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Working Party on Road Traffic Safety

Group of Experts on Improving Safety at Level Crossings

Eighth session
Geneva, 1-2 June 2016
Item 2 (a) of the provisional agenda
Part I of the final report

Part I of the final report

Note by the Secretariat

This document, prepared by the secretariat in consultation with the chair, contains the draft part I of the final report.

Introduction

Establishment of a Group of Experts on safety at level crossings

1. At its seventy-third session (Geneva, 1-3 March 2011), the Inland Transport Committee (ITC) discussed the importance of addressing key issues related to enhancing safety at level crossings. The Committee recommended that the Working Party on Road Traffic Safety (WP.1), the Working Party on Road Transport (SC.1) and the Working Party on Rail Transport (SC.2) consider creating a joint Group of Experts of limited duration to work on enhancing safety at level crossings, taking into account all relevant experience within other bodies such as the European Railway Agency (ECE/TRANS/221, para.50). At its sixty-first session on 21-23 March 2011, WP.1 noted the Inland Transport Committee's invitation to consider creating a multidisciplinary group of experts to work on improving safety at road and rail interfaces (level crossings) and agreed to take part in this initiative (ECE/TRANS/WP.1/131, para. 21).

2. Subsequently, the Terms of Reference (see below) of the Group of Experts on Safety at Level Crossings was prepared in line with the UNECE Guidelines for the Establishment and Functioning of Teams of Specialists. The Group of Experts, in general, was to aim at bringing together safety specialists from the road and rail sectors so as to better understand the issues at this intermodal interface. In accordance with the Guidelines, participation in the Group of Experts was open to all UNECE member States, the European Union, academia and the private sector. The Group of Experts was also open to non-UNECE member States. The original duration of the Group of Experts was until 31 December 2015 (at the time of writing an extension was granted until 31 December 2016). The Executive Committee at its meeting on 11 July 2013 approved the establishment of the Group of Experts on Safety at Level Crossings and its Terms of Reference.

Terms of Reference of the Group of Experts on Safety at Level Crossings

(a) The Group of Experts (GE) on Safety at Level Crossings will provide an international discussion platform for increasing safety at the interface of road and rail systems, by bringing together specialists from the public and private sectors, as well as academia and independent research. A "Safe System" approach will be adopted by taking into consideration the five key elements (5E's) typically used in level crossing safety: Engagement, Education, Engineering, Enforcement and Economics.

(b) The Group of Experts, based on existing resources of the secretariat, and possibly with additional financial support provided by participating countries and in close collaboration with other international organizations, will take stock of available data to describe, assess and better understand the safety issues at a road/rail interface as well as to develop a multidisciplinary strategic plan aimed at reducing the risk of death and/or injury at level crossings.

(c) Specifically, the Group of Experts will:

- collect all relevant information with a view to describing and assessing the current safety performance at level crossings in UNECE member States and selected non-UNECE member States

- conduct, in a coordinated manner, a cross-country survey of prevailing national legislation and/or legal arrangements at level crossings
- describe and evaluate key factors contributing to unsafe conditions at level crossings in areas such as infrastructure, national legislation, user behaviour, management, education and enforcement
- develop a road/rail interface strategy with a supporting action plan that will contribute to achieving the goal of enhancing safety at level crossings
- develop and maintain a network of contacts in the relevant fields, including key stakeholders such as governments, enforcement agencies, academia, industry, road and railway stakeholders and users, with a view to exchanging information and best practices
- develop a general framework to guide and support a consistent implementation of initiatives that would set best examples in enhancing safety at level crossings
- explore the possibility of developing (pilot) projects that would aim to ensure that priority is given to safety initiatives based on a system approach
- consider organizing workshops intended to support the core objectives that will be developed in the strategic plan of action
- monitor and report on the effectiveness and sustainability of initiatives deployed under the strategy, including recommending remedial actions in the areas of safety measures, emergency responses, risk management and training tools
- identify future strategic and operational research needs and mechanisms for delivery, taking into account, where possible, availability of existing resources.

(d). Membership to the Group of Experts will be open to government appointed officials and experts from UNECE and non-UNECE member States. It will also be open to representatives of international organizations, non-governmental organizations, academics and researchers, as well as representatives of the private sector.

(e) The Group of Experts will be assisted in its work by the UNECE secretariat and will report to the Working Party on Road Traffic Safety.

3. The Group of Experts met eight **(CHECK)** times between 20 January 2014 and 16 September 2016 **(CHECK).** The meeting agendas and reports as well as documents submitted by experts are available at https://www.unece.org/trans/roadsafe/eg_level_crossings_07.html.

4. This Group of Experts prepared this report which consists of two parts:

5. Part 1 describes the substantive elements discussed by the Group of Experts, presents the assessment of safety performance at level crossings in UNECE member States and other selected countries and their work done with the objective to improve it, as well as formulates recommendation by the Expert Group to further help improve safety at level crossings, and

6. Part II contains a strategy for improving safety performance at level crossings and an accompanying action plan

7. To develop the part 1 of its report, the Group of Experts carried out a survey in UNECE member States and other selected countries, to get a better understanding on various issues related to level crossings and safety at level crossings.

8. The following countries responded to the survey:

9. UNECE member States: Belarus, Belgium, Bulgaria, Estonia, France, Georgia, Germany, Greece, Hungary, Ireland, Italy, Lithuania, Norway, Poland, Portugal, Republic of Moldova, Romania, the Russian Federation, Spain, Sweden, Switzerland, Turkey and the United Kingdom of Great Britain and Northern Ireland (United Kingdom), and

10. Other selected countries: India.

11. Unless stated otherwise in this report, it is understood that terms ‘surveyed countries’ or ‘responding countries’ refer to the countries listed above.

Safety issues at level crossings, introduction

12. Despite the fact that accidents at level crossing account for only a small percentage of all road accidents, the numbers are not negligible. Recent statistics have shown that annually in the European Union only, there are more than 300 people killed in more than 1,200 accidents at level crossings. Accepting the fact that the European Union has a better overall road safety record than other regions, the statistics shows that there is a problem that needs to receive a due consideration.

13. The problem does not have simple solutions. Many level crossings are a by-product of a largely uncoordinated evolution of road and rail systems during an industrialization era. Today with ever increasing road and rail traffic and with increasing speeds, many level crossings have become dangerous spots. Because of different legal, access and spatial separation issues they cannot be simply closed sometimes even if replaced by under- or overpasses.

14. At the same time, closure of level crossings is seen as the only way of eliminating the safety risk. Any other solutions – introducing active protection at the level crossing – only help to decrease the risk. And yet, given the number of level crossings, it is not financially possible to introduce active protection systems at all those crossings that cannot be closed. In addition, the delays and congestion at level crossings when the active protection is used, especially at crossing with high train frequency, create a number of challenges that so far technology has struggled to overcome.

15. Identification and application of acceptable solutions is necessary if accidents at level crossings are to be prevented. These accidents are not only more severe – it is estimated that the risk of fatal injuries is 10 times higher in accidents between trains and motor vehicles than in accidents between vehicles only – they can also be more costly than those between vehicles. This is due to the fact that damage can be caused not only to road infrastructure but also to rail equipment and infrastructure. In addition there are indirect costs related to disruption of service on the damaged railway. These costs can be further exacerbated if cargo trains carrying dangerous goods get involved in accidents what can cause major (catastrophic) environmental or human health impacts and related costs.

16. The current knowledge suggests that a due consideration of safety at level crossing requires an implementation of a safe system approach. An important part of such an approach is application of risk management, which is supported by different risk management tools. Such tools can serve their purpose better if they could be tested and calibrated with data on safety performance at level crossing and when quantifiable costs of accidents involving trains and road vehicles are available.

This report …………

Safety performance at level crossings in UNECE member countries and other selected countries

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

- Data available for 29 UNECE member States (ie. all member States of the European Union except Malta as well as Norway and Switzerland) contained in a database managed by the European Railway Agency (ERA) (https://erail.era.europa.eu/safety-indicators.aspx). These countries are referred to in this chapter as ERA countries;
- Data available for ………….

18. 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 uniformity of definitions and methods of calculations between the ERA countries and other countries. As a result, the performance indicators are not directly comparable between ERA countries and other countries and between any of the other countries.

19. 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 subdivision of active level crossings and passive level crossings) are generally available for the period 2010-2014. The data on the number of significant accidents[1], killed or injured users are available as totals, whereas the disaggregation of these data per type of level crossing is only available for several countries for 2014 only. Disaggregation by type of level crossing user is not available at all. The normalized data ie. number of track kilometers[2], train kilometers[3] and line kilometers[4] are generally available.

20. As for as other countries data are concerned …..

21. In the ERA countries, there are between no level crossing (Cyprus) to nearly 16, 000 in France. The number of level crossings in individual ERA countries usually depends on the size of the country and density of the rail and road networks (Figure 1).

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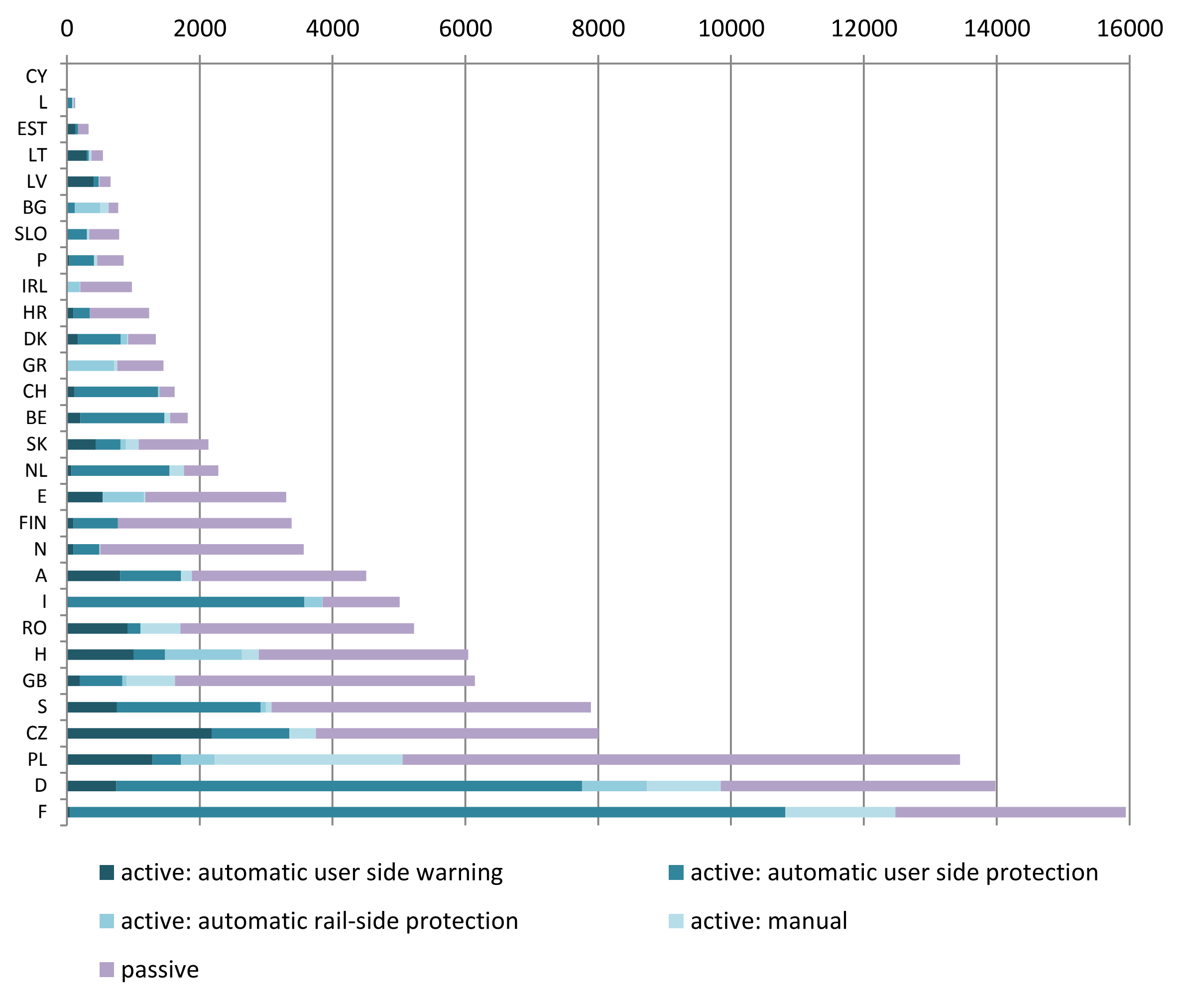
[1] Definition as per EU Commission Directive 2014/88/EU: Any accident involving at least one rail vehicle in motion, resulting in at least one killed or seriously injured person, or in significant damage to stock, track, other installations or environment, or extensive disruptions to traffic, excluding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

