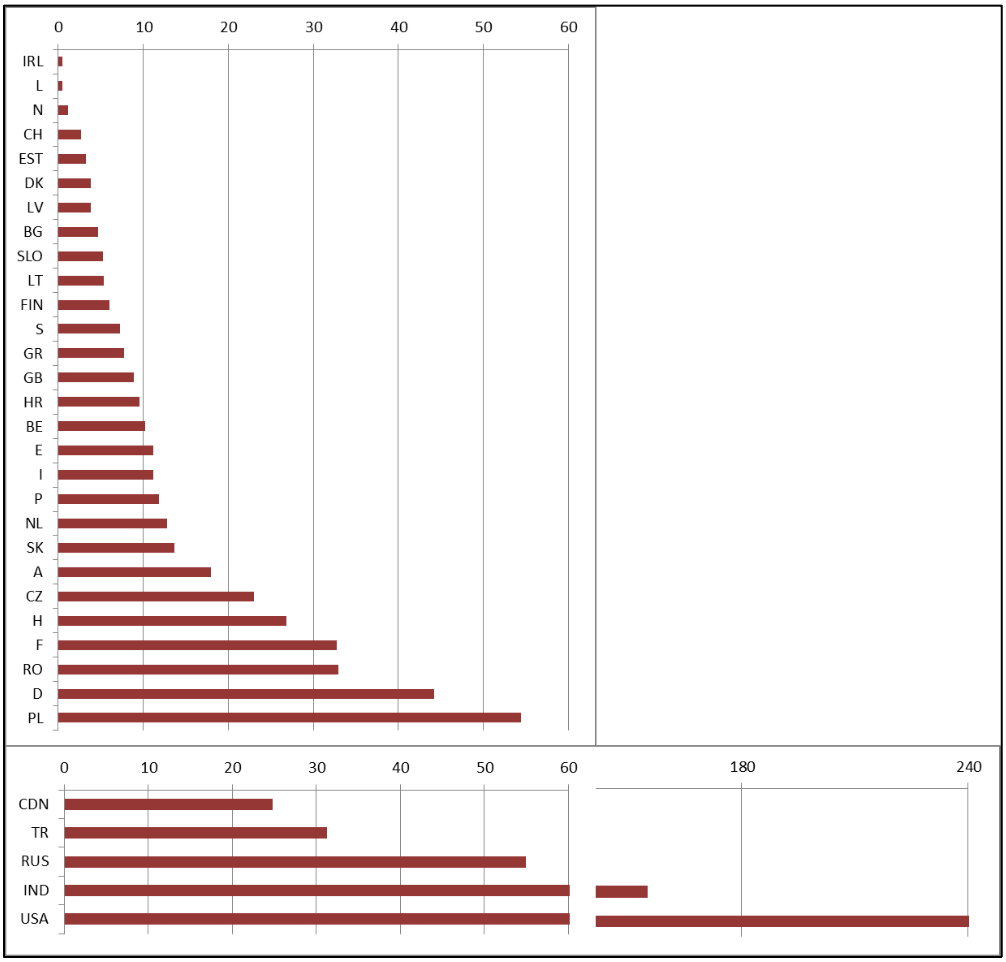


Source: ERA database, Canadian and US databases, data submitted to UNECE, UNECE secretariat calculations.

13. The average annual number of users who died at level crossings varied considerably in the "ERA countries" in 2006-14. The number ranged from the annual average of less than one fatality (Ireland) to as many as 54 fatalities (Poland) (Figure 10). For "other countries", the average annual number of fatalities was as many as 155 (India) and 240 (United States of America).

Figure 10

Number of level crossing fatalities in significant accidents, “ERA” and “other” countries, annual average of 2006-2014



Source: ERA database, Canadian and US databases, data submitted to UNECE, UNECE secretariat calculations.

Note: In Croatia calculated for 2010-2014, in Czech Republic: 2006-2013, Estonia: 2007-2014, Luxembourg: 2009-2014, Switzerland: 2009-2014, India, Turkey and United States of America: 2009-2014 and Russian Federation 2010-2014.

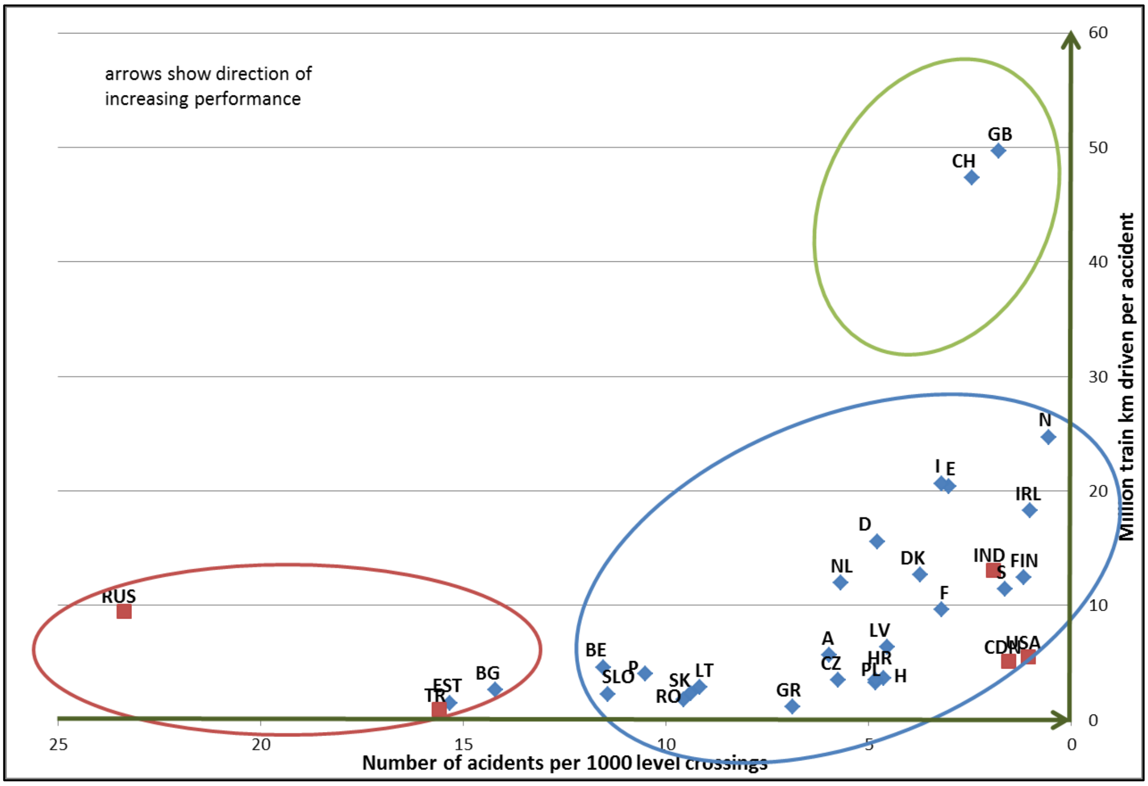
14. The “ERA countries” with a higher annual average of significant accidents typically have a higher annual average number of fatalities. The number of significant accidents is higher for every “ERA country” than the number of fatalities, which shows that multiple fatalities per accident are not common. At the same time, there are “ERA countries” (Denmark, Netherlands, Portugal and Spain) where a large majority of significant accidents resulted in a fatality. For “other countries”, it is notable that in India the number of fatalities is high compared to the number of fatal accidents. This shows that multiple fatalities are common in fatal accidents.

15. The safety performance of level crossings can be assessed, taking into account the data available, by combining the data on the number of accidents (significant accidents in “ERA countries” and fatal accidents or accident with serious consequences in “other countries”) and the normalization data for the number of level crossings and train kilometres driven. The fewer accidents per level crossings the better is the safety

performance. Similarly the more train kilometres are driven between accidents the better is the safety performance. However, the performance is best if there is comparatively lower number of accidents per level crossings and at the same time most train kilometres driven per accident. Two countries (Switzerland and United Kingdom) achieve best performance in such analysis (Figure 11).

Figure 11

Safety assessment of level crossings, significant accidents to number of level crossings versus million train kilometers driven per accident, "ERA" and "other" countries, 2014



Source: ERA database, Canadian and US databases, data submitted to UNECE, UNECE secretariat calculations.

B. Data on safety at level crossings

16. In conclusion, while the responding countries informed on their collection and processing of a vast array of data and on publishing them, the Group of Experts, as presented in chapter 1, noted that these data are not available in a common database for all UNECE countries and that they are not publicly and easily available (e.g. Internet). There seems thus to exist a gap between the reported and actual data availability for international comparisons.

17. Moreover, UNECE member countries do not use the same data and terms definitions except for the member countries of the European Union and cooperating countries. For that reasons, data - even if made available on the Internet - could not be directly used for international comparison, benchmarking, or for testing and or calibrating risk management models.

Recommendations

18. The Group of Experts agrees this challenge should be addressed in the near future. To this end, the Group of Experts recommends a set of level crossing safety indicators (Table 1) that UNECE countries should be invited to collect and publish annually on the official websites. These indicators should be produced in accordance with the common definitions, as based on the Eurostat/OECD/UNECE methodology (Annex I) and be reported to UNECE. The UNECE should maintain a common level crossing database for all UNECE members. Other countries should be encouraged to also report data to UNECE using the agreed data definitions. They should also publish the data on official websites of competent authorities.

19. The Group of Experts invites the UNECE Working Party of Transport Statistics (WP.6) to manage the common level crossing database, and to encourage those UNECE countries that may fail to do so, to collect and publish the proposed set of level crossing indicators. It recommends that the collection and publishing of data by UNECE countries should be periodically evaluated and invites WP.6 to undertake this evaluation, with the first evaluation to possibly take place in 2018.

