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MODELLING THE RANKING OF LITHUANIAN RAILWAYS LEVEL CROSSING BY SAFETY LEVEL

Summary. The article describes the assessment of safety of Lithuanian Railways level crossing. The statistical analysis of the railway accidents in Lithuania and abroad in recent years has shown that about 30% of all transport accidents in railway occur at railway level crossings. The safety assessment of the country's crossings is carried out considering the following technical criteria: the category of crossing, visibility, the intensity of the movement of trains and road vehicle, the width of the railway crossing, and the maximum speed of trains. Applying the binary model of logistic regression, the probability of accidents at the 337 railway crossings of the country was calculated. Depending on the degree of risk or the probability of accident, the country's railway crossings are ranked. The most dangerous crossings of four regions in the country were identified. Finally, the main conclusions and recommendations are presented.

1. INTRODUCTION

The safety of passenger and freight transportation by railway network has a significant influence on the growth of its attractiveness and competitiveness. Safety is one of the most important "cornerstone" of passenger and freight transportation. This issue is even more important than trip duration and tariffing; however, for the railway transport, it is a complex and complicated problem. The safety of railway vehicle traffic contains a complex set of problems, associated with moving rolling-stock, traffic control automation, as well as the signalling system and infrastructure. So, the railway transport system is susceptible to and comprises many potential risks [1]. The analysis and assessment of these risks in railway should be done to guarantee transportation safety. Assessment of these potential risks should be the basis for rail safety decision-makers, which would allow them to act toward maintaining the safety of the system [6, 15]. The management of the rail transport safety should help to reduce the harmful effect of rail transport on the environment and ensure the interaction between rail transport systems of various countries. Using the available multiple criteria evaluation methods, various researchers have analysed risk management problems associated with traffic safety of rail transport. The researchers Bureika et al [2] offered to apply the Analytic Hierarchy Process (AHP) approach to the evaluation of risks to infrastructure of various elements of the railway system.

Recently, various models for evaluating railway traffic risk and for its management have been offered. The Australian Railways traffic risk management model (ALCAM) was created and implemented as an assessment tool designed to prioritise level crossing safety improvement in the period of 2001-2007. The scientific papers by Ishak et al and Lerner et al [4, 5] presented the level crossing research methods, safety modelling and analysis. The Π–tool based on the Petri net approach model was tested at ten critical level crossing locations in South Australia. Other approaches, including a nonparametric statistical method and the hierarchical tree-based regression (HTBR), which are used for exploring train–vehicle crash prediction and the analysis of risks at passive highway-rail grade crossings, are discussed in the papers of Yan et al [14] and Saccomanno et al [11].

Hu et al [3] analysed several studies about the application of log-it or prob-it models and their versions to fit the data on accident severity on roadway segments. Compared to accident risk analysis in terms of accident frequency and severity of a highway system, the investigation of the factors contributing to traffic accidents at a railway level crossing (thereafter – RLC) seems to be more complicated because of additional highway–railway interactions. A generalized log-it model with stepwise variable selection was used instead to identify the explanatory variables, which were strongly associated with the severity of collisions. Most of the rail traffic accidents are associated with the human factor, involving the violation of traffic regulations on a road or a railway by the vehicle or locomotive driver's non-observance of traffic regulation signals and traffic signs, as well as their dazzling and tiredness, the use of alcohol, etc. [7]. There are low-cost innovative RLC-protection systems available worldwide, with the opportunities for application in Australia due to their effectiveness and appropriateness [12]. Researcher Wullems in his paper [13] discusses major obstacles to the adoption of low-cost level-crossing warning devices (LCLCWDs) in Australia and reviews those trialled in Australia and internationally. The argument for the use of LCLCWDs is that, for a given investment, more passive level crossings can be treated, therefore increasing safety benefits across the rail network.

There is a lot of publications on modelling the risks at level crossings. The statistical risk-estimating technique based on the explanatory variables in the regression was described by Mok and Savage in their paper [8]. Various statistical models are used to examine the relationships between crossing accidents and the features of crossings. Oh et al [9] compared the accident models developed in the United States and the safety effects of crossing elements obtained using the Korean data. The persons killed were mainly highway users, but there were also fatal injuries sustained by the train crew members and passengers.