[2] 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.

[3] 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.

[4] 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.

Figure 1: Number of level crossings, ERA countries, 2014



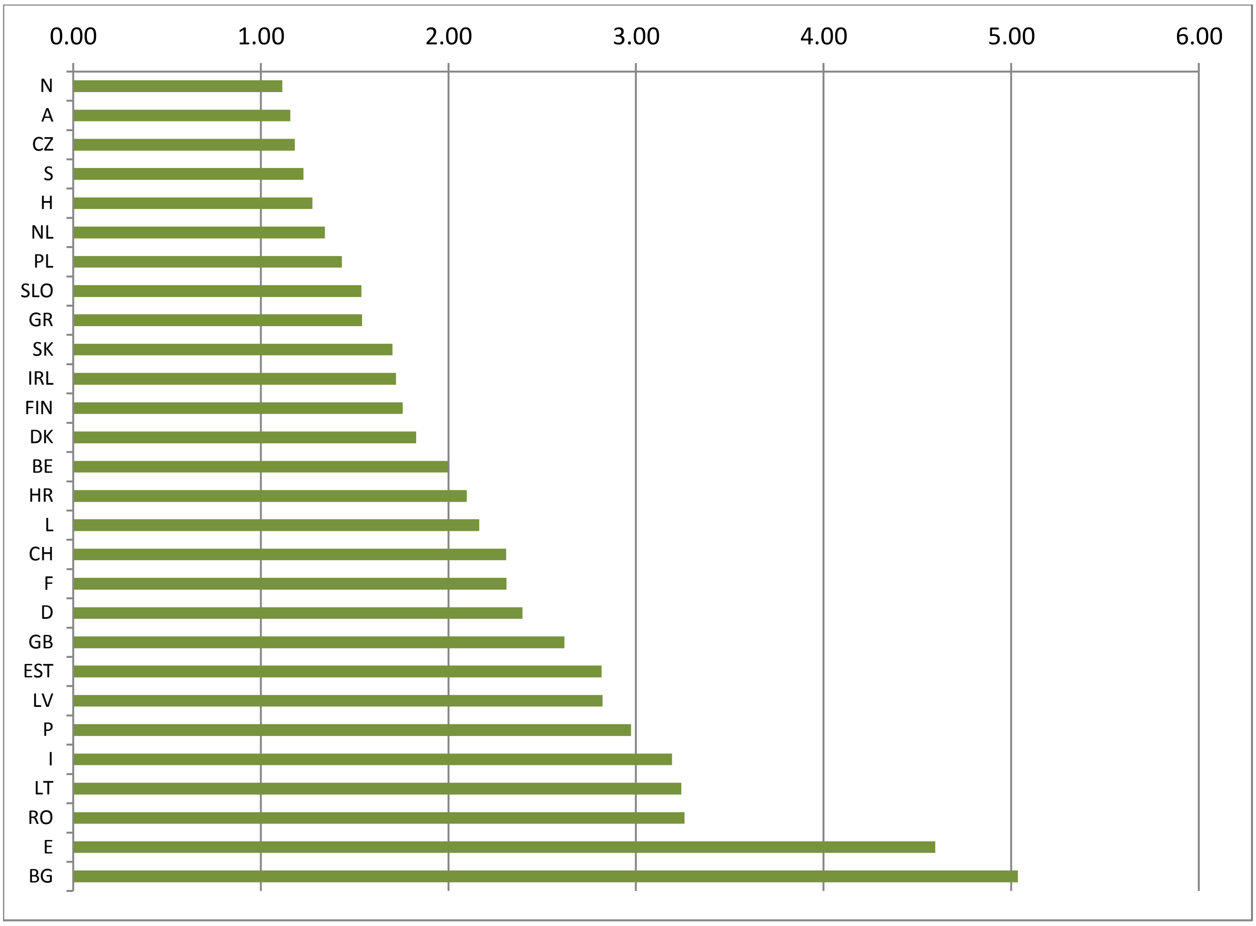
Source: ERA database, UNECE secretariat calculations

Note: Country codes 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.

22. Available data for other countries:
See excel file 'data-non ERA countries' Figure 1

23. The distribution of active (with it various types) and passive level crossings is different from country to country and depends on many factors not subject of this assessment. On average, level crossings are located between every one (Norway) to five (Bulgaria) rail line kilometres in ERA countries (Figure 2).

Figure 2: Average distance between level crossings, ERA countries, line kilometers, 2014

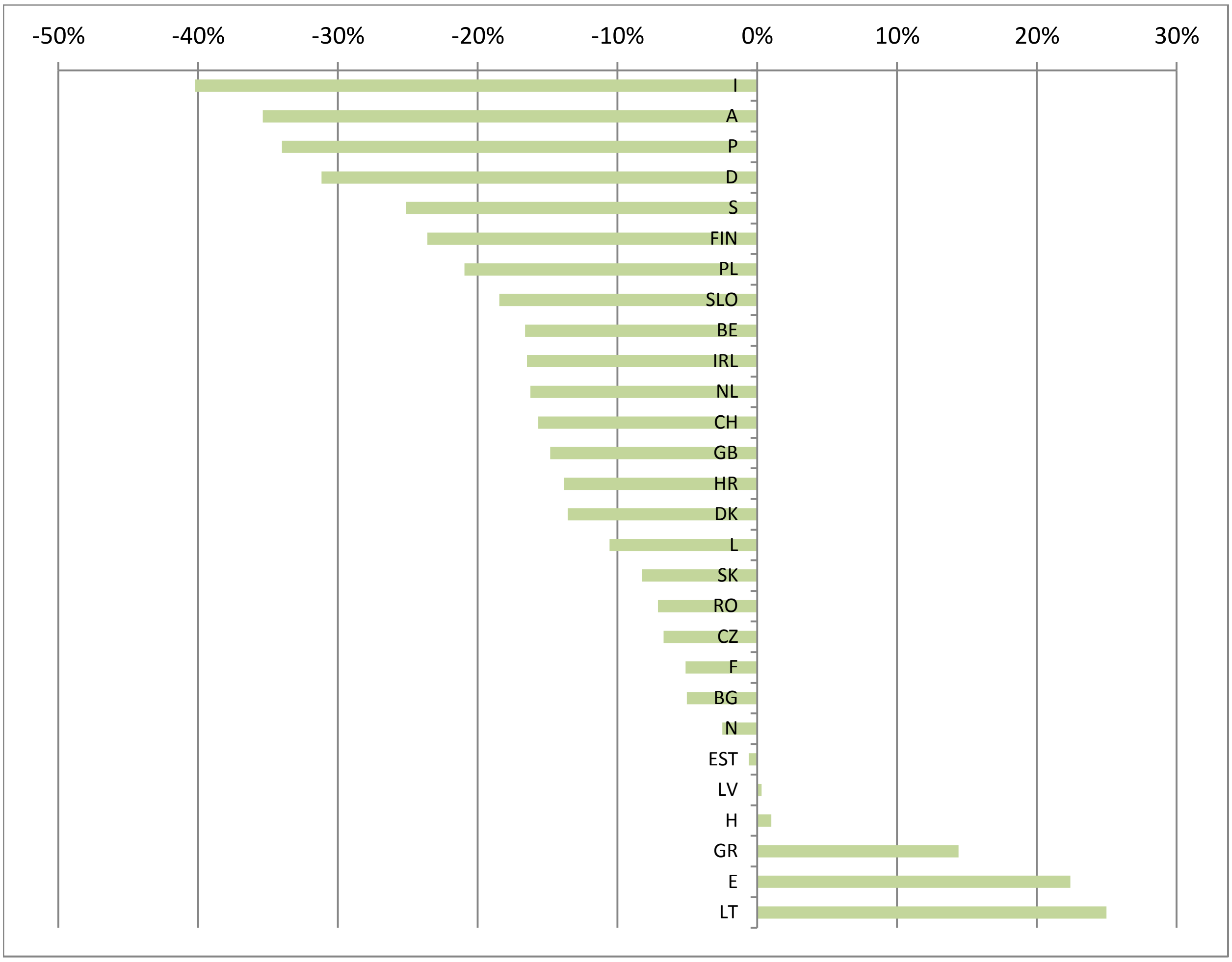


Source: ERA database, UNECE secretariat calculations

24. Available data for other countries:
See excel file 'data-non ERA countries' Figure 2

25. The number of level crossings decreased in the majority of ERA countries in 2006-2014 (Figure 3). The decrease ranged from as high as 40 per cent (Italy) to a negligible one per cent (Estonia). 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). This increase can be explained by opening of new railway lines only in one out of the three countries (Spain). In the other countries the length of the railway lines decreased, hence, the new level crossings were constructed at existing railway lines most probably as a result of an expansion of the road network.