Table 1
Indicators for assessing safety performance at level crossings

Issue	*Main indicator*		*Sub-indicator*	
Train network characteristic	1	Million train-km		
	2	1,000 line-km		
Level crossing characteristics	3	Total number of level crossings		3.1. 1,000 level crossings
	4	Passive level crossings		
	5	Active level crossings	5.1	Manual
			5.2	Automatic with user-side warning
			5.3	Automatic with user-side protection
			5.4	Rail-side protected
Type of accident	6	Total number of fatal accidents	6.1	Per 1,000 level crossings: indicator 6 per indicator 3.1
			6.2	Per million train-km: indicator 6 per indicator 1
			6.3	Per 1,000 line km: indicator 6 per indicator 2
			6.4	At passive level crossings
			6.5	At active level crossings
			6.6	At active level crossings – manual
			6.7	At active level crossings – with user side warning

Issue	*Main indicator*		*Sub-indicator*	
			6.8	At active level crossings – with user-side protection
			6.9	At active level crossings – with rail-side protection
	7	Total number of significant accidents	7.1	Per 1,000 level crossings: indicator 7 per indicator 3.1
			7.2	Per million train-km: indicator 7 per indicator 1
			7.3	Per 1,000 line km: indicator 7 per indicator 2
			7.4	At passive level crossings
			7.5	At active level crossings
			7.6	At active level crossings – manual
			7.7	At active level crossings – with user side warning
			7.8	At active level crossings – with user-side protection
			7.9	At active level crossings – with rail- side protection
	8	Total number of all railway accidents	8.1	Per 1,000 level crossings: indicator 8 per indicator 3.1
			8.2	Per million train-km: indicator 8 per indicator 1
			8.3	Per 1,000 line km: indicator 8 per indicator 2
			8.4	At passive level crossings
			8.5	At active level crossings
			8.6	At active level crossings – manual
			8.7	At active level crossings – with user side warning
			8.8	At active level crossings – with user-side protection
			8.9	At active level crossings – with rail-side protection
Fatalities	9	Total number of persons killed	9.1	Per 1,000 level crossings: indicator 9 per indicator 3.1
			9.2	Per million train-km: indicator 9 per indicator 1
			9.3	Per 1,000 line km: indicator 9 per indicator 2

Issue	*Main indicator*		*Sub-indicator*	
			9.4	Of which pedestrians
			9.5	Of which cyclists
			9.6	Of which motor-vehicle users
			9.7	Of which other level crossing users
			9.8	Of which railway passengers
			9.9	Of which railway employees
			9.10	Of which other persons (excluding trespassers)
Injuries	10	Total number of persons seriously injured	10.1	Per 1,000 level crossings: indicator 10 per indicator 3.1
			10.1	Per 1,000 level crossings: indicator 10 per indicator 3.1
			10.2	Per million train-km: indicator 10 per indicator 1
			10.3	Per 1,000 line km: indicator 10 per indicator 2
			10.4	Of which pedestrians
			10.5	Of which cyclists
			10.6	Of which motor-vehicle users
			10.7	Of which other level crossing users
			10.8	Of which railway passengers
			10.9	Of which railway employees
			10.10	Of which other persons (Excluding trespassers)

Note: Definitions of terms and their source are provided in Annex I

C. Assessment of costs of level crossing accidents

20. In conclusion, the Group of Experts noted that the assessment of costs of level crossing accidents is not undertaken in many UNECE countries. In countries where such assessment is done, it only covers a limited number of areas. Moreover, only a few of the UNECE member countries aggregate the cost data at national level.

21. At the same time, the Group of Experts acknowledged that insufficient information about the accident costs represents a limitation to making an effective judgment on public or private investment expenditures for safety at level crossings. Among others, this is due to the fact that this complete lack or insufficient information translates into a clear deficiency in attracting decision makers’ attention to the matter. Finally, it implies a reduced ability to apply risk-based decision making to safety improvements at level crossings.

Recommendations

22. The systematic quantification of the costs of level crossing accidents should be applied in all UNECE countries. The Group of Experts agrees to propose a taxonomy or categorization of accident attributable costs for assessing the costs of level crossing accidents (table 2, Annex II). UNECE members are invited to apply for every individual level crossing accident. They should also aim at establishing annual accident cost values at the national level.

23. While there are benefits from having a higher degree of disaggregation of the attributable costs (NCHRP methodology), the Group of Experts recommends giving priority to those that represent relatively high shares of cost (CSIs methodology). These costs fall under the category "primarily effect" and arise mostly from harm to people, damage to property and to operational impact. It is essential that in all instances, the costs incurred at both rail and road sides are considered.

Table 2
Taxonomy of attributable costs of level crossing accidents

Effect	*Impart*	*Cost Component (from TRB/NCHRP)*	*Cost component (from CSIs)*
Primarily	Direct	Property Damage	Cost of material damages to rolling stock or infrastructure
		Other direct costs	Cost of damage to the environment
	Indirect	Work-related productivity loss	
		Tax loss	
	Intangible	Quality of life	Economic impact of casualties
		Pain and suffering	
Secondary	Supply chain disruption	Rerouting and increased emissions	
		Freight and passenger delays and reliability	Cost of delays
		Increased inventory and its spoilage	
		Prevention	
		Lost sales	

Source: Group of Experts based on TRB/NCHRP report N. 755 and ERA Implementation Guidance on Common Safety Indicators (CSIs).

24. Where it is difficult for a country to assure regular accident cost data collection, the Group of Experts recommends to determine unit of different types of level crossing accident from a sample of accident reports and apply them for a rough estimation of annual costs of level crossing accidents.

25. The proxy costs can be also determined using methodologies such as for example Developing Harmonized European Approaches for Transport Costing and Project Assessment (see deliverable 5, Proposal for Harmonized Guidelines: http://heatco.ier.uni-stuttgart.de/). List values can be also consulted in the ERA Implementation Guidance for

CSIs available at http://www.era.europa.eu/Document-Register/Documents/ERA%20Guidance_for_Use_of_CSIs_ERA-GUI-02-2015.pdf.

D. Prevailing legislation for ensuring safety at level crossings

26. In conclusion, the Group of Experts found that countries appear to have in place legislative framework for design, operation and management of level crossings. At the same time, the Group believes that the legislative solutions chosen may not be always the most effective ones. For example, addressing conflicting interest of road and rail users at level crossings may not be effectively done if by law only one - rail or road - party is responsible for managing safety at level crossings.

27. The Group noted that only few responding countries have legal provisions in place which enable to claim reimbursement of costs incurred in level crossing accidents.

28. The Group also concluded that it is for the internal operational rules, standards and procedures, rather than for the international legal framework, to govern the protection at different types of level crossings that is matching the in situ conditions with the type of level crossings.

29. With regard to the signs and signals, the Group of Experts believed that the symbol used to indicate “gates” in sign A, 25 a is not recognized as indicating the approach to gate (barrier) while the symbol to indicate “no gates” in signs A, 26 which uses an old fashioned symbol of a steam locomotive may also not be well recognized. The Group noted, however, that the 1968 Convention on Road Signs and Signals (Article 8, para.1) allows modifications of the prescribed symbols (where necessary) as long these modifications do not alter the symbol’s “essential characteristics”. As such, the Convention provides a certain built-in degree of flexibility without the necessity of formal amendment.

30. The Group also concluded that the international conventions are lacking important provisions to instruct necessary user behavior. The Group believed that an international sign is needed introducing the obligation for road drivers to break down the barriers when trapped at a level crossing. Also, international rules are needed prescribing the use of level crossings by vulnerable road users such as cyclists and pedestrians. There is also a need for guidance for road traffic calming and road traffic signage systems at passive and open level crossings. Such systems should slow down road traffic, focus drivers' attention on the railway hazard ahead, encourage them to stop and look both ways before crossing.

Recommendations

31. The Group of Experts agrees that countries should learn from each other and consider solutions implemented in other countries. To this end, the Group of Experts recommends that countries should consider assigning responsibilities for managing safety al level crossing to both road and rail parties and other relevant parties, as well as endeavor to establish high level of cooperation and coordination between them, if not done so yet. Countries that have not put in place legislation allowing claims for reimbursement of costs from accidents should consider solutions from countries having implemented such legislation.

32. The Group of Experts also recommends that internal operational rules, standards and procedures should govern the protection of different types of level crossings. The Group recommends that the decision on the protection level should be a function of a risk analysis and available resources and that it should be the domain of infrastructure managers.

33. With regard to the international legal frameworks for level crossings, the Group of Experts recommends that the international convention should be scrutinized to understand whether provisions pertaining to horizontal marking, signaling and signage are sufficient, complete and effective or whether they should be improved. The Group of Experts, as minimum, recommends that a sign for breaking gates when trapped between them should be introduced into the 1968 Convention on Road Sign and Signals.

E. Use of management techniques including risk management to prevent unsafe conditions at level crossings

34. The Group of Experts appreciated the application of risk management for level crossings in a number of countries. The Group believed that a systematic evaluation of risks and improvement of safety by eliminating the highest risk can deliver best results. At the same time, the Group of Experts noted challenges preventing countries from applying risk management for level crossings, among them incomplete or unknown data sets around level crossings, lack of consistent validation procedures, general knowledge gaps, for example, on including user behavioral aspects into risk evaluation formulas.

Recommendations

35. The Group of Experts agrees that exchange between countries on the application of risk management for level crossings should intensify and experience and good practice should be shared.

36. The Group recommends that consistent risk validation procedures and risk assessment methodologies be developed at international level to facilitate future national implementation.

37. The Group of Experts also recommends that standardized training and competence for staff involved in the risk management for level crossing is developed at international level.

F. Use of enforcement to prevent unsafe conditions at level crossings

38. The Group of Experts has found that countries have created laws on the road user behaviour at level crossings, in particular regulations prescribing the necessary behaviour for drivers of motor vehicles. In many countries the regulations also cover pedestrian obligations at public level crossings. The legislation that governs private level crossings has been found inconsistent and fragmented.

39. The Group of Experts underlined that most countries rely entirely on police for detection of violations at level crossings. Technology to support enforcement is new and emerging. It is not used to the extent it could be used anywhere at this time. Even in the countries that have access to detection technology, infrastructure managers still rely mainly on police for detection. Inevitably, the police cannot provide sufficient enforcement coverage and therefore users know that violations at level crossings have low probability of being detected and result in punishment. Technology however offers a potential solution to this problem. It could provide a wide-scale permanent and consistent detection coverage.

40. At the same time, the Group of Experts acknowledged the fact that there has been very little analysis and evaluation carried out into the effect of enforcement technology on user behaviour (except in France). Such analysis is needed in order to define how much risk

reduction enforcement can achieve – availability of cameras to deter users from violations at level crossings – and how it can be optimized. This is necessary in order to provide the basis for the safety case/business case for member countries investing in camera detection technology. This will inform whether there is a true potential for a wider application of technology throughout countries.

Recommendations

41. The Group of Experts agrees that countries should learn from each other and consider solutions implemented in other countries. In this context, the Group of Experts recommends to countries lacking regulatory framework for private level crossings to optimize it based on existing good practices including by increasing enforcement powers for infrastructure managers.

42. As far as the roll out of violation detection technology is concerned, the Group of Experts agrees that more assessment of the effect of enforcement technology on user behavior is needed. To this end, the Group of Experts recommends countries carry out a joint project that would evaluate the effects of violation detection technology on user behavior. Such a project should include before/after benchmarking exercises to quantify whether violations and risk are reduced once detection technology has been installed at level crossings, if so by how much, and whether it has a beneficial effect in long term.

43. For countries interested in pursuing development of violation detection technology, the Group of Experts recommends that infrastructure managers work closely with ministries of the interior (or other competent authorities) on developing video system of facial recognition linked with databases of identity cards. Such technology would identify pedestrians or cyclists when violating level crossing rules. They could further develop a detection system for identification of road vehicles by their number plates when their drivers violate level crossing rules.

44. The Group of Experts further recommends that national partnerships between the railway infrastructure manager, police authorities and insurance companies are established with the aim to offer violation prevention training for users having committed them. Such training should be made compulsory supplementing any punitive measures foreseen by the national legislation.

45. As far as pedestrians or cyclists are concerned, the Group of Experts recommends that national legislation establishes to impose punitive measures on their violations of level crossing rules on par with those imposed on motor-vehicles users.

G. Education for preventing unsafe conditions at level crossings

46. The Group of Experts agreed that sensitizing the general public as well as specific user groups about dangers of level crossings is important. At the same time, the Group believes that a better safety impact is achieved when education tools are targeted to specific users. The Group also agrees that more research is needed to better understand the safety impacts through education.

Recommendations

47. The Group of Experts recommends that railway and road managers as well as other relevant authorities work together at a national level to develop targeted level crossing safety campaigns and education programmes, including for children of school age, specific

user groups such as e.g. corporate users. In this regard, the national authorities should develop a broad range of tools such as digital tools, site visits and peer-to-peer learning. They should also work closely with their counterparts from other countries to exchange experience, knowledge and lessons learned in developing level crossing safety campaigns as well as specific education programmes. An establishment of an international forum for sharing good educational practice would be very helpful.