Authors of the present article suggest a model for ranking Lithuanian RLC based on the logistic regression. During the investigation, the creation of an interactive model of risk management and control for RLCs was suggested. This means that the model had to be easily adjusted to suit the latest statistical data on traffic accidents in the country.

2. RAILWAY LEVEL CROSSING SAFETY PROBLEMATIC

Lithuanian Railways carry approximately 45 million tons of cargo every year. As the shipping volume increases and the rolling stock use intensifies, the risk of railway traffic increases as well. During the period of 2010-2016, 576 traffic accidents occurred in the infrastructure of Lithuanian Railways, including 83 accidents at railway level crossings. Taking into account that an average of 3 persons died at railway level crossings every year during the period of 2010-2016, it leads to approximately 18% of all fatalities in Lithuanian Railways. The number of fatalities and injuries at railway level crossings of Lithuanian Railways during the period of 2010-2016 is shown in Fig. 1.

In order to ensure efficient supervision of railway level crossing safety, it is necessary to determine their safety level. Risk level is used to identify dangerous railway level crossings, which require immediate application of measures for increasing traffic safety.

Ensuring safety at railway level crossings is a significant problem in most countries of the world, just as in Lithuania. There are over 7,000 railway level crossings in operation in Great Britain, of which more than 1,500 are car traffic crossings. Even though the situation according to the number of traffic accidents for one kilometre of railway traffic is among best in Europe (this indicator was approximately 0.01 in 2016), use of ALCRM (All level crossing risk model) has begun in 2007 in order to reduce the risk of traffic accidents at railway crossings [10]. More than 200 independent variables (criteria for evaluation of railway crossing safety) are used for assessment of railway crossing safety: name of railway crossing, its type, geographical location, train flows, speeds, types, tunnels, overpasses, locations of stations, etc. In order to reduce the risk of traffic accidents in railway level crossings and find the most dangerous ones in Australia, a model assessed the statistics of the previous year (place/transition net).

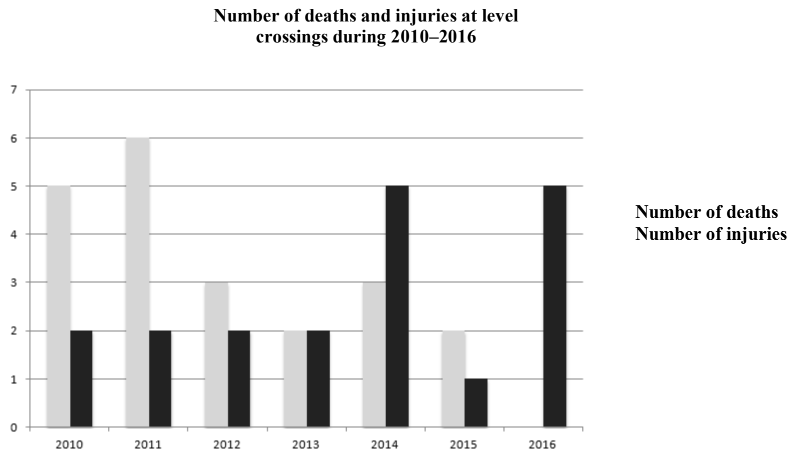

Fig. 1. The number of fatalities and injuries in railway level crossings of Lithuanian Railways in 2010-2016

3. RAILWAY TRAFFIC SAFETY RISK AND CONTROL

In general, safety is assessed as risk. Risk is a potential possibility that a traffic accident with certain probability will occur. Usually, risk is related to vulnerability, threat and damage:

RISK = Vulnerability x Treat x Damage;
or
RISK = Possibility x Damage.

The risk management process consists of risk assessment and its analysis. Risk assessment is the determination of its quantitative and qualitative properties, related to a particular situation or an identified threat. The "volumetric" expression of risk is shown in Fig. 2.