Figure 3: Percentage change in the number of level crossings, ERA countries, 2006-2014



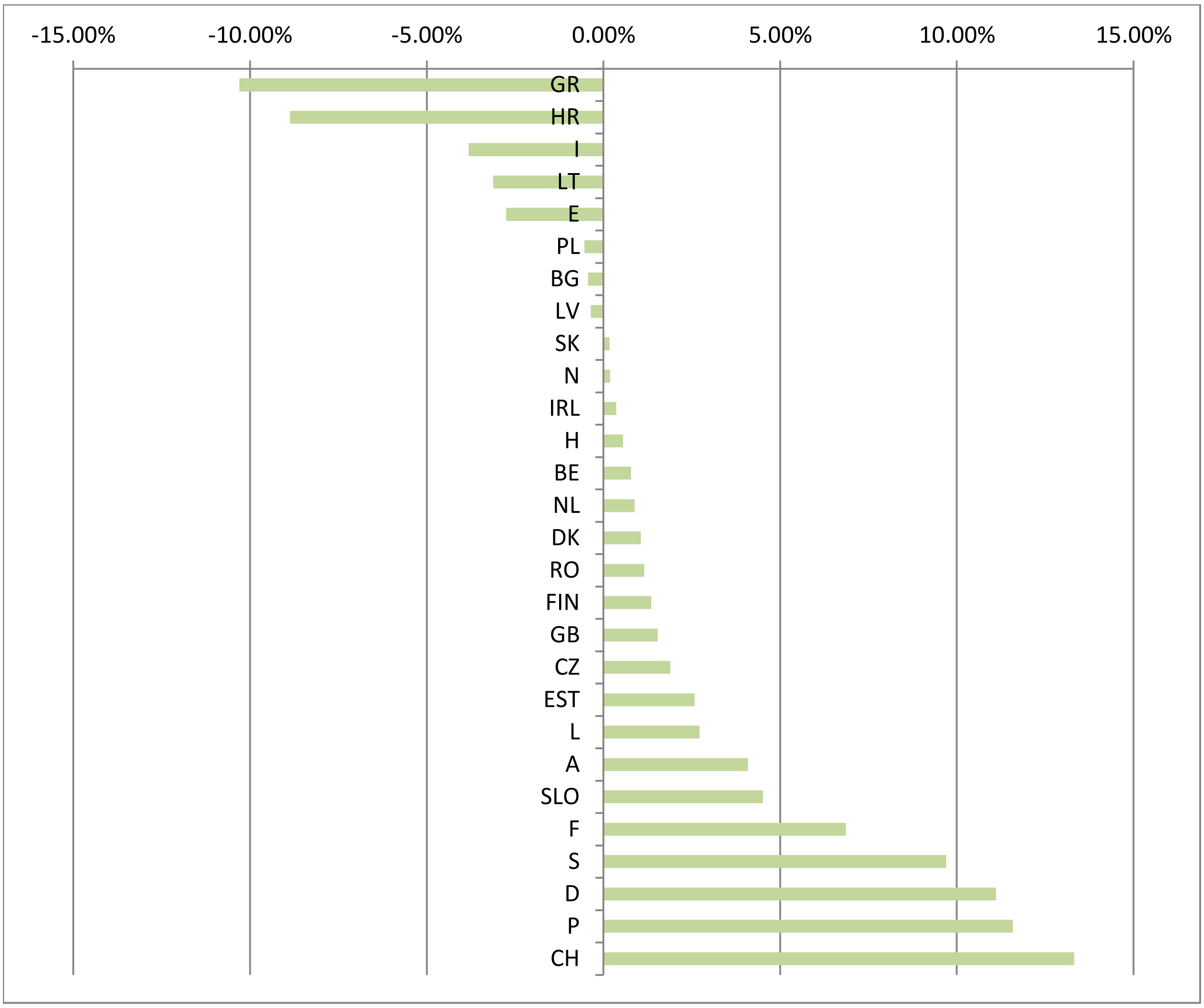
Source: ERA database, UNECE secretariat calculations

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

26. Available data for other countries:
See excel file 'data-non ERA countries' Figure 3

27. The ratio of active level crossing to all level crossings increased in the majority of ERA countries (Figure 4) in the period 2010-14. This was achieved by upgrading passive level crossing to active ones or by eliminating passive level crossings. Although the particular reasons are unknown, the increase ranged from less than one per cent (Belgium, Ireland, Netherlands, Norway and Slovakia) to as high as 13 per cent (Switzerland). The ratio decreased in several ERA countries, most prominently in Croatia and Greece by 8-10 per cent.

Figure 4: Change in the ratio of active level crossings to all level crossings, ERA countries, percentage points, 2010-2014



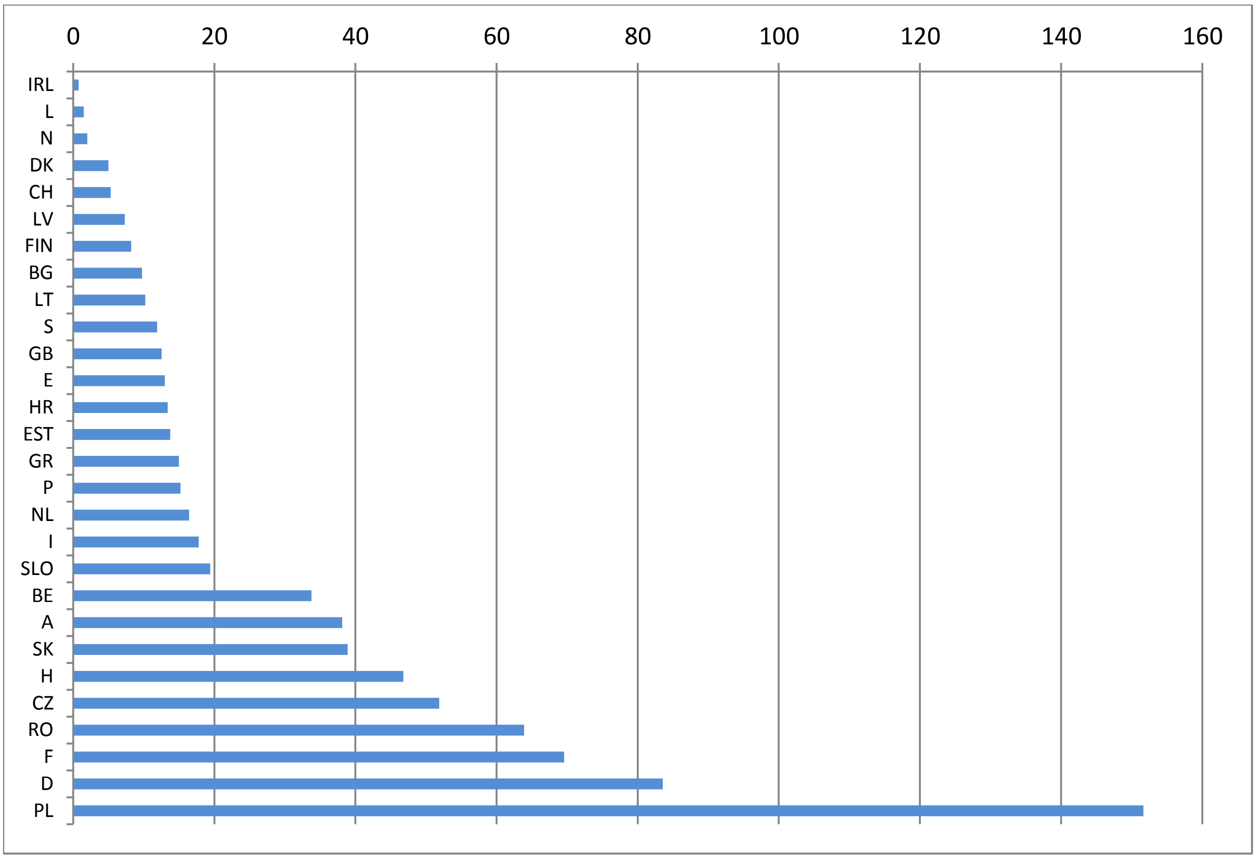
Source: ERA database, UNECE secretariat calculations

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

28. Available data for other countries:
See excel file 'data-non ERA countries' Figure 4

29. The average annual number of significant accidents at level crossings varies considerably in ERA countries in the period 2006-14. It ranged from the annual average of one significant accident (Ireland) to as many as 152 in Poland (Figure 5).

Figure 5: Number of significant accidents, ERA countries, annual 2006-2014 average



Source: ERA database, UNECE secretariat calculations

Note: Calculations for Croatia for 2010-2014, Estonia: 2007-2014, Luxembourg: 2009-2014, and Switzerland: 2009-2014;
For the definition of a significant accident- see footnote 1

30. Available data for other countries:

See excel file 'data-non ERA countries' Figure 5

31. The number of significant accidents followed a decreasing trend in the majority of ERA countries during 2006-14 (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 showing the significance of the trend confirms it for majority of the 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.

Figure 6: Coefficient of linear trend for number of significant accidents, ERA countries, 2006-2014

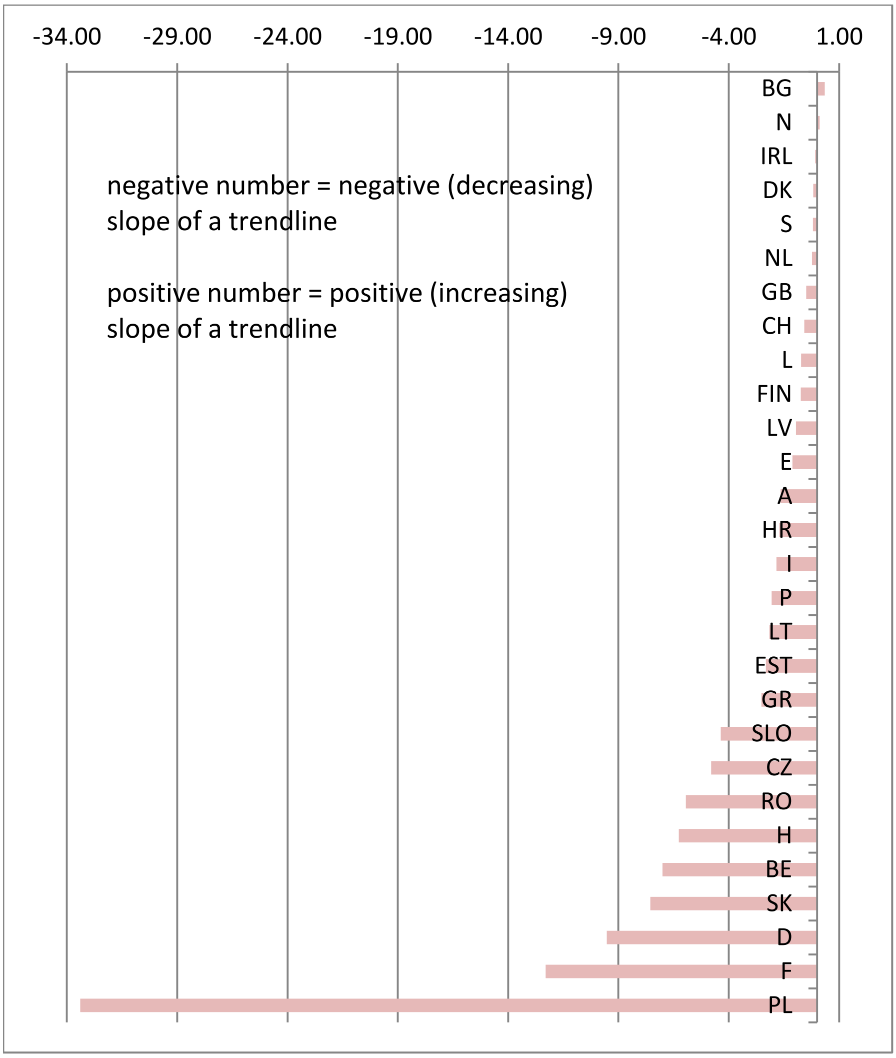
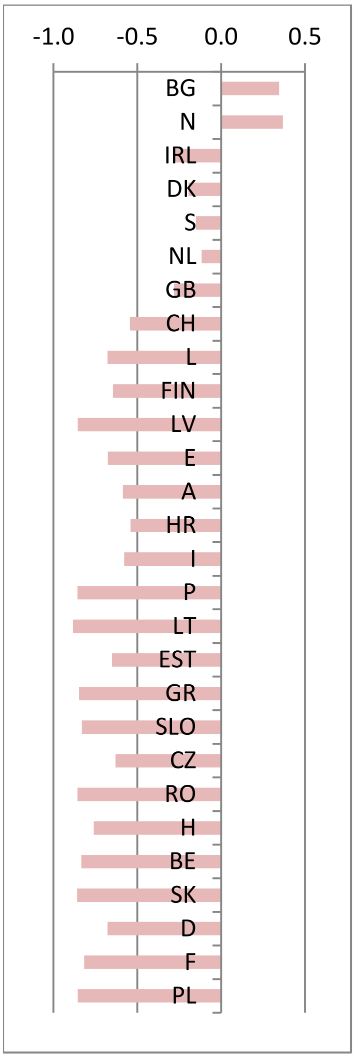