48. The Group of Expert also recommends to introduce specific training modules on the safe use of level crossing to be part of curriculum during training for driving permits and, to this end, establish partnerships with driving schools.

49. The Group of Experts further recommends to develop methods of measuring the effectiveness of educational tools, campaigns and programmes. The methods of measurement could be discussed and possibly refined in an international forum.

H. Analysis of human factors to prevent unsafe conditions at level crossings

50. The Group of Experts found that there seems to be little experience and good practice in UNECE members in terms of addressing specific causative human factors. It was further noted that none of the existing solutions and tools are knowledge or research based. They are usually technology focused and implemented based on a trial-and-error method and often do not consider road user behaviour in a sufficient manner. Furthermore, the effectiveness of such measures is usually not evaluated. The experts also believe that a distinction of different user groups (motorized road users, bicyclists, pedestrians) is essential to identify most suitable measures. Campaigns to raise awareness are found to have limited effect if of general nature rather than being dedicated to specific accident causative human factors at level crossings.

Recommendations

51. The Group of Experts agrees that human factors must be identified as a major issue in improving level crossing safety.

52. The Group of Experts also agrees that assessment and solutions to human factors issues are essential. Human factors which cause or contribute to accidents must be put at the heart of actions for improving safety at level crossings. To this end, the Group of Experts invites countries to engage in an in-depth analysis of human factors so that human factor founded solutions are worked out, tested and evaluated, including those necessary for the design of safe level crossings. In this context, the Group of Experts recommends that countries carry out a joint project that would lead to the development of a standardized toolbox for human factors analysis at level crossings. Such a toolbox should standardize the assessment of level crossing accidents in terms of human factors. Above all, the investigation of causative human factors should be mandatory for accident investigation bodies and be supported with human factors templates for accident analyses to enable adequate conclusions and derive appropriate countermeasures. The Group of Experts encourages countries to include such a standardized human-factors analysis tool to the accident investigation reports.

53. The Group of Experts also invites countries to strengthen the expertise on human factors, in particular on investigation analysis as well as on research for low cost solutions for addressing human factors. It recommends to distinguish between the level crossing users in a proper manner and to consider the different characteristic features of each user group. It recommends focusing on empirically founded human factors when developing

technological solutions for improving safety at level crossings and to share good knowledge and good practice. It suggests establishing solution evaluation criteria to understand if improvements to safety have been achieved.

54. The Group of Experts recommends that an international database be developed containing excerpts from investigation reports, in particular, on human factors analyses. This can support the research for lost cost human factors solutions. Such a database could be managed by a level crossing international forum.

I. Level crossing infrastructure and technology to prevent unsafe conditions at level crossings

55. Despite emergence of new technological solutions, the Group of Experts agreed that the look and feel of level crossings has not changed much in the last few decades. The life-costs of active protection layouts and of the technological solutions are often too high to be widely applied, especially at low risk active or passive level crossings. Moreover, the prevailing technological solutions are applied at rail side while there are is comparably little done regarding road side technological solutions.

Box 1: Lifetime costs of level crossings

Overhead costs:
- Administration, procurement, regulatory framework;
- General planning (keep the crossing, increase the protection, remove the crossing);
- Customer Service (Error reports, press, education, enforcement).

Cost of increasing protection, improving a level crossing, or removing it:
- Design work (road design, signaling);
- Land purchase;
- Components (signal components, road surface slabs);
- Land construction (road construction work, ducting, raising poles, barriers, fences);
- Install (or remove) signaling system;
- Inspection (road, signaling) and approval process.

Costs of level crossing usage:
- Maintenance (Inspections, preventive maintenance, corrective maintenance);
- Simple modification (e.g. Add an extra signal including inspection and approval);
- Software upgrading.

56. The cost and time required to develop and approve new technological solutions that meet industry standards and achieve the safety integrity levels often required, means a strong business case is necessary for most responsible authorities to justify and authorize such investment. This is a constant challenge in the development of technological solutions for pedestrians and other users of level crossings and is why the methods used to detect trains and provide the audible or visual outputs are still fairly traditional and primarily designed for road vehicle drivers.

57. Safety cases and the high levels of safety required add a level of cost that often means the ideal of a low cost solution suitable for many different types of crossing, with lower levels of risk and usage is unachievable. This creates a real difference in the

application of technology and a stark contrast to crossings used by vehicles and to those used only by pedestrians, which often rely only on the pedestrian using their own sensory perception to detect trains and to decide if it is safe to cross.

58. The increased demand for rail means that many networks face the same challenges of increasing capacity and adding to the timetable and improving journey times for commuters and passengers. This often requires more trains and or faster trains. Enhancements to infrastructure have to properly consider the impact on level crossing users and particularly the most vulnerable user groups who may be using unprotected passive crossings on relatively high speed lines with high numbers of trains and users without any technology to assist them.

59. For crossings used by road vehicles, additional challenge is to reduce road congestion and pollution as well as to reduce journey times and meet the increased demand at both the road and rail sides. Currently, more trains will often mean longer waiting times and longer road closer times. This creates a significant issue and one where technology is required.

60 Investment in technology to enable road vehicle drivers is far in advance of some of the infrastructure that will be used by the likes of autonomous and connected vehicles. Intelligent infrastructure is being developed but not at locations where road and rail meet.

61. Similar to the historical separate evolution of road and rail networks in many countries, the rate and pace of change on the road side is far in advance of parts of the road rail network that it will use.

62. The opportunity to plan how level crossings and their users can better use technology now and in the future is something that should be taken advantage of and considered as part of a more rounded approach to transport networks.

Recommendations

63. The Group of Experts agrees that the technology for road-rail interface does not seem to be advancing at the satisfactory pace, especially for low cost technological solutions that would be also suitable for passive level crossings. To change this situation, the Group of Expert believes that a joint vision of what future technology may look like and a supporting implementation road map may help change this unsatisfactory situation.

64. The Group of Experts invites countries to establish a joint, long term vision and a supporting roadmap for technology development for level crossings. It recommends countries to collaborate on implementing the roadmap once established and, to that end, to undertake multinational technology development projects that would encompass solution development, testing, evaluation and approvals.

65. The Group of Experts also recommends that railway and road managers work together to establish benchmarks for developing innovative level crossing solutions and new concepts for level crossing infrastructure design, among them, low costs solutions specifically for pedestrian crossings, as well as solutions aimed at more automated vehicles, allowing a future computer driver to use level crossing in a safe way.

66. For any new solution, the Group of Experts recommends developing evaluation criteria for assessing the effectiveness of the solution. Such criteria should allow to specifically establish the level of improvement achieved (safety level before and after implementation) and its long term benefits.

Part two
Strategic framework for improving safety at level crossings

I. Background

67. Despite efforts to make intersections between road and railway tracks safer, accidents at level crossing continue. These accidents—while not numerous—usually have grave consequences. The risk of dying or being severely injured as a result of an accident at a level crossing is several times higher than in a road traffic accident. Even if fatalities or serious injuries do not occur, bills to pay for repairs to infrastructure and foregone revenues due to disruption and delays of services are significant.

II. A Vision for Governments

68. An accident at level crossings is very likely to have severe consequences. As there are only minimal chances for a road user to survive such an accident or not to be seriously injured in it, any accident at level crossing is one accident too many.

69. Governments should thus, seek to prevent accidents at level crossings by striving to achieve 'vision zero' – zero accidents: no loss of life, no serious injuries, and also no infrastructure damage, no revenue loss, and no disruptions or delays.

III. Strategic framework

70. Governments should engage in achieving the 'vision zero' by implementing a safe system approach for level crossings. This requires various institutions at a national level – those responsible for road user education and training, enforcement of rules, level crossing design and operations – to engage with each other to undertake coordinated actions in a systematic manner to enhance safety at level crossings. The objective should be to deliver appropriate road user specific education, training and enforcement solutions and introduce appropriate level crossing specific engineering solutions. The objective should also be to reduce the number of level crossings.

A. A systems approach

71. In many safety critical domains, safety has been improved by the application of contemporary human error models and management methods. In road safety, however, the common strategic approach has mainly been built on the view that individual road users are solely responsible when crashes occur and countermeasures have consequently been aimed at changing the behaviour of the road user. This approach is however slowly shifting and there is a growing understanding that the strategies must be based on human factors principles.

72. The human factors discipline treats human error as a systems failure, rather than solely an individual's failure. It considers the interactions among humans and between humans and technology within a system. It considers the presence of system wide latent conditions and their role in shaping the context in which operators make errors. Therefore, human errors are no longer seen as the primary cause of accidents. Instead, they are considered as a consequence of latent failures created by decisions and actions within the broader organizational, social or political system in which processes or operations take place (e.g. government, local authorities, organizations/companies and their different

management levels). The systems approach appears to be dominant in many safety critical domains where it is often denoted as Human Factors or Man, Technology and Organization.

73. Accidents occur when components of a system interact with each other and these interactions are not possible to predict because of their complexity. Therefore, systems theory provides the theoretical foundation for systems engineering, which views each system as an integrated whole even if it is composed of diverse individual and specialized components.

74. The optimization of individual components or subsystems in a systems theory, in general, will not lead to a system optimum. Improvement of a particular subsystem may in fact worsen the overall system performance because of complex, non-linear actions among the components.

B. The level crossing as a complex socio-technical system

75. Analyses of the road system from a complexity point of view have concluded that roads were complex in nature due to the diverse physical elements such as road users, vehicles and infrastructure components, and the many interactions between road users and vehicles and between vehicles and infrastructure. The randomness of interactions between components within the system is evident, even with the presence of road rules. Finally, the road system is open to the environment, and is largely subject to road user behaviour, which can be highly variable. The influence of the rail environment provides further complexity, both in relation to the interactions between the physical components, and in terms of the coordination required of various organizations to manage the risks to safety at these specific intersections.

C. Safe System Approach

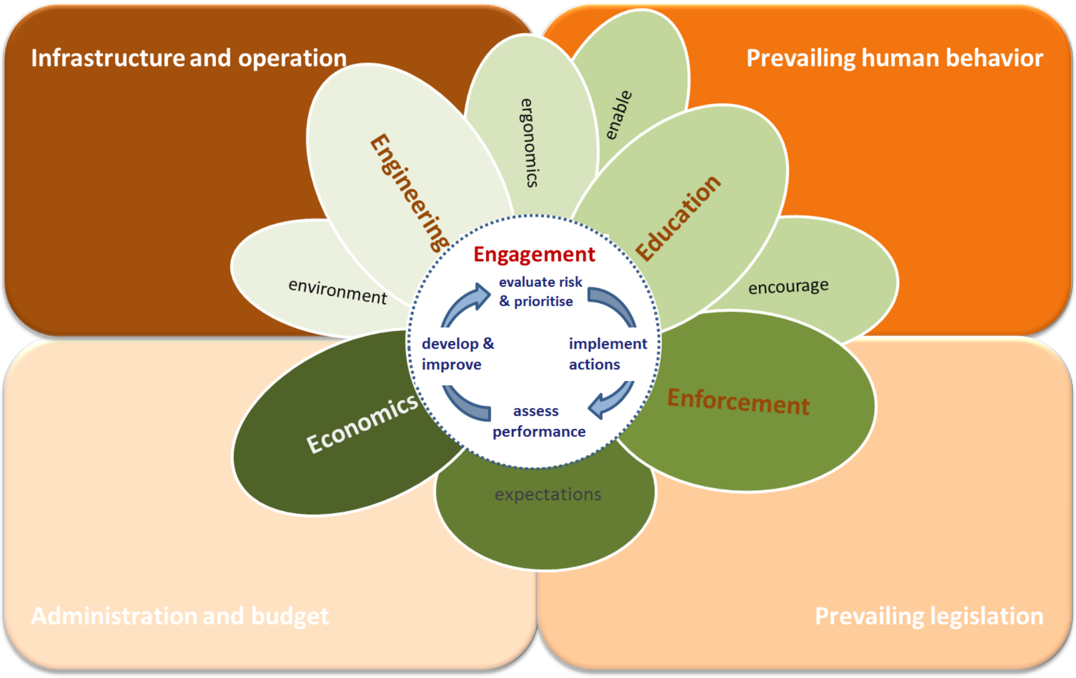
76. A Safe System is a pro-active, forward-looking approach to road safety that constitutes a departure from traditional ways of addressing safety on roads and hence at level crossings. The Safe System principles acknowledge that people make mistakes in traffic and there are known limits to the capacity of the human body to absorb kinetic energy before harm occurs.