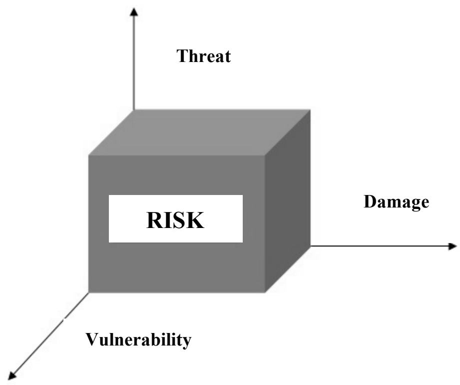

Fig. 2. "Volumetric" expression of risk

As seen in Fig. 2, risk can be expressed as a volumetric relation between threat, vulnerability and damage.

Vulnerability is the whole of certain undesirable safety criteria of a railway level crossing, which influence the occurrence of threats. Vulnerabilities of railway level crossings are the following: poor visibility of the crossing, excessive traffic intensity, high permissible speed of trains, low category of the crossing, absence of signalling installations, poor lighting at nights, etc.

Threat is the whole of certain circumstances that could cause an accident or damage to occur. The most common threats at the railway level crossings are the following:

I. Collision of railway rolling stock with pedestrians crossing the railway at level crossings.
II. Collision of railway rolling stock with vehicles crossing the railway at level crossings.
III. Collision of railway rolling stock with foreign object crossing the railway at level crossings.
IV. Collision with unauthorised persons or foreign objects present in the railway protection zone.

Also, in order to assess the risk at railway level crossings, potential damages and losses of operators of railway infrastructure, passengers and carriers are determined. The data of damage identification according to order of the Minister of Communications of the Republic of Lithuania are presented in Table 1.

Table 1

Damage identification data

Event	Injury of people	Material loss	Damage rate	Calculating value
Disruption	(1 – 5) casualties	up to 100 thousands €	1	0.1
Traffic accident	casualties more than 5	more than 100 thousands €	2	0.2
	group of casualties and 1 death	more than 200 thousands €	3	0.3
Catastrophe	2 deaths	more than 300 thousands €	4	0.4
	more than 2 deaths	more than 500 thousands €	5	0.5
	group of deaths	up to 2 million €	6	0.6
	> 5 deaths	more than 2 million. €	7	0.7

3.1. Aspects of probability of traffic accident on level crossing

In order to determine the traffic safety level at railway level crossings, the probability of traffic accident in them is calculated first. For calculation of such probability, the criteria of level crossings influencing its safety are evaluated.

The safety assessment criteria of a level crossing used in research are as follows:

1) category of the crossing;
2) visibility of the crossing from the odd train driver's cab, m;
3) visibility of the crossing from the even train driver's cab, m;
4) daily train traffic intensity on the main road (in both directions);
5) daily vehicle traffic intensity (including buses, tractors, horse-drawn carriages, and motorbikes) in both directions;
6) width of the crossing, m; and
7) the maximum permissible speed of trains at level crossings, km/h.

Safety criteria of 337 railway level crossings of the country were used for safety level assessment. The crossings were broken down into regions of Vilnius, Kaunas, Klaipėda and Šiauliai. Railway level crossings in Lithuania fall into 4 categories according to vehicle traffic intensity. Category IV level crossings are considered the safest with 0.9, followed by category III – 0.7, II – 0.5 and I – 0.3.

Following assessment of categories of level crossings with mathematical expression, the value of safety assessment criterion $P(Z_1)$ is determined.

According to the rules of installation and operation of level crossings, safe visibility of a level crossing from the driver's cab is 1,000 m. Such or greater distance is assigned the value of 1.0. If safety evaluation criteria of shorter than 1,000 m distances, safety criteria are calculated according to following formula:

$$Z_{2,3} = \frac{M_{driver}}{1000} \tag{1}$$

where M_{driver} is the visibility of the level crossing from the driver's cab, m, and 1000 is the safe visibility of the level crossing, m.

This method is used for calculation of safety evaluation criteria X_2 and X_3. Criterion X_2 is visibility of a level crossing from the even train driver's cab, and X_3 – odd train driver's cab. Evaluation of train traffic intensity safety criterion requires the minimum and maximum daily number of trains at the level crossing. The daily number of trains at a level crossing ranges I_{train} varies from 1 to 202. Traffic intensity of 0 is considered safe and assigned the value of 1.0. Safety assessment criterion of a greater number of trains is calculated according to following formula:

$$Z_4 = 1 - \frac{I_{train}}{202}. \tag{2}$$

The daily number of road vehicles at a level crossing ranges from 0 to 28,695. Vehicle traffic intensity of 0 to 100 is considered safe and assigned the value of 1.0. Safety assessment criterion of greater intensity of vehicles is calculated according to formula:

$$Z_5 = 1 - \frac{N_{\text{vehicle}}}{28695}, \tag{3}$$

where $N_{vehicle}$ is the daily vehicle traffic intensity at a level crossing in both directions, and 28,695 is the maximum daily vehicle traffic intensity at a level crossing in both directions.