Figure 7: Correlation coefficient of the linear trend



Source: ERA database, UNECE secretariat calculations

Note: Calculations for Croatia for 2010-2014, Estonia 2007-2014, Luxembourg 2009-2014, Switzerland 2009-2014;

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;

32. Available data for other countries:
See excel file 'data-non ERA countries' Figures 6 and 7

33. The assessment of safety performance at level crossing in relative terms shows different results. ERA countries with a high absolute number of accidents (France, Germany and Poland) and a high number of level crossings achieve relatively good results in terms of accidents per number of level crossings while some countries with few accidents and few level crossings (Bulgaria and Estonia) do not(Figure 8). Similarly, the ERA countries with a high absolute number of accidents and many train kilometres driven annually (Germany) achieve better performance in terms of average distance driven by

trains per accident than countries with fewer accidents but a relatively low number of train kilometres driven (Greece) (Figure 9).

Figure 8: Number of significant accidents per 1000 level crossings, ERA countries, 2014

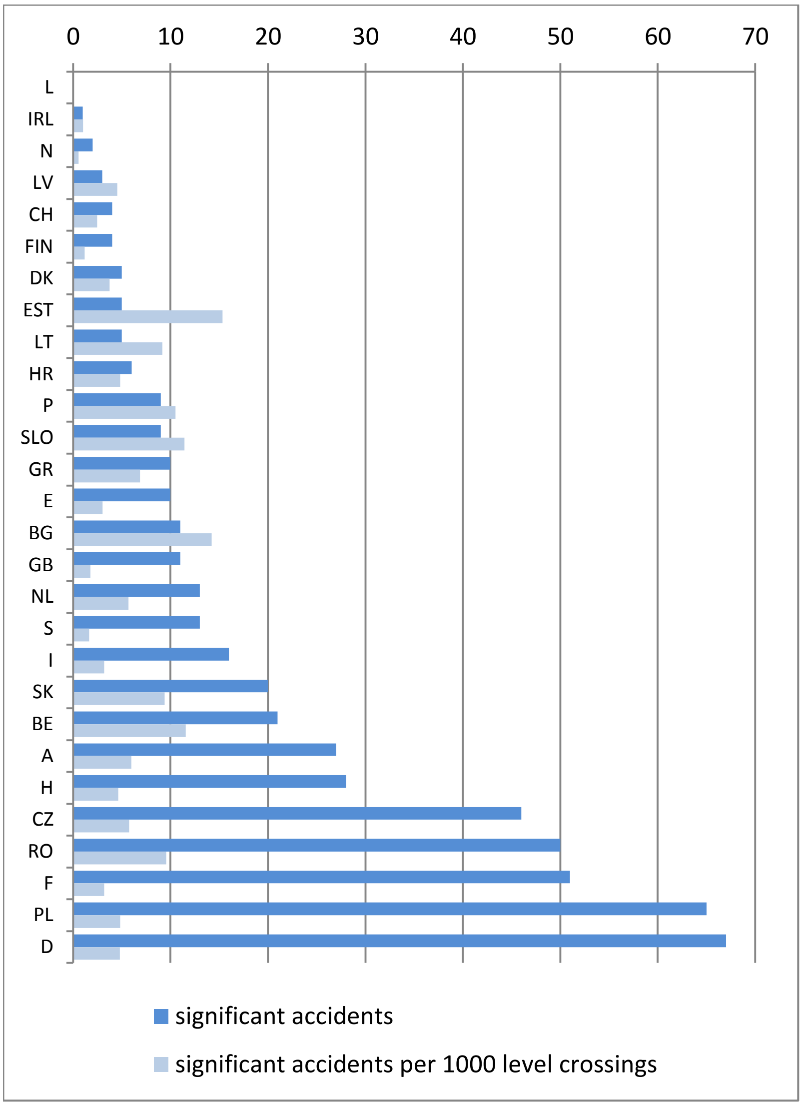
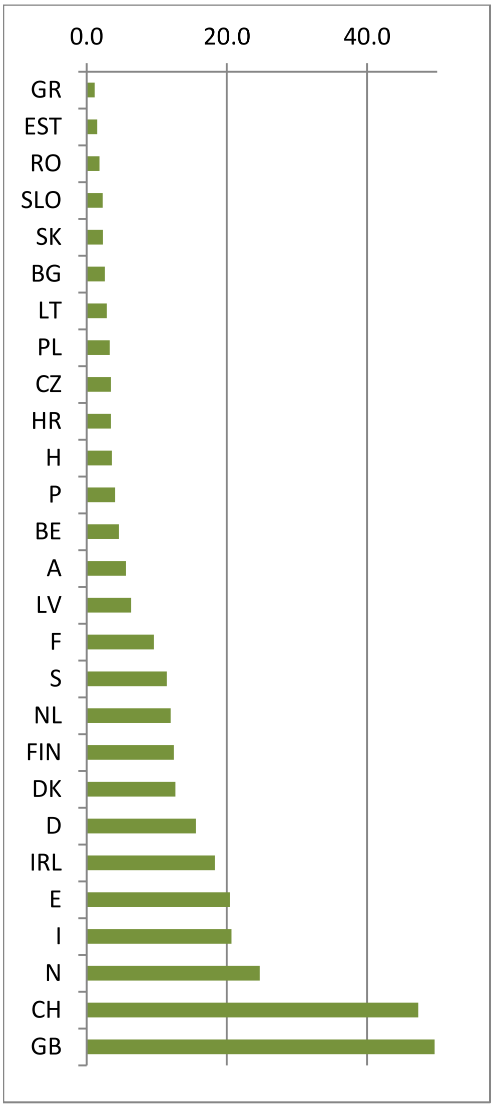


Figure 9: Million train kilometers driven per accident, ERA countries, 2014



Source: ERA database, UNECE secretariat calculations

34. Available data for other countries:
See excel file 'data-non ERA countries' Figures 8 and 9

35. The average annual number of users killed at level crossings varied considerably in the ERA countries in 2006-14. It ranged from the annual average of less than one user killed (Ireland) to as many as 54 user killed (Poland) (Figure 10). Similar variation exists for the number of users seriously injured at level crossings (Luxemburg 0 users versus Poland 61 users seriously injured) (Figure 11).

Figure 10: Number of level crossing users killed in significant accidents, ERA countries, annual average of 2006-2014

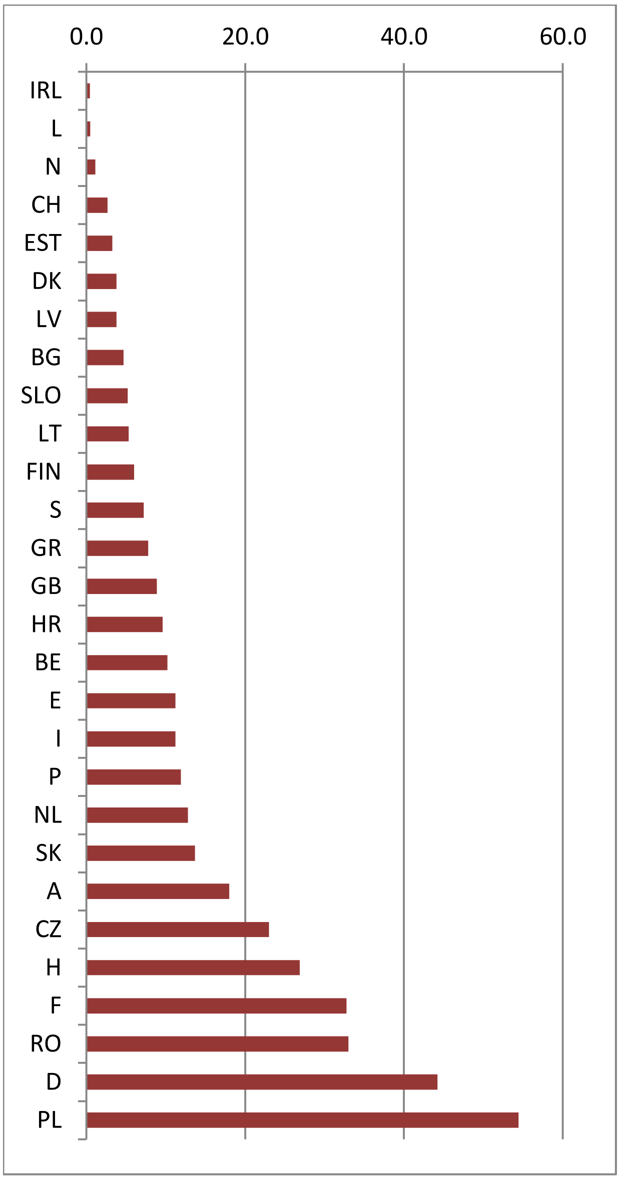
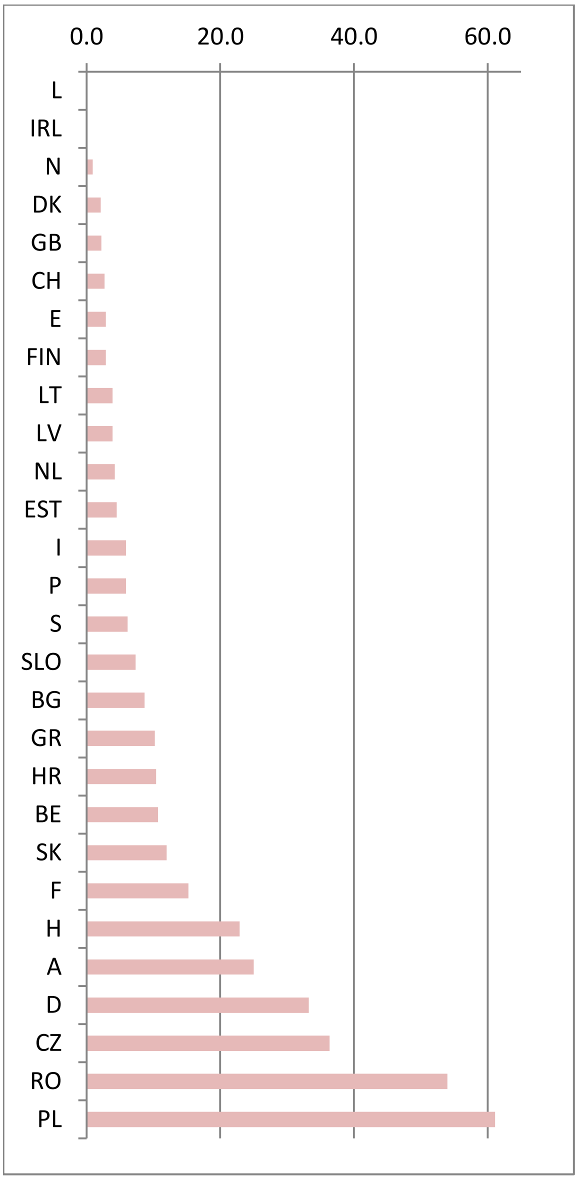