77. The Safe System requires understanding and managing the complex and dynamic interaction between operating speeds, vehicles, road infrastructure and road user behaviour in a holistic way. The aim is to link the sum of the individual components of the system with each other for a greater overall safety effect in which other components are to prevent serious injuries even when one of the components has failed.

78. In a Safe System, road users bear the responsibility to obey traffic rules and they are expected to use roads with due care for safety. Those responsible for designing, building and operating the road system (the “system designers”) bear responsibility to ensure it encourages and supports safe use, addresses inherent safety risks, anticipates errors that users will make and ensure they do not result in serious harm. A safe and sustainable speed management and limits system that safely manages the interaction between vehicles, users and road infrastructure is a key feature of a Safe System.

79. Within this Safe System, a specific Safe System Approach for level crossings is defined to help enhance the safety performance at level crossings.

Figure 12
Safety System Approach



Source: UNECE secretariat based on a scheme from Ireland's Commission for Railway Regulation.

80. The Safe System Approach addresses three action spaces for improving safety at level crossings:

Figure 13
Safety System Approach, Action Spaces

Source: UNECE secretariat based on scheme from Ireland's Commission for Railway Regulation.

81. **Engineering** – includes actions to implement a known engineering solution at a specific level crossing, or to undertake a research project aimed at working out new solutions for a specific type of level crossing. This can also include any relevant legislative or administrative intervention needed for an effective implementation of engineering solutions.

82 The engineering solution should **enable** the safe use of the level crossing by taking account of the physical **environment** of the level crossing and the prevailing human behaviour at the level crossing by applying **ergonomics** i.e. understanding how engineering may be deployed within the environment in a way that takes account of and positively influences user behaviour, thereby reducing the risk of human error.

83. The engineering solutions may be applicable to rail or road infrastructure or to vehicles and their operation. The elimination of a level crossing by installing a grade separated passage or roadway or merging passive level crossings to an active one are also an engineering solution.

84. **Education** – includes actions to conduct training based on existing training material, or to design and conduct tailored-made training for addressing a behavioural aspect of a specific group of users, including users of a particular level crossing.

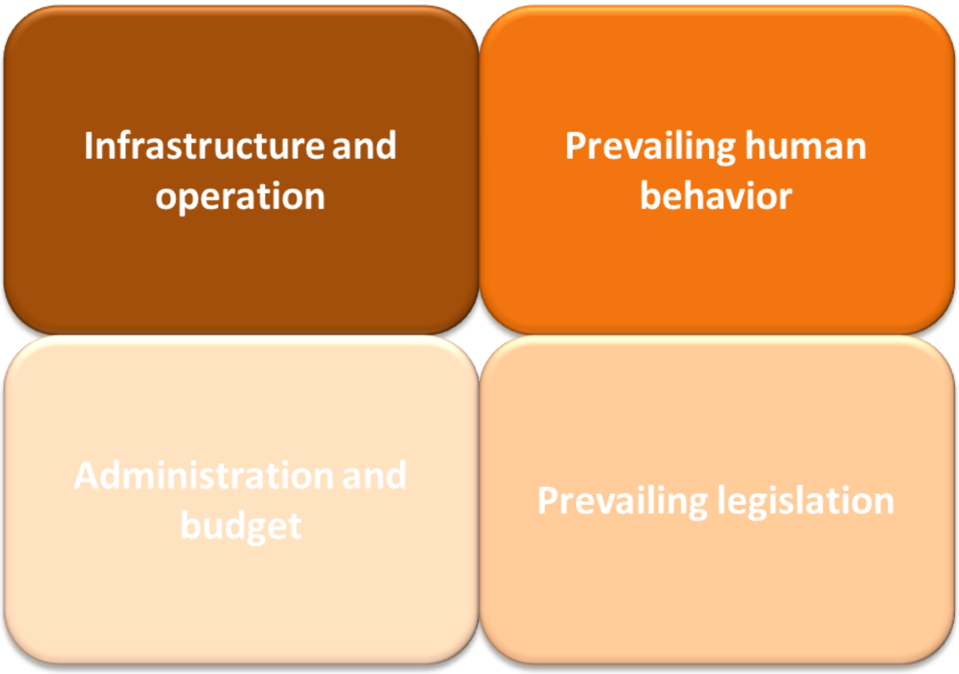
85. It may also include more general periodic intervention aimed at awareness raising about the consequences of incorrect behaviour at level crossings and thereby **encourage** users to act safely at level crossings. Any legislative or administrative intervention aimed at improving training implementation can also belong to this space.

86. **Enforcement** – includes actions to discourage unsafe behaviour while recognising the reasons for this unsafe behaviour, and developing complementary approaches to **encourage** safe behaviour and address underlying risk at problematic level crossings. Legislative and administrative interventions to enhance enforcement are also included.

87. The Safe System Approach incorporates a model of **economics** that determines the necessary budget to implement specific prioritized action in any of the three action spaces. The economics is related to socio-political **expectations**, i.e. the public demand for improvement in safety performance at level crossings, including intervention to address legislative, administrative and efficiency gaps. Depending on nature of the legislative, administrative or efficiency gaps, relevant intervention is implemented through engineering, education or enforcement action space.

88. The Safe System Approach also incorporates risk management to determine needful and prioritized action. In the Safe System Approach, risk management is by assesses the risk factors in four areas:

Figure 14
Safety System Approach, Risk Areas



Source: UNECE secretariat based on a scheme from Ireland's Commission for Railway Regulation.

89**.** **Infrastructure and operations** – includes assessment of probability of occurrence of an event at a level crossing, such as infrastructure failure, operational error, or road user error or violation due to elements of the infrastructure or operation at a level crossing. Examples of infrastructure elements include road design features at the approach and exit of level crossing, signage, number of tracks, type of protection, and lateral views at the crossing. Examples of operational elements would include train frequency, road traffic frequency, train speed, road traffic speed.

90. **Prevailing human behaviour** – includes assessment of the probability of occurrence of events related to road users making errors or committing intentional violations in the context of waiting times, prevailing traffic culture, social norms and pressures, and related levels of receptivity to distraction or appetite for risk. Preferably such assessment is done for various types of level crossing users, characterized by their mental concentration, motivation or performance as well as taking into account their frequency of use.

91. **Prevailing legislation** – includes assessment of the prevalence of road user errors or intentional violations in the context of current legislation. For example, (i) the effectiveness of signage and protection at a level crossing in preventing road user error, and (ii) the effectiveness of punitive measures for misuse of level crossings on the road user's appetite for risk.

92. **Administration and budget** – includes assessment of the prevalence of harmful occurrences in the context of interagency cooperation, agencies' engagement and expertise, investment in infrastructure and the resulting degree of implementation of safety improvements.

93. Risk management includes assessment of potential consequences of an accident. Preferably such assessment should determine expected loss (loss of life, injury, infrastructure damage and loss of revenue due to disruptions or delays) due to accident in monetary terms.

94. The Safe System Approach prioritizes action for level crossings based on the likelihood for an accident to occur and the potential consequences. The assessment of risk factors shows the type of action needed, i.e. whether the action should be provided in the space of engineering, education or enforcement. It further shows whether the action should be specific to a particular level crossing or type of level crossing, or aimed at all users or a specific group of road users.

IV. Implementation of the Safe System Approach

95. The national implementation of the Safe System Approach requires continuous engagement of the relevant authorities. They should implement the Safe System Approach in project cycles that encompass:

(a) Government initiated engagement with road and rail authorities in active consultation with the persons tasked with implementation, to formally agree on the objectives, secure a budget for the project cycle, and regularly report back on progress of implementation.

(b) Risk management of level crossings and users: Plan-Do-Check-Act [8], continuous improvement process

(i) Plan: evaluate risk and prioritize corrective actions;

(ii) Do: implement corrective actions per available budget;

(iii) Check: assess and review performance;

(iv) Act: research, develop and implement improvements.

[8] Citation: ISO 9001:2015

Figure 15
Safe System Approach, Engagement and Continual Improvement steps

Source: UNECE secretariat based on a scheme from Ireland's Commission for Railway Regulation.

96. The project cycles should be of fixed duration.

97. The first project cycle needs to include the development of a level crossing inventory that is fit for the risk assessment purpose. The subsequent cycles may include changes in inventory as a result of the implementation of corrective action at level crossings.

98. Each project cycle may also incorporate improvements to risk assessment by refining and recalibrating the risk assessment models based on real accident data and findings from accident investigation or from 'near-miss' reporting.

99. The implementation of the Safe System Approach can be more effective if done through an action plan assigning clear implementation responsibilities. Its implementation can be further supported by international cooperation, delivered through a plan for international action.

V. Recommended international actions in support of national implementation of the Safe System Approach

100. There are three actions recommended for implementation at international level:

(a) Establishment of an international working group on safety at level crossings,

(b) Creation of an international online database on level crossing, and

(c) Creation of an international online database on lessons learned from accidents investigations

A. Establishment of an international working group on safety at level crossings

101. The international working group on safety at level crossings (a “forum for safer level crossings”) could offer a platform for exchange of experience and good practices in:

(a) Applying risk management,

(b) Understanding the effectiveness of various solutions in spaces of engineering, education and enforcement,

(c) Standardizing training and competence for staff involved in the management of risk and safety at level crossing,

(d) Developing a methodological harmonized basis for risk assessment in the context of the Safe System Approach,

(e) Improving methods for estimating the losses of level crossing accidents in monetary terms,

(f) Designing and implementing qualitative assessment for benchmarking the condition of assets, usability and providing a more comprehensive way of measuring and evaluating the management of level crossings; and

(g) Developing a standardized toolbox for human factors analysis to be used in national accident investigation reports.

102. It could also provide a platform for identifying joint research or analytical projects in search for better safety solutions as well as assess the level of implementation of the recommendations formulated in this report.

103. Its terms of reference should ensure that it has no overlapping functions with already existing international groups or intergovernmental bodies.