Figure 11: Number of level crossing users seriously injured in significant accidents, ERA countries, annual average of 2006-2014



Source: ERA database, UNECE secretariat calculations

Note: In Croatia calculated for 2010-2014, in Czech Republic: 2006-2013, Estonia: 2007-2014, Luxembourg: 2009-2014, Switzerland: 2009-2014.

36. Available data for other countries:
See excel file 'data-non ERA countries' Figures 10 and 11

37. The ERA countries with a higher annual average of significant accidents typically have a higher annual average number of users killed. However, the significant accidents do not always result in fatalities – the number of significant accidents is higher for every country than the number of users killed. At the same time, there are a few ERA countries (Denmark, Netherlands, Portugal and Spain) where a large majority of significant accidents resulted in a fatality or, in other words, there is a high probability of dying in a significant accident in those countries (Figure 12). The probability should however be assessed based

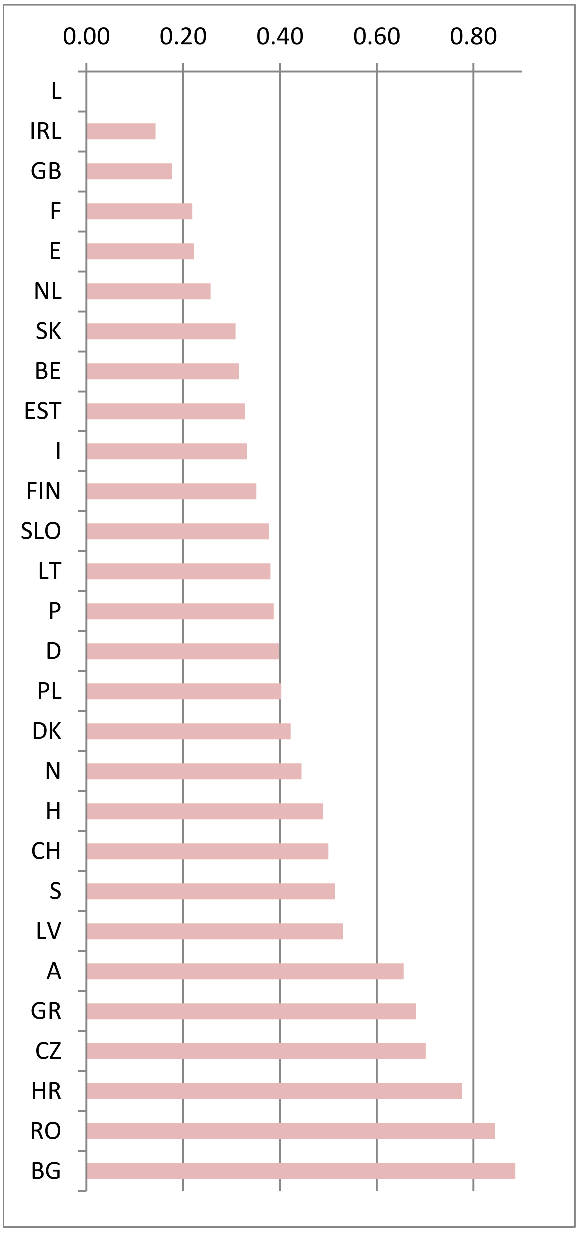
on data available for longer time periods than several years. In any case, based on the short time-series data, the probability of dying can be 1.5 times higher in two countries (Portugal, Spain) than the average for all ERA countries.

38. For several countries (Bulgaria, Romania, Croatia) a large number of significant accidents resulted in serious injuries. Again, these data, if available for longer time periods, can be interpreted as a probability of serious injury (Figure 13). Based on the data available for 2006-2014, the probability of a serious injury can be two times higher in a few countries (Bulgaria, Romania) than the average for all ERA countries.

39. There are several ERA countries that recorded comparatively high probability of dying in a significant accident and at the same time comparatively low probability of serious injury and vice-versa. Two countries (Luxembourg, Slovakia) recorded a comparatively low probability while one country (Croatia) recorded a comparatively high probability for both dying and being seriously injured in a significant accident.

Figure 12: Probability of dying in a significant accident, average annual number of users killed divided by average annual number of significant accidents, ERA countries, 2006-2014

Figure 13: Probability of being seriously injured in a significant accident, average annual number of users seriously injured divided by average annual number of significant accidents ERA countries, 2006-2014



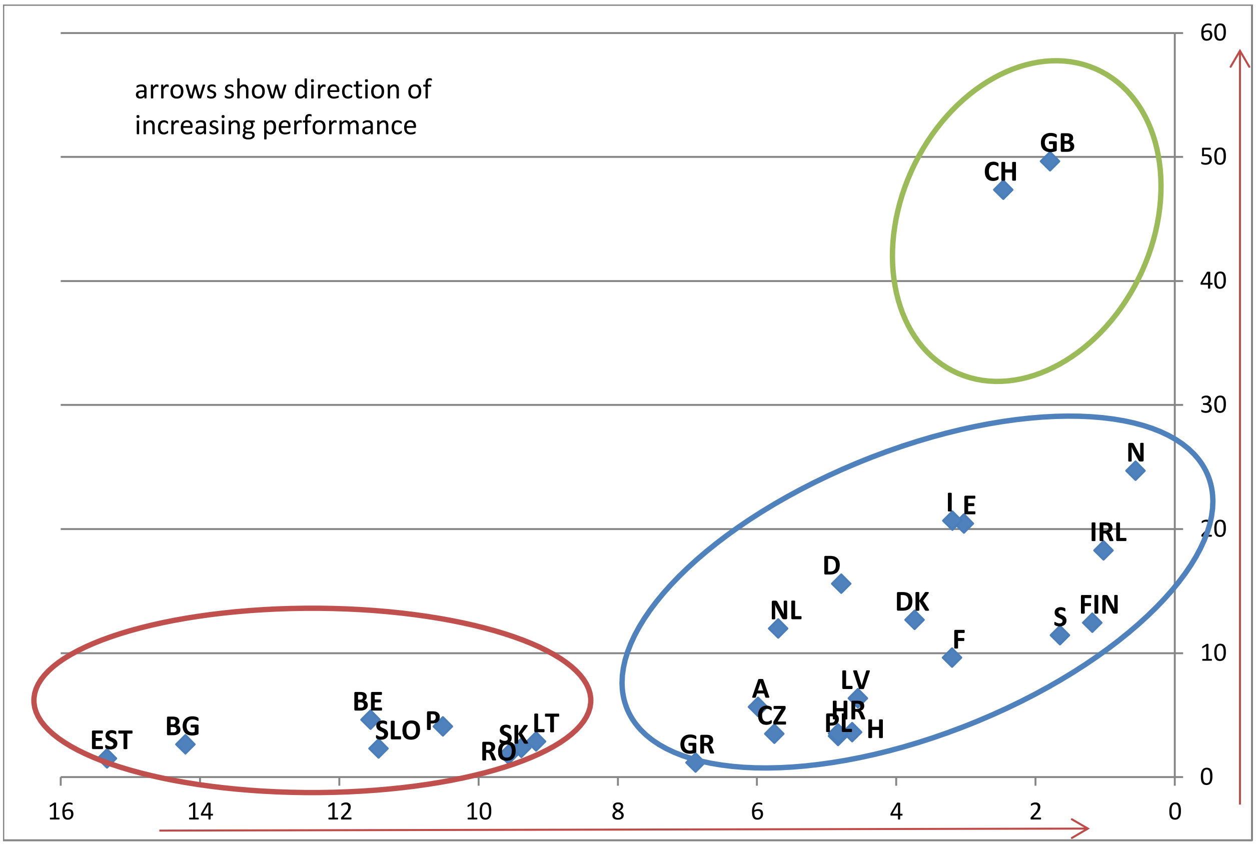
Source: ERA database, UNECE secretariat calculations

Note: Calculations for Croatia for 2010-2014, Czech Republic: 2006-2013, Estonia: 2007-2014: Luxembourg: 2009-2014, Switzerland: 2009-2014

40. Available data for other countries:
See excel file 'data-non ERA countries' Figures 12 and 13

41. Given that fatalities and serious injuries are a result of significant accidents, the performance of safety at level crossing can be best assessed looking at significant accidents relative to both the number of level crossings and the millions of train kilometres driven. The best performance is achieved when most train kilometres are driven for an accident to happen and when there are fewer accidents relative to all level crossings. There are ERA countries (Switzerland and United Kingdom) that are outliers in this assessment (Figure 14).

Figure 14: Safety assessment of level crossings, significant accidents to number of level crossings versus million train kilometers driven, ERA countries, 2014



Source: ERA database, UNECE secretariat calculations

42. Available data for other countries:
See excel file 'data-non ERA countries' Figure 14

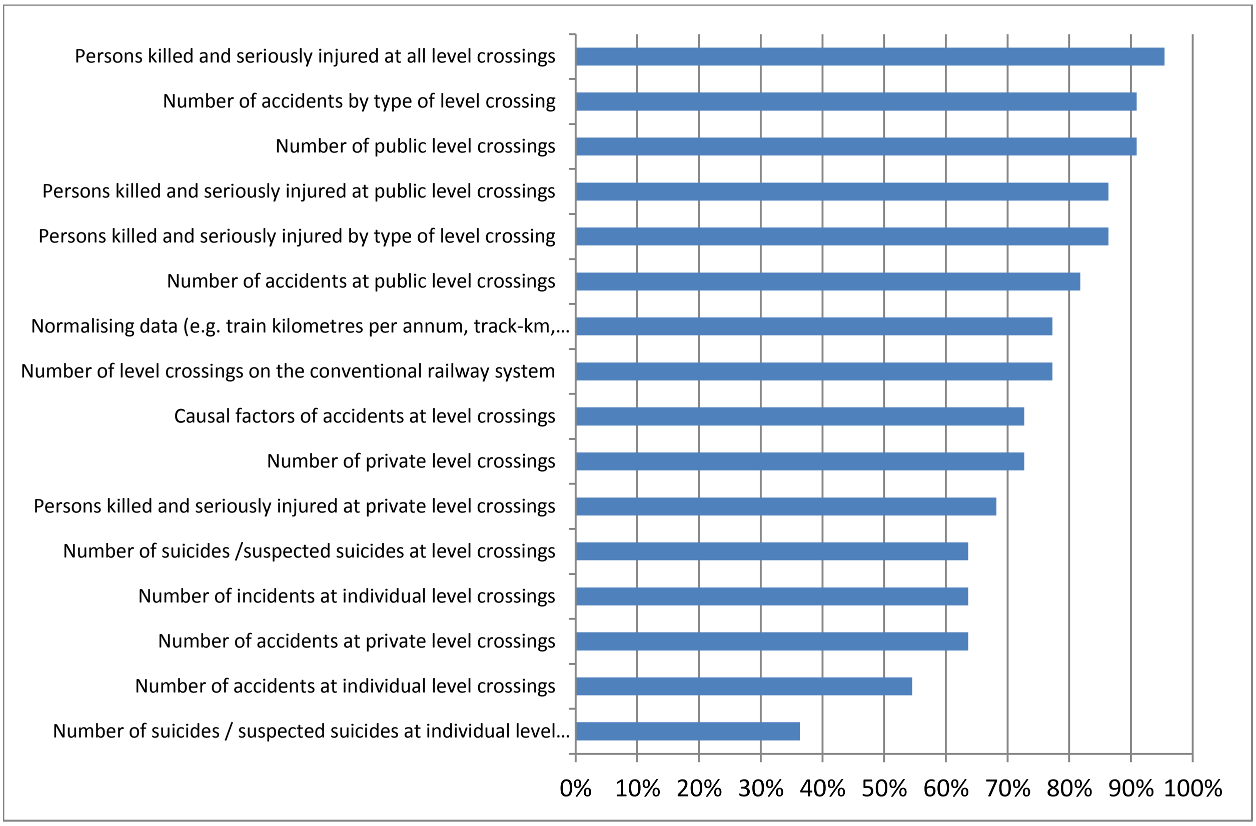
Data on safety at level crossings in UNECE member countries and other selected countries

Assessment

43. The Group of Experts reviewed through the survey the issue of collection and use of data on level crossing.

44. The survey results show that countries, generally, collect a vast array of data on level crossings. The data pertain 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 suicides data are also collected. Many countries normalize the level crossing data by relating them to rail traffic volumes or network length data (Figure 15).

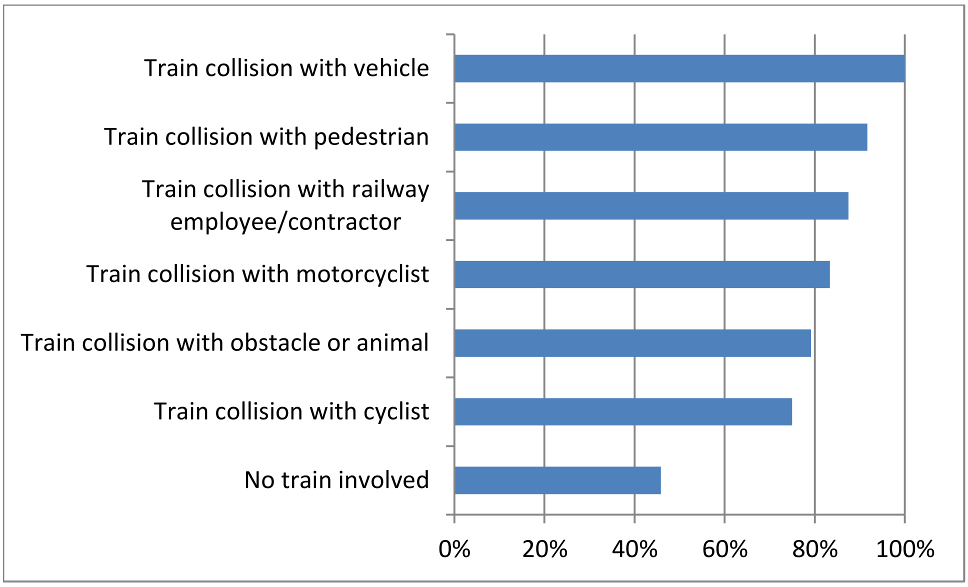
Figure 15: Type of data collected on level crossing and safety of level crossing, UNECE countries and other selected countries,



Source: UNECE survey, UNECE secretariat calculations
Note: Based on responses from 23 countries except Lithuania. 100% means type of data collected by all responding countries.

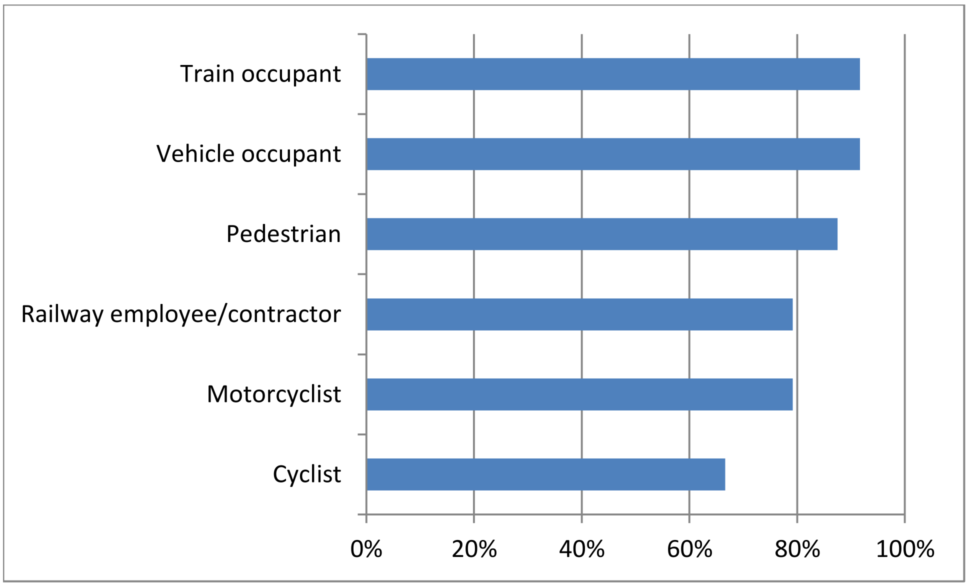
45. Regarding the data on accidents, fatalities and injuries, responding countries reported their collection as totals and at disaggregated levels. The accident data are in many countries collected per type of level crossing users, on collisions with obstacles or animals and accidents without involvement of a train (Figure 16). The fatalities and injuries data are also disaggregated at the level of level-crossing specific user or train occupants (Figure 17).

Figure 16: Disaggregation of accident data by type of level crossing user, UNECE countries and other selected countries



Source: UNECE survey, UNECE secretariat calculations
Note: 100% means type of data collected by all responding countries.

Figure 17: Disaggregation of fatalities and injuries data by type of level crossing user, UNECE countries and other selected countries.



Source: UNECE survey, UNECE secretariat calculations
Note: 100% means type of data collected by all responding countries.

46. 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 developing national and local 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 (e.g. United Kingdom).

47. The responding countries also reported on the data production methodologies and data publishing. As far as the methodologies are concerned, 16 out of 17 countries of the

European Union and one other country (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.

48. As far as publishing of data is concerned, the responding countries informed about authorities responsible for data publishing. In many countries there is just one authority, usually the 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.

49. 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 available (e.g. Internet). There seems thus to exist a gap between the reported and actual data availability for international use.

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

Recommendations

51. The Group of Experts agreed this challenge should be addressed in the near future. To this end, the Group of Experts recommended a set of level crossing safety indicators (Table 1) that UNECE countries should be invited to collect and publish. These indicators should be produced in accordance with the common definitions, as based on the Eurostat/OECD/UNECE methodology (Annex XX) and be reported to UNECE which should maintain a common level crossing database for all UNECE member States. Other countries should be encouraged to also report data to UNECE using the agreed data definitions.

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		
	3	1,000 level crossings		
Level-user characteristic	4	Total level crossing user	4.1	Pedestrians
			4.2	Cyclists
			4.3	Motor-vehicle user
			4.4	Other level crossing user
	5	Railway passengers		
	6	Railway employee		
	7	Other persons (excluding trespassers)		
Type of level crossing	8	Total number of level crossings		

Table 1. Indicators for assessing safety performance at level crossings

Issue	Main indicator		Sub-indicator	
	9	Passive level crossings		
	10	Active level crossings	10.1	Manual
			10.2	Automatic with user-side warning
			10.3	Automatic with user-side protection
			10.4	Rail-side protected
Type of accident	11	Total number of fatal accidents	11.1	Indicator 11 per ind. 1
			11.2	Indicator 11 per ind. 2
			11.3	Indicator 11 per ind. 3
			11.4	Indicator 11 per ind. 8
			11.5	Indicator 11 per ind. 9
			11.6	Indicator 11 per ind. 10
			11.7	Indicator 11 per ind. 10.1
			11.8	Indicator 11 per ind. 10.2
			11.9	Indicator 11 per ind. 10.3
			11.10	Indicator 11 per ind. 10.4
	12	Total number of significant accidents	12.1	Indicator 12 per ind. 1
			12.2	Indicator 12 per ind. 2
			12.3	Indicator 12 per ind. 3
			12.4	Indicator 12 per ind. 8
			12.5	Indicator 12 per ind. 9
			12.6	Indicator 12 per ind. 10
			12.7	Indicator 12 per ind. 10.1
			12.8	Indicator 12 per ind. 10.2
			12.9	Indicator 12 per ind. 10.3
			12.10	Indicator 12 per ind. 10.4
	13	Total number of all railway accidents	13.1	Indicator 12 per ind. 1
			13.2	Indicator 13 per ind. 2
			13.3	Indicator 13 per ind. 3
			13.4	Indicator 13 per ind. 8
			13.5	Indicator 13 per ind. 9
			13.6	Indicator 13 per ind. 10
			13.7	Indicator 13 per ind. 10.1
			13.8	Indicator 13 per ind. 10.2
			13.9	Indicator 13 per ind. 10.3
			13.10	Indicator 13 per ind. 10.4
Fatalities	14	Total number of persons killed	14.1	Indicator 14 per ind. 1
			14.2	Indicator 14 per ind. 2
			14.3	Indicator 14 per ind. 3

Table 1. Indicators for assessing safety performance at level crossings

Issue	Main indicator		Sub-indicator	
			14.4	Indicator 14 per ind. 4
			14.5	Indicator 14 per ind. 4.1
			14.6	Indicator 14 per ind. 4.2
			14.7	Indicator 14 per ind. 4.3
			14.8	Indicator 14 per ind. 4.4
			14.9	Indicator 14 per ind. 5
			14.10	Indicator 14 per ind. 6
			14.11	Indicator 14 per ind. 7
Injuries	15	Total number of persons seriously injured	15.1	Indicator 15 per ind. 1
			15.2	Indicator 15 per ind. 2
			15.3	Indicator 15 per ind. 3
			15.4	Indicator 15 per ind. 4
			15.5	Indicator 15 per ind. 4.1
			15.6	Indicator 15 per ind. 4.2
			15.7	Indicator 15 per ind. 4.3
			15.8	Indicator 15 per ind. 4.4
			15.9	Indicator 15 per ind. 5
			15.10	Indicator 15 per ind. 6
			15.11	Indicator 15 per ind. 7

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

Assessment of costs of level crossings accidents in UNECE member countries and other selected countries

Assessment

52. The Group of Experts also examined through the survey the economic costs of accidents at level crossings in UNECE member countries and other selected countries.