104. The Group of Experts recommended in part I of the report that countries should be exchanging experience and good practice, and join forces for implementing research projects (new engineering solution, better understating of human factors,) and to develop supportive tool boxes and other material. Doing so, through participation in a formal body focused on delivery of products, may be an effective way of international cooperation. The Group of Experts also believes that improvements to safety performance can be achieved through the implementation of the Group’s numerous recommendations and the application of the level crossing Safe System Approach. Assessment of and support to implementation by an international group can make the safety improvement process more effective.

B. Creation of an international online database on level crossing

105. The Group of Experts recommended a set of level crossing core safety indicators to be collected and published by all UNECE members and other countries so that:

(a) International comparison and benchmarking of level crossings safety could be made; and

(b) International data be available for testing and calibrating risk management models.

106. The Group of Experts recommended that level crossing safety indicators are collected and managed by UNECE within its activities falling under the Working Party on Transport Statistics (WP.6).

C. Creation of an international online database on lessons learned from accidents investigations

107. The Group of Experts recommended the creation of a database to document lessons learned from accident investigations published by UNECE countries so that:

(a) International comparison and benchmarking of lessons could be made, and

(b) International data be available to generate common solutions for enhancing safety at level crossings.

108. According to the Group of Experts, this database is not a simple a collection of investigation reports, but should contain selections of analyses from the reports considered crucial for designing solutions for enhancing level crossing safety. Such a database could be managed by the international working group for level crossings (see point A of this plan of action).

VI. Recommended national actions for implementation of Safe System Approach for level crossings

109. There are four actions recommended for implementation at national level:

(a) Government engagement and commitment for 'vision zero',

(b) Creation of a national working group/task force to apply the Safe System Approach,

(c) Establishment of national (online) database on level crossing, and

(d) Establishment of national (online) database on lessons learned from accident investigations.

A. Government engagement and commitment for 'vision zero'

110. The Government should engage competent authorities to implement the Safe System Approach for level crossings and through it achieve the 'vision zero'. The Government should also ensure the provision of financial resources necessary for the implementation of the Safe System Approach.

B. Creation of a national working group/task force to apply the Safe System Approach

111. The national working group/task force to apply the Safe System Approach should be convened by the governmental ministry in charge of roads and railways, and should typically comprise of the following institutions:

(a) Railway infrastructure managers;

(b) National safety authority for railways;

(c) National safety advisory authority for roads;

(d) National road traffic enforcement authority, and

(e) Experts.

112. Apart from the above institutions, the following should be consulted parties:

(a) Railway undertakings;

(b) Road infrastructure managers;

(c) Road public transport organizations;

(d) Trucking representative organizations;

(e) Farming representative organizations.

113. The Group should assume the following tasks:

(a) Establishment and management of a level crossing inventory;

(b) Specification of elements for risk assessment and future refinement;

(c) Distribution of responsibilities for risk assessment in the areas of:

(i) infrastructure and operations;

(ii) prevailing human behaviour;

(iii) prevailing legislation; and

(iv) administration and budget.

(d) Distribution of responsibilities for action implementation including securing of budget;

(e) Joint assessment of impact of implemented actions,

(f) Participation in an international working group to share national experience and learn from others;

(g) Participation in international research projects; and

(h) Reporting to government on progress achieved.

C. Establishment of national (online) database on level crossing

114 The database on level crossing should be established and contain, as minimum, the data as per the set of level crossing indicators recommended by the Group of Experts.

D. Establishment of national (online) database on lessons learned from accident investigations

115. The database on lessons learned from accident investigations should be established to offer a source of information for working out analysis-founded solutions for enhancing safety at level crossings.

Annex I

Definitions of terms and their sources used in indicators for assessing safety performance at level crossings

Accidents at level crossings and their outcomes (Common Glossary of transport statistics)[9]

Accident (railway) [A.VII-01]

Unwanted or unintended sudden event or a specific chain of such events which have harmful consequences. Railway accidents are accidents in which at least one moving rail vehicle is involved.

Level crossing accidents [A.VII-13]

Any accident at level crossings involving at least one railway vehicle and one or more crossing vehicles, other users of the road such as pedestrians or other objects temporarily present at or near the track.

Fatal accident [B.VII-02]

Any injury accident resulting in a person killed.

Person killed [A.VII-09, B.VII-05]

Any person killed immediately or dying within 30 days as a result of an (injury) accident, excluding suicides.

Person seriously injured [A.VII-10, A.VII-6]

Person seriously injured.

Any person injured who was hospitalised for more than 24 hours as a result of an accident.

Level crossing users [A.VII-16]

Persons using a level crossing to cross the railway line by any mean of transportation or by foot.

(Bi) cycle [B.II.A-05]

A road vehicle which has two or more wheels and generally is propelled solely by the muscular energy of the persons on that vehicle, in particular by means of a pedal system, lever or handle (e.g. bicycles, tricycles, quadricycles and invalid carriages).

Road motor vehicle [B.II.A-06]

A road vehicle fitted with an engine whence it derives its sole means of propulsion, which is normally used for carrying persons or goods or for drawing, on the road, vehicles used for the carriage of persons or goods.

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[9] Illustrated common glossary for transport statistics (UNECE, OECD, Eurostat) http://www.unece.org/fileadmin/DAM/trans/main/wp6/pdfdocs/glossen4.pdf.

Convention on Road Signs and Signals, of 1968 (Vienna Convention)

Motor vehicle [Article 1 (n)]

Any power-driven vehicle which is normally used for carrying persons or goods by road or for drawing on the road, vehicles used for the carriage of persons or goods. This term embraces trolley-buses, that is to say, vehicles connected to an electric conductor and not rail-borne. It does not cover vehicles, such as agricultural tractors, which are only incidentally used for carrying persons or goods by road or for drawing, on the road, vehicles used for the carriage of persons or goods.

EU Commission Directive 2014/88/EU - Appendix to Annex I – Common definitions for CSIs

Indicators relating to accidents

Significant accident [Item 1.1]

Any accident involving at least one rail vehicle in motion, resulting in at least one killed or seriously injured person, or in significant damage to stock, track, other installations or environment, or extensive disruptions to traffic, excluding accidents in workshops, warehouses and depots.

Train [Item 1.4]

means one or more railway vehicles hauled by one or more locomotives or railcars, or one railcar travelling alone, running under a given number or specific designation from an initial fixed point to a terminal fixed point, including a light engine, i.e. a locomotive travelling on its own.

Indicators relating to technical safety of infrastructure

Level crossing [Item 6.3]

Any level intersection between a road or passage and a railway, as recognised by the infrastructure manager and open to public or private users. Passages between platforms within stations are excluded, as well as passages over tracks for the sole use of employees[10].

Road [Item 6.4]

For the purpose of Rail Accidents Statistics, means any public or private road, street or highway, including footpaths and bicycle lane.

Passage [Item 6.5]

Any route, other than a road, provided for the passage of people, animals, vehicles or machinery.

[10] CSI definition of ‘level crossing’ includes a ‘passage’, so it is more universal than the Eurostat definition.

Passive level crossing [Item 6.6]

A level crossing without any form of warning system or protection activated when it is unsafe for the user to traverse the crossing.

Active level crossing [Item 6.7]

A level crossing where the crossing users are protected from or warned of the approaching train by devices activated when it is unsafe for the user to traverse the crossing.

Protection by the use of physical devices includes:

- half or full barriers;
- gates.

Warning by the use of fixed equipment at level crossings includes:

- visible devices: lights;
- audible devices: bells, horns, klaxons, etc.

Active level crossings are classified as:

(a) **Manual:** a level crossing where user-side protection or warning is manually activated by a railway employee;

(b) **Automatic with user-side warning**: a level crossing where user-side warning is activated by the approaching train;

(c) **Automatic with user-side protection**: a level crossing where user-side protection is activated by the approaching train. This shall include a level crossing with both user-side protection and warning;

(d) **Rail-side protected**: a level crossing where a signal or other train protection system permits a train to proceed once the level crossing is fully user-side protected and is free from incursion.

Definitions of the scaling bases

"**train-km**" **[Item 7.1]**

The unit of measure representing the movement of a train over one kilometre. The distance used is the distance actually run, if available, otherwise the standard network distance between the origin and destination shall be used. Only the distance on the national territory of the reporting country shall be taken into account.

"**line-km" [Item 7.3]**

The length measured in kilometres of the railway network. For multiple-track railway lines, only the distance between origin and destination is to be counted.

"track-km" [Item 7.4]

The length measured in kilometres of the railway network. Each track of a multiple-track railway line is to be counted.

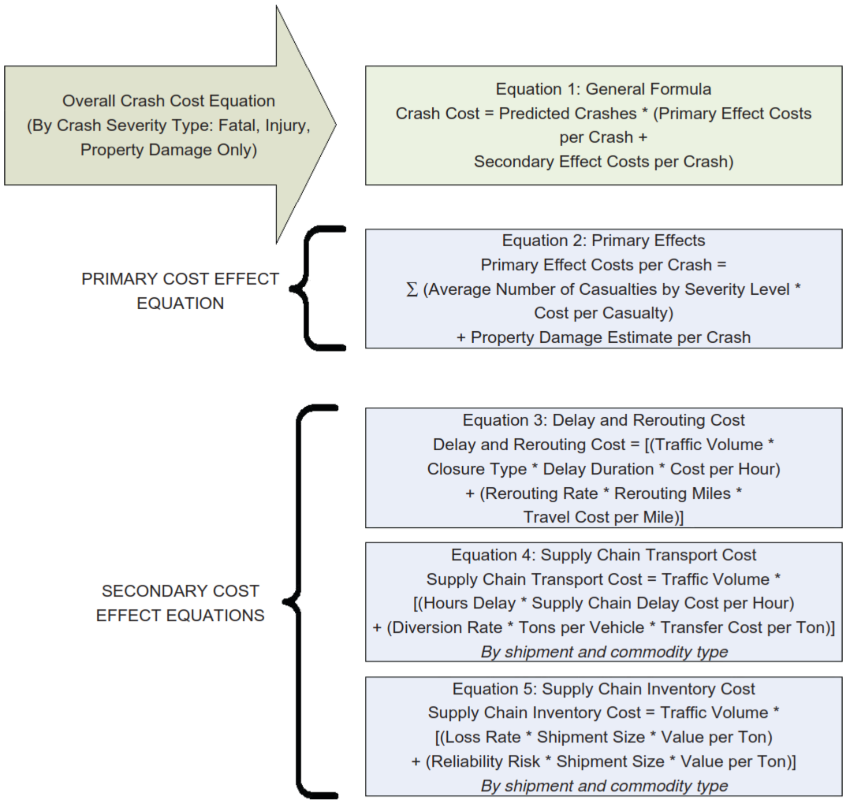
Annex II

Recommend methodology to estimate costs of accidents at level crossings

1. The recommended methodologies provide a high level framework for the categorization of different types of costs. In both methodologies, cost categories can be itemized by effect and impact. Primary effects occur at the crash site and include casualties (with related costs) and property damage (to highway vehicles, railroad equipment, and infrastructure). Secondary effects are associated with supply chain and business disruptions. The NCHRP methodology can also include effects associated with rare catastrophic crashes. Impact describes how each cost component affects society (i.e., directly, indirectly, or intangibly); the process through which the impact is perceived (e.g., through business supply chain disruption); or—in the case of rare catastrophic events— it may describe the approaches taken to evaluate the cost.

2. For the NCHRP methodology, both the indirect and intangible costs are captured in the Willingness-To-Pay measures for loss of life and injury. The methodology is supported by a system of equations that practitioners can use to estimate the costs of different types of level crossings accidents. These equations are presented in figure xx. Further details can be found in NCHRP 755 report: Comprehensive Costs of Highway-Rail Grade Crossing Crashes to be consulted at: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_755.pdf

Figure 1
Equations for estimating costs of different types of level crossings accidents



Source: NCHRP 755 report: Comprehensive Costs of Highway-Rail Grade Crossing Crashes.

3. The ERA CSIs methodology in support of implementation the European Commission Directive 2014/88/EU can be used to calculate four cost components reported under CSIs. The methodology can be consulted at http://www.era.europa.eu/Document-Register/Documents/ERA%20Guidance_for_Use_of_CSIs_ERA-GUI-02-2015.pdf.

4. The value of preventing a casualty should be established by either Willingness-To-Pay or Human Capital/Lost Output approaches. It is essential to consider not only fatal injuries, but also serious (or even minor injuries) in this statistical life valuation exercise.

Annex III

[English only]

Assessment of key factors contributing to unsafe condition at level crossings in UNECE member countries and other selected countries

I. Data on safety at level crossings

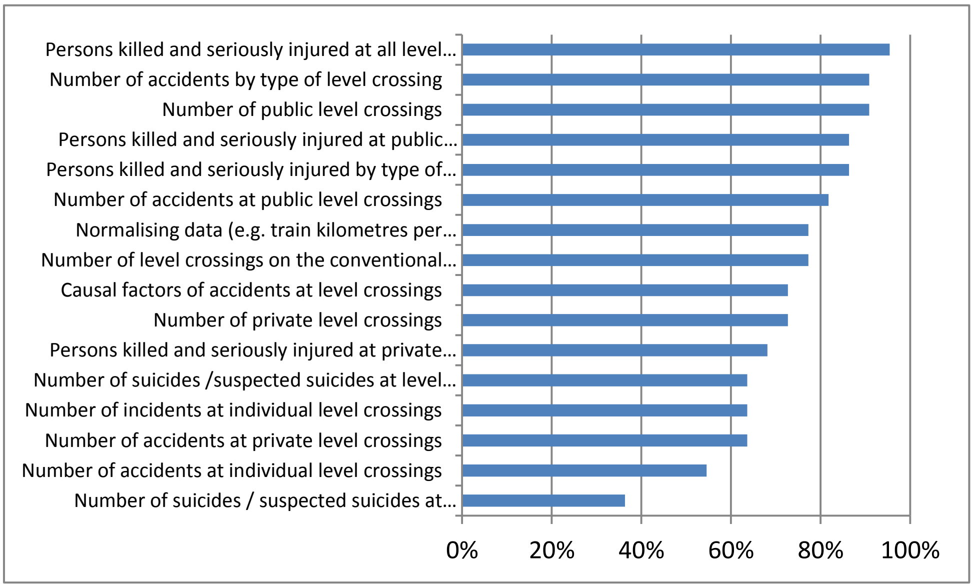
Assessment

1. The Group of Experts reviewed collection and use of statistical data on level crossings.

2. The Group conducted a survey in UNECE members and other selected countries. The survey results show that responding countries, generally, collect a vast array of data on level crossings. The data pertains to number of level crossings, their type and status, accidents, numbers of persons killed and seriously injured. In many countries data on causal factors of accidents as well as on suicides are also collected. Many countries normalize the level crossing data by relating them to rail traffic volumes or network length data (Figure 1).

Figure 1

Type of data collected on level crossing and safety of level crossing, UNECE countries and other selected countries,



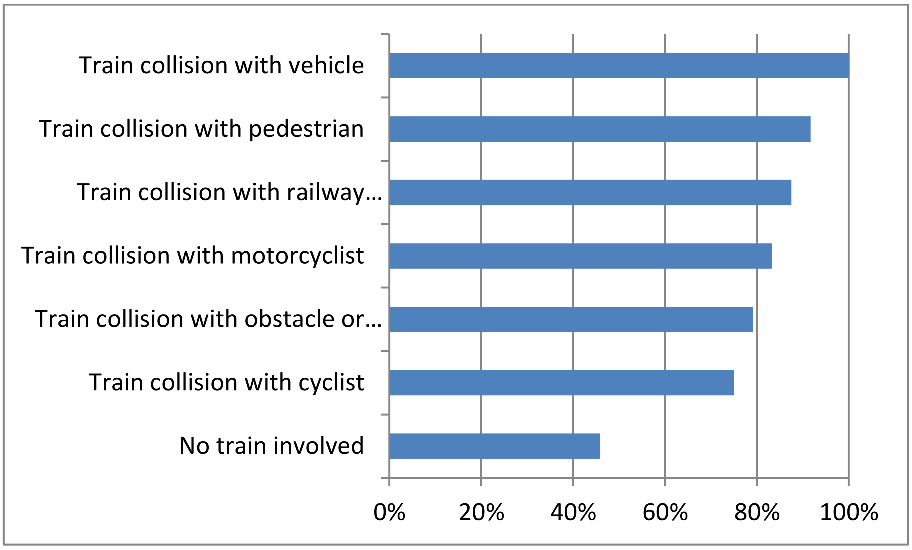
Source: UNECE secretariat survey, UNECE secretariat calculations.

Note: Based on responses from 23 countries except Lithuania. 100% means type of data collected by all responding countries.

3. Regarding the data on accidents, fatalities and injuries, responding countries report their collection as totals and at disaggregated levels. The accident data are in many countries collected per type of level crossing users, on collisions with obstacles or animals and accidents without involvement of a train (Figure 13). The fatalities and injuries data are also disaggregated at the level of level-crossing specific user or train occupants (Figure 2).

Figure 2

Disaggregation of accident data by type of level crossing user, UNECE countries and other selected countries

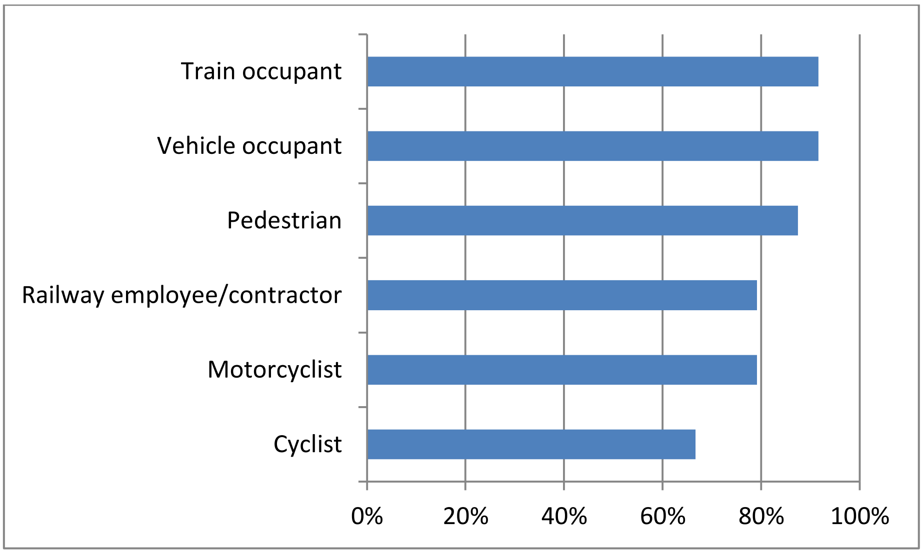


Source: UNECE secretariat survey, UNECE secretariat calculations.

Note: 100% means type of data collected by all responding countries.

Figure 3:

Disaggregation of fatalities and injuries data by type of level crossing user, UNECE countries and other selected countries



Source: UNECE secretariat survey, UNECE secretariat calculations.

Note: 100% means type of data collected by all responding countries.

4. The responding countries reported that the data collected are used to inform the work of national safety and other authorities. More specifically, the data are analyzed by the authorities to understand the impact of past actions and to develop safety initiatives. In a number of responding countries, the data are used to monitor and assess specific risks, so that the future level crossing safety initiatives can be targeted in a more cost effective way (United Kingdom).

5. The responding countries also reported on methodologies and publishing. As far as the methodologies are concerned, 16 out of 17 countries of the European Union and Russian Federation informed that they collect the data in accordance with data definitions prescribed by Eurostat/OECD/UNECE. Other seven countries informed of using other definitions without providing any specific information in this regard. At the same time four of these countries (Belarus, Republic of Moldova, Switzerland and Turkey) informed that data could be collected in accordance with the Eurostat/OECD/UNECE definitions.

6. As far as publishing of data is concerned, the responding countries informed about authorities responsible for publishing. In many countries, there is just one authority, typically a national safety authority for railway, which publishes the data. In some cases, there are also individual rail infrastructure managers who publish the level crossing data. There are also countries where several bodies publish the data.

II. Assessment of costs of level crossing accidents

Assessment

7. The Group of Experts also examined the economic costs of accidents at level crossings in UNECE member countries and other selected countries. To this end, the Group conducted a survey.

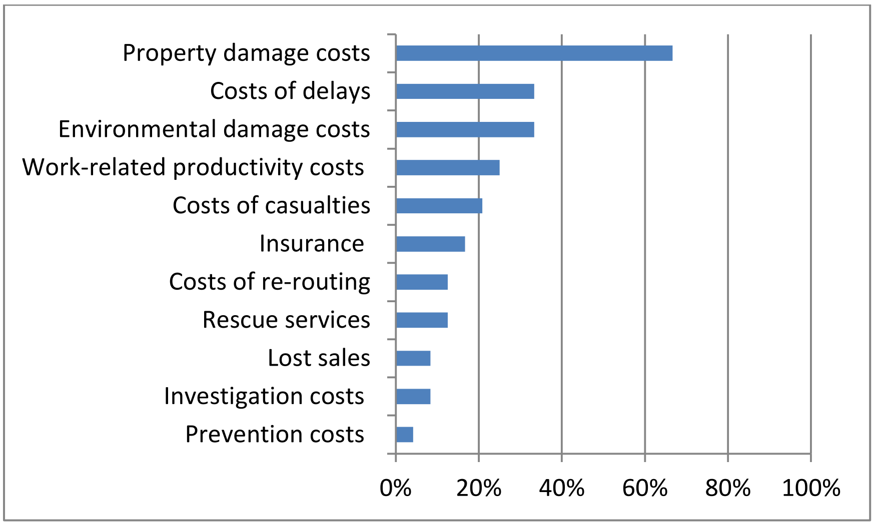
8. The survey shows that of 24 responding countries only eight (Belgium, Greece, Hungary, India, Ireland, Norway, Switzerland and United Kingdom) calculate the costs of level crossing accidents and aggregate them at the national level. In all countries, except Hungary, the cost statistics is compiled on an annual basis (even if the costs are established for each individual accident separately).

9. The motivation for calculating level crossing accidents costs and for collecting the necessary statistics vary between countries. The accident costs serve as an input to national safety plans (India, Greece); they are reported to ERA under Common Safety Indicators (CSI) data (Belgium, Ireland); they are estimated as they represent criteria for accident notification (Switzerland); they are used in cost-benefit studies (Hungary) and they are collected for statistical purposes (Norway).

10. While only several countries aggregate the costs of accidents at the national level, there are 16 surveyed countries that register different types of attributable costs for individual accidents. Typically, surveyed countries register 3-4 different types of costs for a level crossing accident, while one country (Russian Federation) informed to register 11 different types of costs.