53. The survey shows that only in eight (Belgium, Greece, Hungary, India, Ireland, Norway, Switzerland and United Kingdom) out of 24 surveyed countries the costs of level crossing accidents are aggregated at the national level. This is done by various actors and 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).

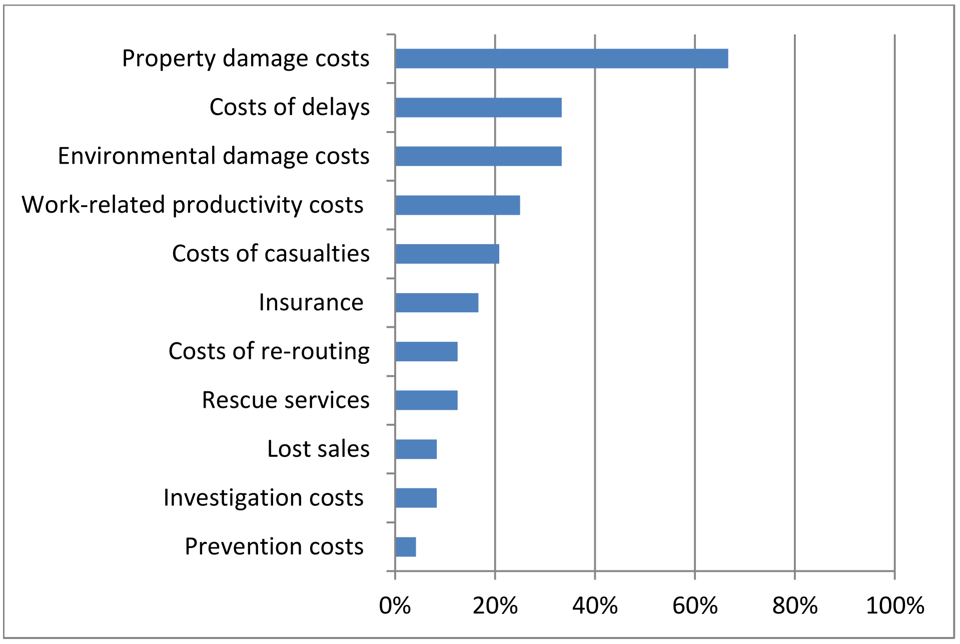
54. The motivation for establishing level crossing accidents costs and collecting relevant statistics vary between countries: They serve as input to national safety plan (India, Greece); they are reported to ERA under Common Safety Indicators (CSI) data (Belgium, Ireland); they are established as they represent criteria for accident notification (Switzerland); they are used in cost-benefit studies (Hungary) or they are collected for statistical purposes (Norway).

55. 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 would 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.

56. 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 18).

Figure 18: Type of costs registered for individual accidents at level crossings, UNECE countries and other selected countries



Source: UNECE survey, UNECE secretariat calculations.

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

57. 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 Fatality (VPF), Developing Harmonized European Approaches for Transport Costing & Project Assessment (HEATCO), or expert opinion.

58. In conclusion, the Group of Experts noted that the assessment of costs of level crossing accidents is not undertaken in many UNECE countries, and in countries where such assessment is done, they do only cover a few of the types of attributable costs. Moreover, only a few of the UNECE member countries aggregate the cost data at national level.

59. At the same time, the Group of Experts acknowledged that no or little information about the accident costs represents a limitation to making an effective judgment on public spending for safety at level crossings. Among others, this is due to the fact that this lack or little information translates into a difficulty to attract decision makers attention to the matter as well as it implies a reduced ability to apply risk-based decision making to safety improvements at level crossings.

Recommendations

60. The systematic quantification of the costs of level crossing accidents should be applied in all UNECE countries. Therefore, the Group of Experts agreed on a taxonomy (categorization of accident attributable costs) for assessing costs of level crossing accidents (table 2, annex ZZ) that UNECE member countries should be invited to apply every individual level crossing accidents as well as to establish annual accident cost values at national level.

Table 2, Taxonomy of attributable costs of level crossing accidents

Effect	*Impact*	*Cost Component*
Primarily	Direct	Property Damage
		Other direct costs
	Indirect	Work-related productivity loss
		Tax loss
	Intangible	Quality of life
		Pain and suffering
Secondary	Supply chain disruption	Rerouting and increased emissions
		Freight and passenger delays and reliability
		Increased inventory and its spoilage
		Prevention
		Lost sales

Source: Group of Experts based on TRB/NCHRP report N. 755

Use of enforcement by UNECE member countries and other selected countries to prevent unsafe conditions at level crossings

Assessment

61. The Group of Experts assessed through the survey the use of enforcement by UNECE member countries and other selected countries for improving user behavior at level crossings.

62. The survey shows that 18 of 24 surveyed countries carry out some enforcement activities at level crossings and five countries (Estonia, Georgia, Norway, Spain and Sweden) do not.

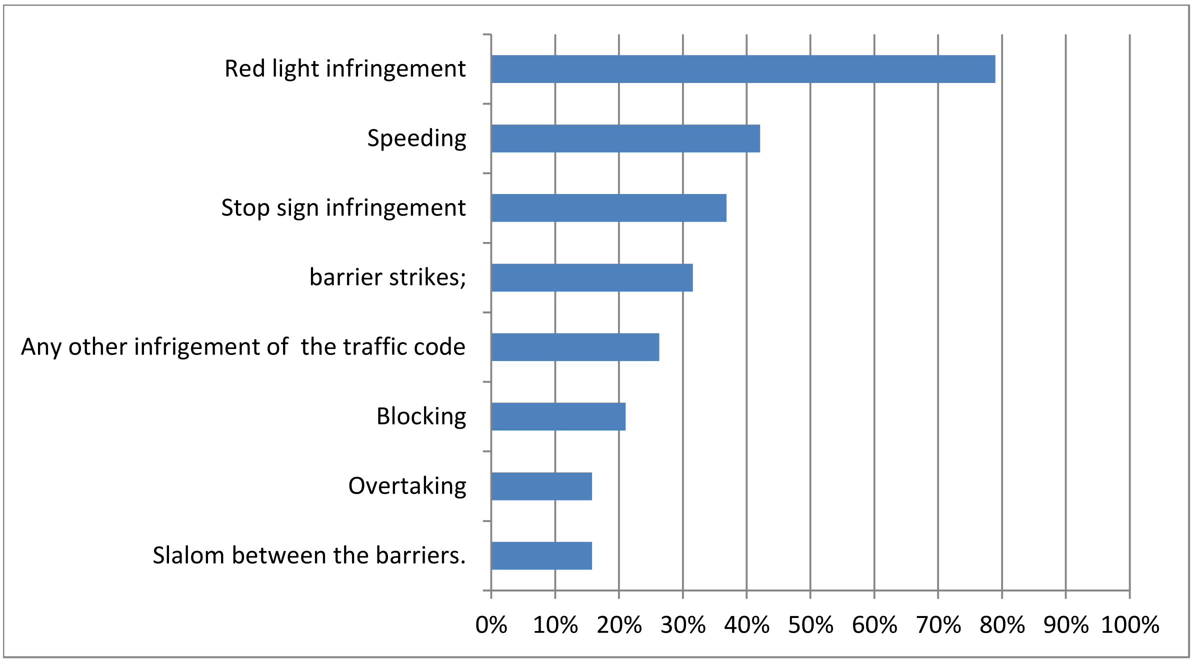
63. The enforcement is carried out according to the legislation in force. All the surveyed countries informed that they have laws in place around public behaviour at level crossings. In particular, regulations covering road vehicle drivers at public road level crossings appear to exist in all countries. The regulations covering pedestrian users of public level crossings seem to exist in many but not all the countries. For example, this is not the case in the

United Kingdom where the applicable regulations do not apply to pedestrians, which creates a potential weakness for enforcing safe use of level crossings by pedestrians.

64. The legislation for private level crossings is found inconsistent and fragmented in countries where private level crossings exist, for example in United Kingdom.

65. The surveyed countries informed on the various types of violations falling under enforcement. The most enforce violation seems to be red light infringement followed by speeding at level crossing and stop sign infringement (Figure 19).

Figure 19: Types of violations enforced, UNECE countries and other selected countries



Source: UNECE survey, UNECE secretariat calculations

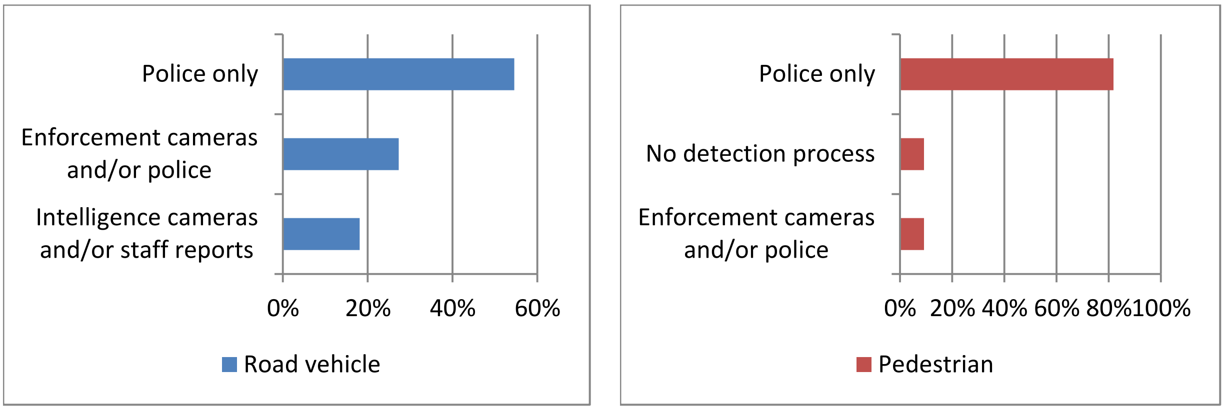
Note: 100% means type of violation enforced by all responding countries applying enforcement.

66. All surveyed countries stated that the police were responsible for enforcement of public road crossings, with one country (not clear which one) stating that the infrastructure owner also had some responsibility for enforcement on public road level crossings alongside the police(the term ‘police’ included national, regional or railway police).

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

68. As for detection methods, the prevailing method seems to be detection of violation by the police, based on responses from 11 surveyed countries, for both road vehicle violations as well as pedestrian violation at public level crossings (Figure 20).

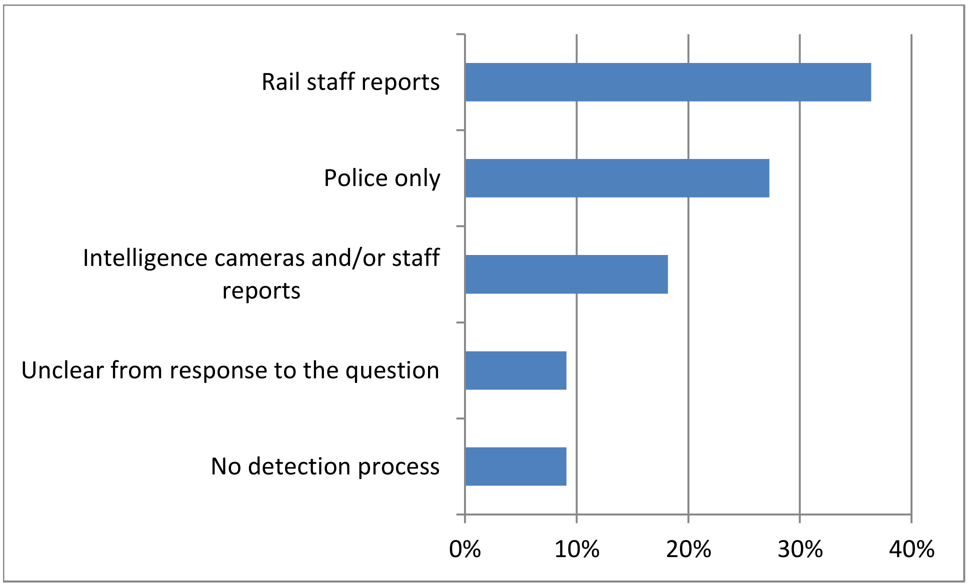
Figure 20: Detection methods at public level crossings, in per cent, UNECE countries and other selected countries



Source: UNECE survey, UNECE secretariat calculations

For private level crossings, a relatively greater onus is placed on rail staff while some surveyed countries have no method of detecting violations (Figure 21)

Figure 21: Detection methods at private level crossings, in per cent, UNECE countries and other selected countries.



Source: UNECE survey, UNECE secretariat calculations

69. At the same time, the surveyed countries informed that the detection of violations is a challenge. The use of police officers 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 – including the safety and welfare of officers – means that 24 hour, 7 days per week enforcement work could never be provided by the police. Detection of violations through police only is, therefore, sporadic and dependent on resources and tasking commitments.

70. However, technology to support enforcement is emerging. Enforcement cameras are being introduced in some UNECE countries. However, even in those countries, cameras are only in place at a tiny proportion of level crossings. For example, in the United Kingdom, 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 (representing 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 cameras in situ. The placement of detection technology is often decided on the case by case basis. Typically, countries decide to deploy detection technology at the level crossings that have had accident history and based on risk assessment/structured expert judgement.

71. While the police cannot provide extensive coverage and detection technology is used rather sporadically, users know that the probability of detecting violations at level crossings is low.

72. As for punitive measures, the most wieldy used punishments seem to be fixed penalty charges (fines) and demerit points on driving permit or loss of it for road vehicle drivers (based on responses of eight countries). For the most dangerous offences, violations can lead to prison sentences in two countries (Hungary and United Kingdom). Two countries use driver re-education programmes (Spain and United Kingdom). Interestingly, in two countries the abuse of safe protocols at private crossings can lead to removal of access rights (France and Spain).

73. In conclusion, the Group of Expert found that there are inconsistent legislative provisions to support enforcement at private level crossings. The result of this is that some countries do not effectively enforce compliance with legislation and safe protocols at private level crossings.

74. The Group of Expert 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 extensively anywhere at this time. Even in countries with emerging detection technology, infrastructure managers still mainly rely on police for detection. Inevitably the police cannot provide extensive coverage, therefore, users know that violations at level crossings are unlikely to be detected and result in punishment. Technology offers a potential solution to this problem, it could provide wide-scale permanent and consistent detection coverage across the level crossing estate.

75. 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. 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 optimised. 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 roll out of technology throughout countries.

Recommendations

76. The Group of Experts has agreed 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.

77. As far as the roll out of violation detection technology is concerned, the Group of Experts agreed that more assessment of the effect of enforcement technology on user behavior is needed. To this end, the Group of Experts recommends countries to carry out jointly a 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 reduce once detection technology has been installed at level crossings, if so by how much, and whether the beneficial effect is long term.

78. The role of the police in enforcement is worth further research.

Analysis of human factors in UNECE member countries and other selected countries to prevent unsafe conditions at level crossings

Assessment

79. The Group of Experts assessed through the survey the attention UNECE member countries and other selected countries give to human factor analysis for improving safety at level crossings.

80. The survey shows that all 22 surveyed countries recognize human factors as main causes behind accidents at level crossings. Among them, countries refer in particular to users' failure and a lack of risk awareness but also to users' lack of care or distraction.

81. Two-thirds of the surveyed countries informed that they have a range of solutions in place to address human factors as a cause of accidents at level crossings. These countries refer mainly to awareness campaigns and technological solutions such as level-crossings closure or replacement with over- or underpasses as well as installation of obstacle detection devices on trains. One-third of the surveyed countries informed of not possessing any solutions to handling human factors at level crossings.

82. A closer look into the solutions revealed that as far as the awareness campaigns are concerned, they are of general nature and may not address specific accident causative human factors. The technical solutions have limited application due to financial inability to replace level crossing 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. The closure of level crossings may also be impossible due to existing legal rights.

83. The countries informed that they do not possess any research studies on human factors.

84. In conclusion, the Group of Expert found that there seems to be little experience and good practice in UNECE countries with addressing specific causative human factors. It was further noted that any existing solutions and tools are not knowledge or research based. They are often technology focused and implemented based on a trial-and-error method. The awareness raising campaigns were found to have limited effect if being of general nature rather than being dedicated to specific accident causative human factors at level crossings.

Recommendations

85. The Group of Experts agreed that human factor analysis and specific solutions to accident causative human factors should be put in the center 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 recognized as main causes of accidents at level crossings, so that more human factors specific solutions are worked out and tested, including for the design of level crossings. In this context, the Group of Experts recommends countries to carry out jointly a project that would lead to a development of a standardized toolbox for

human factors analysis at level crossings. Such a toolbox should standardize the assessment of usage of level crossing, the investigation of accidents specific to causative human factors and, analysis of solution development and their validation.

86. The Group of Experts also invites countries to strengthen their own research on human factors, in particular related to accident investigation analysis. It recommends focusing on human factors when developing technological solutions for improving safety at level crossings and to share good knowledge and good practice with other countries.

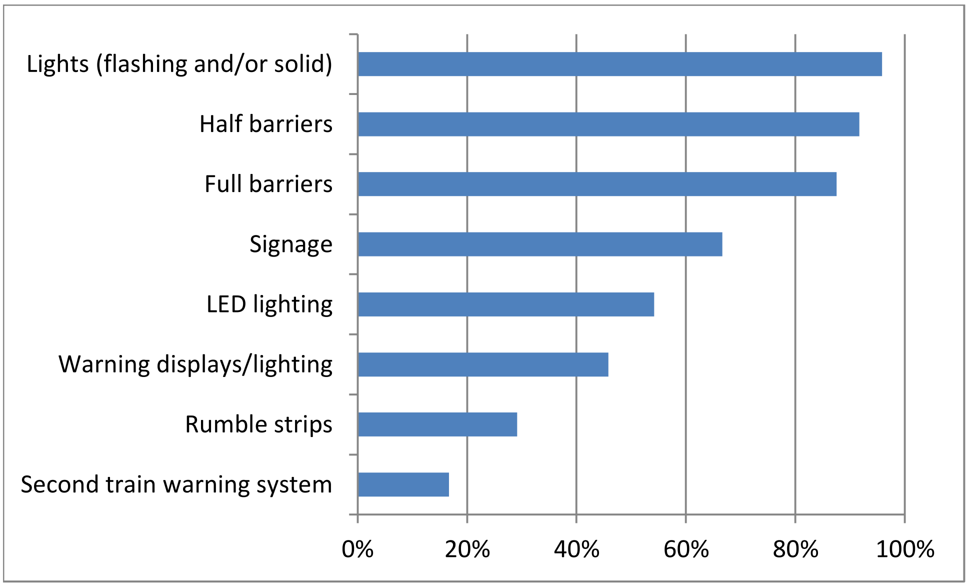
Level crossing infrastructure and technology in UNECE member countries and other selected countries to prevent unsafe conditions at level crossings

Assessment

87. The Group of Experts reviewed through the survey the available infrastructure and technology at level crossings in UNECE member countries and other selected countries to improve their safety.

88. The responses to the survey show that the warning lights, half and/or full barriers are commonly used at active level crossings. Surveyed countries also use, though to a lower degree, LED lighting, rumble stripes and second train warning. There are also some other design layout or arrangements mentioned, for example, design features for pedestrians and cyclists in Belgium such as zigzag system for entering level crossing or small barriers.

Figure 22: Layout of level crossings, UNECE countries and other selected countries



Source: UNECE survey, UNECE secretariat calculations
Note: 100% means type of layout available in all responding countries.

89. As for specific technology, surveyed countries use technologies at the rail side to detect trains such as track circuit, axle counters, mechanical or electronic treadles. There are also systems in place to provide indication to train drivers of the track clearance. Countries use central train control systems and/or intermittent train control systems. There are also systems at user side, based on magnetic sensors built in the road, to give an alert to road vehicle users on approaching a level crossing. GPS technology has been used for

improved information on train position and communications to train and road vehicle drivers.

90. New types of audible warnings, barriers and barrier machines and improvements to the materials used for crossing surfaces and innovations to aid installation and maintenance are largely anonymous to the end user but have realised greater efficiencies.

91. Enforcement systems are also in use. 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.

92. Other are dedicated violation 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.

93. In conclusion, 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 20 years or more. 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.

Recommendations

94. The Group of Experts agreed 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.

95. 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.

Annex XX 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[5])

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).

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

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

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[6]

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.

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

Passage [Item 6.5]

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

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 ZZ Recommend methodology to estimate costs of accidents at level crossings

The recommended methodology provides a high level framework for the categorization of different types of costs. In that model, cost categories are 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. Also considered are the 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—the approach taken to evaluate the cost.

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.

Where the national estimate for the VSL (value of statistical life) is not available, a default VSL/GDP ratio values estimated in IRAP research project could be used instead as follows:

- Value of fatality 70 (60-80) x GDP per Capita
- Value of serious injury 17 (12-24) x GDP per Capita

Regarding the costs of delays and rerouting costs, the method described in the EU legislation (Appendix to Commission Directive 2014/88/EU) should be used. It produces unit estimates of costs due to one minute of delay on the lines directly and indirectly affected by the traffic suspension following an accident. As regards rerouting costs, they may be assumed minor and disregarded if they cannot be obtained from involved parties.