11. Among the costs most commonly registered by countries are the property damage costs. They are followed by the environmental costs and costs of delays (Figure 4).

Figure 4
Type of costs registered for individual accidents at level crossings, UNECE countries and other selected countries



Source: UNECE secretariat survey, UNECE secretariat calculations.

Note: 100% means type of costs registered by all responding countries.

12. The responses to the survey also show that eight (Hungary, Ireland, Portugal, Russian Federation, Sweden, Switzerland, Turkey and United Kingdom) out of 24 countries established the costs of human life at the national level. The methods used for establishing this value differ among countries. The methods referred to in responses are: Value to Prevent Casualty (VPC), Developing Harmonized European Approaches for Transport Costing & Project Assessment (HEATCO), or an expert opinion.

III. Prevailing legislation for ensuring safety at level crossings

Assessment

13. Domestic legal frameworks play a critical role in the design, operation and management of level crossings. They establish how and by whom level crossings are managed and used. The frameworks also determine the level of risk as set by decision makers. They do so by assigning a variety of standards and prerogatives whose implementation is needed to create a level crossing characterized by a certain level of safety. A more stringent design or more effective management – if required by domestic legislation – induces safer behaviour which in turn is expected to reduce the number of fatalities and injuries at level crossings. Finally, in the states which are Contracting Parties to the 1949 Convention on Road Traffic, 1949 Protocol on Road Signs and Signals, 1968 Convention on Road Traffic or 1968 Convention on Road Signs and Signals (all of which contain a number of level crossing safety provisions), domestic legislation must be in conformity with those international legal instruments.

14. Using a survey, the Group of Experts assessed prevailing national legislation and/or legal arrangements at level crossings in order to identify good practices as well as gaps in the national and international legal frameworks (in particular related to conventions on road traffic and on road signs and signals).

15. The survey shows that in about two-thirds of responding countries the national legislation assigns a joint – to both rail and road managers - legal responsibility for managing level crossings while in one-third responding countries a single body is responsible for safety at level crossings.

16. Domestic legislation also assigns clear responsibility for maintenance and safety at level crossings (80 per cent of survey respondents). In contrast, only one in five survey respondents indicated that their national legislation regulated the reimbursement of costs due to an accident at level crossings.

17. According to survey respondents, a typical domestic legislation calls for matching the type of a level crossing with the specific in-situ conditions (e.g. topography, traffic flows). While this is understandable, the Group of Experts noted that there are different requirements on protecting similar types of level crossings internationally.

18. In terms of use of traffic sings and signals as per the 1968 Convention on Road Signs and Signals, almost all responding countries reported using the traffic signs warning of the approach to a level crossing “with no gates” or “with gates” (signs A, 25, A, 26 a and A, 26 b of the Convention). Almost all (except three) survey respondents and Contracting Parties to the 1968 Convention use the St. Andrew’s cross or its alternative (signs A, 28 a, A, 28 b and A, 28 c) as required. It should be noted that the use of St. Andrew’s cross is mandatory at level crossings with no half gates or no gates (with minor exceptions). In addition, two respondents (not Contracting Parties) reported they do not use St. Andrew’s cross at all.

19. In addition to road signs, the road signals are also used to convey information to road users that traversing a level crossing is allowed, forbidden or that the signaling is out of order. While the red light signal is generally used to indicate danger (approaching trains), there are single or double lights allowed and specific features such as flashing or not, colour, intensity, duration are also stipulated. In some countries, white light signal is also used. These regulations show considerable differences between countries (Table 3). They are also largely allowed under the conventions on road traffic and on road signs and signals.

Table1
Signals used for allowing or forbidding traversing a level crossing

	Passage forbidden indication					*Free passage indication*			
Country	*Constant red light*	*Flashing one red light*	*Flashing two red lights*	*Sound warning*	*Other*	*Constant white light*	*Flashing white light*	*No light (out of order)*	*Other*
Belgium			X	X			X		
Belarus			X	X					X
Bulgaria			X	X			X	X	
Estonia	X		X	X			X	X	
France			X	X					
Georgia	X	X		X				X	
Germany	X	X		X					
Greece			X	X					
Hungary			X	X			X	X	
India					X				
Ireland			X	X					
Italy	X		X	X					
Lithuania			X	X		X	X		
Norway		X		X			X		
Poland		X		X			X		X
Portugal	X	X		X					
Republic of Moldova		X		X			X		
Romania			X	X			X	X	
Russian Federation			X	X					
Spain			X	X					
Sweden			X	X			X		
Switzerland		X	X	X					X
United Kingdom			X	X					

IV. Use of management techniques including risk management to prevent unsafe conditions at level crossings

Assessment

20. The Group of Experts assessed – by means of a survey – the different management techniques used in UNECE members and other selected countries aimed at improving safety performance at level crossings.

21. The Group found that when closure of level crossings or grade separation is not possible, countries apply widely the traditional approach to enhancing safety i.e. upgrading the type of protection. The priority of upgrade is often decided based on the accident history or on technical rail aspects and subject to availability of budget.

22. Countries also rely on general education and national awareness or segmented and targeted awareness campaigns for preventing unsafe conditions at level crossings.

Box 1: Handling of risk at level crossings
As a result of a fatal accident at Elsenham level crossing, United Kingdom of Great Britain and Northern Ireland Network Rail adopted a major change to the way it handled a level crossing risk. The company created the position of a level crossing manager, who primarily has a safety role, but also manages minor maintenance and all the inspection of level crossings. Each level crossing manager is assigned a group of level crossings, and the inspections are used to highlight safety or maintenance issues that are found on these inspections. This has enabled the scope of risk to be well understood at all of Network Rail's approximately 6,000 level crossings. The level crossing managers are always consulted as stakeholders when changes to level crossings are planned. The result of creating the Level Crossing Manager positions is that significant improvements of safety of level crossings have been achieved, the risk profile is now better understood, and the users of level crossings have assurance that their interests are now taken into account.

23. Some countries, to enhance safety, (e.g. Portugal or United Kingdom of Great Britain and Northern Ireland) have implemented risk management at level crossing as a management technique. Typically the risk management process consists of four phases: (i) physical examination, (ii) risk analysis, (iii) planning and implementation, and (iv) monitoring.

24. During the first phase all relevant data on each of level crossing are collected. There might be as many as 100 various types of data for each level crossing. In the second phase, the data are combined with railway operation parameters and evaluated from the risk perspective. This is usually done with specific software based on algorithms tailored to a country-specific situation. This phase produces an estimate of risk for an accident to occur and its potential consequences (measured as probability for an accident to happen during a calendar year and a fatality and weighted injury during a calendar year) for each level crossing. The risk estimation and potential consequence measurements allow to rank level crossings. In the third phase, studies are made to work out solutions for reducing risk usually applying cost/benefit analysis. The solutions are subsequently implemented subject to budgetary constraints. The solutions might be in the field of engineering, which may also be a closure or an upgrade of a level crossing, of education and training or some type of enforcement measures. In the last phase, the implementation of solutions is monitored.

25. These four phases constitute a cycle with a new cycle starting when the previous has been completed. The next cycle automatically shows how effective in terms of risk reduction were the measures that had been implemented in the previous cycle.

V. Use of enforcement to prevent unsafe conditions at level crossings

Assessment

26. The Group of Experts assessed - by conducting a survey - the use of enforcement by UNECE members and other selected countries to ensure safer level crossing for road users.

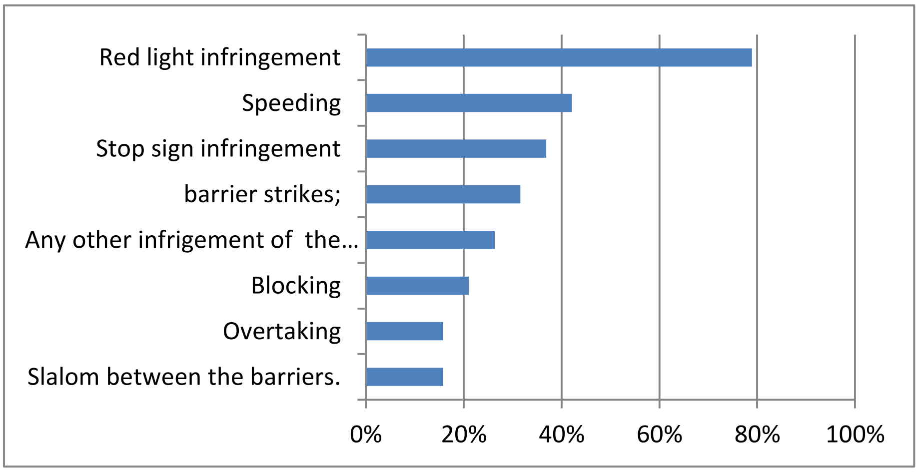
27. The survey shows that 18 of 24 responding countries carry out some enforcement activities vis-à-vis behavior of road users at level crossings and five countries (Estonia, Georgia, Norway, Spain and Sweden) do not.

28. The enforcement activities are carried out according to legislation in force. All responding countries informed that they have domestic laws that relate to road user behaviour at level crossings. In particular, regulations covering motor vehicle drivers at public road level crossings exist in all countries. The regulations covering pedestrians at public level crossings exist in many but not all the responding countries. For example, this is not the case in the United Kingdom of Great Britain and Northern Ireland where the applicable regulations do not apply to pedestrians, which creates a weakness for enforcing a proper use of level crossings by pedestrians.

29. Domestic legislation for private level crossings is found inconsistent and fragmented in countries where private level crossings exist (for example in the United Kingdom of Great Britain and Northern Ireland). In some countries (for example in France and Spain) an agreement or a contract is signed between the railway company and the owner to govern the use of the level crossing.

30. The responding countries informed on the various types of violations which are enforced. The most enforced violation seems to be red light infringement followed by speeding at level crossings and not respecting the stop sign (Figure 5).

Figure 5
Types of violations enforced, UNECE countries and other selected countries



Source: UNECE secretariat survey, UNECE secretariat calculations.

Note: 100% means type of violation enforced by all responding countries applying enforcement.

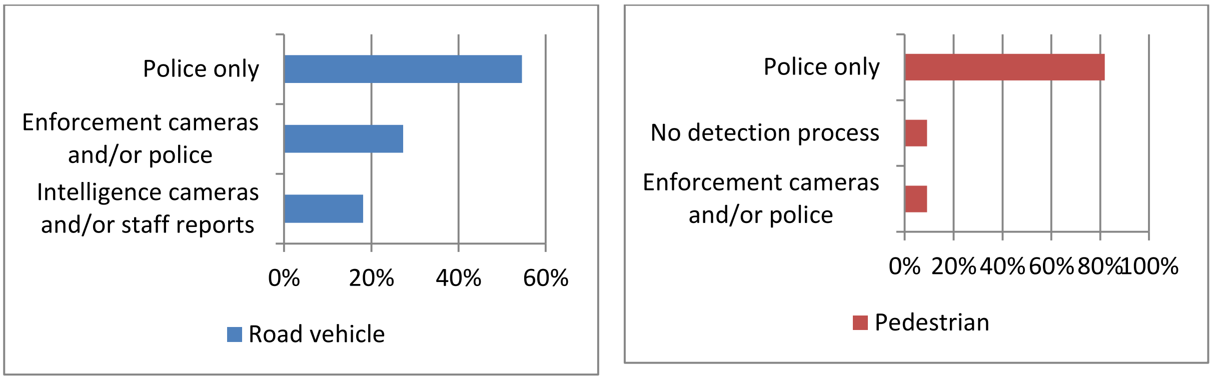
31. All responding countries stated that the police were responsible for enforcement of public road level crossings, with one country stating that the infrastructure owner also had

some responsibility for enforcement on public road level crossings together with the police (the term ‘police’ included national, regional or railway police).

32. There is much more variation with regard to enforcement at private road level crossings. The infrastructure owner is expected to assume a greater level of responsibility for enforcement at private road level crossings compared to public road level crossings.

33. The prevailing enforcement method seems to be detection of violation by the police, based on responses received for both road vehicle violations as well as for pedestrian violations at public level crossings (Figure 6).

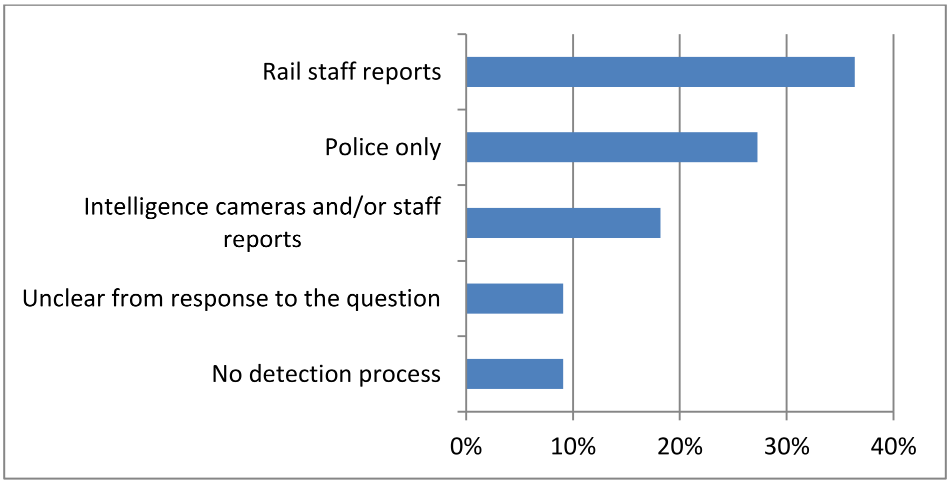
Figure 6
Detection methods at public level crossings, in per cent, UNECE countries and other selected countries



Source: UNECE sec survey, UNECE secretariat calculations.

34. For private level crossings, a relatively greater focus is placed on rail staff while some responding countries have no method of detecting violations (Figure 7)

Figure 7
Detection methods at private level crossings, in per cent, UNECE countries and other selected countries



Source: UNECE sec survey, UNECE secretariat calculations.

35. The responding countries informed that the detection of violations is a challenge. The use of police officers in enforcement activities is labour intensive, expensive and the police do not appear to attach a great priority to enforcing safe user behaviour at level crossings. Cost, resource constraints and other practicalities means that 24 hour, 7 days per week enforcement work could never be provided by the police. Detection of violations through the police is therefore only sporadic and dependent on resources and tasking commitments.

36. However, the development and use of technology to support enforcement is growing. For example, enforcement cameras are being introduced in some UNECE countries. However, even in those countries, cameras are only placed at a tiny proportion of level crossings. For example, in the United Kingdom of Great Britain and Northern Ireland, there are currently 16 mobile safety vehicles and 16 operational fixed enforcement cameras. This provides the potential to detect violations at 32 level crossings out of some 1,500 public road crossings (two per cent). In addition, the use of cameras is challenging in the context of data protection issues and the right to privacy, especially with surveillance in situ cameras. Placement of detection technology is often decided on the case by case basis. Typically, enforcement authorities decide to deploy detection technology at the level crossings that have had accident history or on a basis of a risk assessment or structured expert judgement.

37. While the detection technology can be prone to vandalism or theft, records show little vandalism or theft of devices placed in urban locations and installed at heights well above street levels.

38. In France, records show that detection technology has an impact on user behaviour and contributes to reducing violations at level crossings. The analysis done in France has shown that violations usually happen in the first four seconds from the moment the warning equipment is activated.

39. As for punitive measures, the most widely used punishment are fixed penalty charges (fines) and demerit points on driving permit or loss of it for road vehicle drivers. The most dangerous can lead to prison sentences in two countries (Hungary and United Kingdom of Great Britain and Northern Ireland). Two countries use driver re-education programmes (Spain and United Kingdom of Great Britain and Northern Ireland). Interestingly, the abuse of safety protocols at private crossings can lead to removal of access rights in France and Spain.

VI. Education for preventing unsafe conditions at level crossings provided in UNECE member countries and other selected countries

Assessment

40. The Group of Experts examined the use of education programmes by conducting a survey in UNECE members and other selected countries.

41. The responses show that in the majority of countries there are no education programmes developed to prevent unsafe conditions at level crossings. Only two countries (Hungary and Germany) informed about specific education programmes launched by rail operators.

42. In a number of countries there are level crossing safety awareness raising events, e.g. for school children (Russian Federation), for kindergarten children (Norway) or

children in general (Belgium). In some countries (Poland) information material especially for children is distributed to raise awareness about proper safety behavior at level crossings. Typically there are general campaigns in countries to sensitize about the dangers of level crossings to general public (Belgium, Germany, Portugal, United Kingdom of Great Britain and Northern Ireland) or dedicated events are organized on the occasions of the national awareness day (France, Lithuania).

43. In some countries (United Kingdom of Great Britain and Northern Ireland) user guidance is developed and updated to guide specific users (pedestrians, vehicle drivers, cyclist, horse riders) on the proper use of level crossings. In other countries (Switzerland), videos are produced to sensitize about level crossing dangers.

44. In one country (Ireland), the railway infrastructure manager is developing an educational strategy, concentrating on users of passive level crossings. For this purpose, crossings were visited, discussions were held with the crossings' users to understand what should be a targeted education programme. In some other countries (India), international partners were searched to develop education programme on safety of level crossings.

45. Turkey also reported that safety of level crossing is given attention during driver training for obtaining driving permits. Some others (e.g. Belgium) informed of media campaigns for professional truck drivers.

VII. Analysis of human factors to prevent unsafe conditions at level crossings

Assessment

46. Human factors is concerned with the application of what we know about people, their abilities, characteristics, and limitations to the design of equipment they use, environments in which they function, and jobs they perform[11]. This discipline on human factors with a special focus on the (mis)behaviour of traffic participants at level crossings – vehicles as well as vulnerable road users – is of high importance. It provides an explanatory framework for the occurrence of accidents and subsequently identifies measures to increase safety at level crossings.

47. By conducting a survey, the Group of Experts assessed the attention, concerns and solutions of UNECE members and other selected countries in the area of human factor analysis.

48. The results of the survey show that all 22 responding countries recognize human factors as a main cause behind accidents at level crossings. Countries often refer to road users' error and lack of risk awareness.

49. Two-thirds of the responding countries informed that they have a range of solutions and/or creative and innovative countermeasures in place to solve the human-factors driven problems. These countries refer mainly to awareness campaigns, but also to established engineering and technological solutions such as level-crossings closures and installation of obstacle detection devices on trains or the presence of the police. Despite the fact that some of the countermeasures can be effective, they are often costly when applied to all level crossings and may not address human perception or attention issues. One-third of those responding informed of not possessing any solutions to handling human factor challenges at level crossings.

[11] According to the definition of 'Human Factors and Ergonomics Society'

50. A closer look into the solutions reveals that awareness campaigns are of general nature, are not level crossing specific and may not address specific causative human factors. The technical solutions have limited application due to financial inability to replace all level crossings with over- or underpasses or to install the state of art equipment to warn or detect the danger or to prevent from entering the level crossing when a train is approaching it. In other words, human factor challenges may be unique and often should be addressed by specific human factor countermeasures.

51. The outcomes of accident investigation reports of (independent) accident investigation bodies of several member countries show that most of these reports rather focus on technical, procedural and legal areas. Items in such investigation templates concerning underlying causes on the side of the road user are lacking, therefore oversimplifications of causalities and human error are frequent.

Box 2: Perception of waiting time at level crossings by various users

The UK Network Rail reviewed, by commissioning a human factor study, the public's perception of warning time at "Miniature Stop Light" crossings and other crossings. The study was not able to come to any meaningful conclusion as to the maximum warning time that would be tolerated by the public, but it did confirm that the patience of those interviewed varied considerably. The overall conclusion was that warning time should be minimised so as to match the expectation of the public.

52. Within the UNECE members few studies on human factors in the field of level crossing safety are known. Austria (ÖBB-Infra), England (RSSB), Finland (VTT), Germany (DLR) and Israel (Cognito) have proven to establish knowledge and experience in this field. Nevertheless, the wide majority of respondents informed that neither do they possess nor currently conduct any research studies or in depth evaluations on human factors as causative factors in level crossing accidents.

VIII. Level crossing infrastructure and technology to prevent unsafe conditions at level crossings

Assessment

53. The Group of Experts reviewed – by conducting a survey – the areas of level crossing infrastructure and technology in UNECE members and other selected countries.

54. The responses to the survey show that the warning lights, half and/or full gates (barriers) are commonly used at active level crossings. Responding countries also use, though to a lower degree, LED lighting, rumble stripes and second train warnings. They also use other arrangements such as specific design features for pedestrians and cyclists (zigzag systems or small barriers in Belgium).

55. The responding countries also use technologies to detect trains such as track circuit, axle counters, mechanical or electronic treadles. There are also systems in place to provide indication of rail track clearance. Countries use central train control systems and/or intermittent train control systems. There are also systems, based on magnetic sensors built in the road, to alert road vehicle users about approaching a level crossing. GPS technology has been used for improved information on train positions and communications to train and motor vehicle drivers.

56. New types of audible warnings, gates (barriers) and gate (barrier) machines and improvements to the materials used to pave surfaces and innovations to aid installation and maintenance have also realized greater efficiencies.

57. There is also technology to specifically assist pedestrians using level crossings. It is largely confined to infrastructure based train detection systems providing an audible or visual warning at footpath crossings. Some countries separate pedestrians from motor vehicles by providing separate gates (barriers) and walkways to traverse the crossing. The use of lighting to mark paths and walkways is also common.

58. However, with funding limited and the consequences of an accident with a pedestrian being borne solely by the pedestrian, technology development has been largely focused on level crossings and solutions where the consequence of an accident and the possibility of derailing a train due to conflict with a vehicle, is greatest. Therefore, the numbers of crossings with no technology at all is high. This includes locations where trains frequently travel up to 160 km/h and sometimes at locations with trains reaching speeds of 200 km/h. This includes crossings that are used by the most vulnerable groups in society such as children or the elderly and in all types of weather and light conditions where the burden of making the decision of when it is safe to cross is theirs.

59. In addition, there are also technical enforcement systems in use installed at active level crossings. Some of them provide intelligence only and are not used directly for enforcement. In this case, they are used by infrastructure managers and police to identify problem locations prior to deploying police officers or dedicated enforcement cameras. Some use motion sensors to commence recording while some are on continuous recording loops.

60. Also, there are other dedicated enforcement systems that are to provide still or moving image of the infringement making it unlikely that the enforcement action will be challenged by a third party. These systems activate themselves when a train approaches level crossing and may use one of different solutions for detecting violation, e.g. radar, ground induction loops, video analytics or motion sensors.