Assessment of the safety criterion of width of the level crossing revealed that the narrowest level crossing is 4.3 m wide, whereas the widest is 50.3 m wide. The narrowest crossing is considered the safest; it is assigned the value of 1.0. The safety assessment criterion of wider level crossings is calculated according to the following formula:

$$Z_6 = 1 - \frac{W_{cross}}{50.3}; \tag{4}$$

where W is the width of the railway crossing, m, and 50.3 is the widest railway crossing, m.

The minimum speed of trains determined at a level crossing is 10 km/h, whereas the maximum is 120 km/h. The speed 10 km/h is acceptable and is assigned the value of 1.0. Safety assessment criterion of speed over 20 km/h is calculated according to the following formula:

$$P(Z_7) = 1 - \frac{v}{160}; \tag{5}$$

where v is the maximum determined train speed at level crossing, km/h, and 160 is the maximum permissible train speed at a level crossing, km/h.

4. DETERMINATION OF TRAFFIC SAFETY LEVEL AT LEVEL CROSSING

Authors suggest assessing the safety of railway level crossings as a binary logical regression. Solving it results in an equation which consists of several variables and which expresses the dependence between the traffic safety at level crossings and several quantitative indicators, i.e. it is estimated how a binary variable *Y* (safety at level crossings) depends on one or several variables. Variable *Y* is called the dependent (regressand) variable and variables X_1, X_2, X_3 are called independent variables (regressors). In case of this research, the dependent variable is *safety level at level crossing Y* and independent variables – *safety assessment criteria at level crossings* X_1-X_7.

The Statistical Package for the Social Science (thereafter – SPSS) software package is used for logistic regression analysis. SPSS is one of the most widely used software packages for statistical information processing. SPSS software package is a set of applications used for comprehensive analysis.

Logistic regression model is applied for assessment of safety of level crossings:

$$P(Y=1)=\frac{e^{z(x)}}{1+e^{z(x)}}; \qquad (6)$$

where $z(x)=a+k_1X_1+k_2X_2+k_3X_3+k_4X_4+k_5X_5+k_6X_6+k_7X_7$; *Y* – independent variable (traffic safety at level crossing); k_1-k_7– logistic regression coefficients; X_1-X_7 – independent variables (mathematical expression of safety indicators of level crossings); and a – constant (calculated by using sample data).

First, value *z*(*x*) is determined, followed by probability *P* (*Y* = *1*). Having made the calculations, it is purposeful to check the suitability of the model for the data. Suitability is assessed according to the following indicators: classification table, the maximum likelihood *chi*–square statistics, Hosmer–Lemeshow *chi*-square statistics and coefficient of determination R^2.

Application of logistic regression model to data results in calculation of coefficients of independent variables (of assessment criteria of level crossings) for the data. They can be used to determine which indicators influence the safety of level crossing most. Values of coefficients are given in Table 2.

Table 2

Values of independent variables of the logistic regression model

Variables	Ratio	Standard deviation	Wald statistics	Exponent
k_1 – category of crossing	5.606	1.795	9.752	272.044
k_2 – visibility from even train	1.246	1.295	0.926	3.477
k_3 – visibility from odd train	2.543	1.348	3.559	12.723
k_4 – number of trains	0.824	2.245	0,135	2.280
k_5 – number of vehicles	2.869	1.673	2.939	17.616
k_6 – width of crossing	2.987	1.902	2.468	19.836
k_7 – train speed	0.517	1.815	0.081	1.677
a – constant	10.053	3.193	9.933	0.000

As seen in Table 2, the category of crossing has influenced level crossing safety most with significance ratio of $k_1=5.606$. The width of crossing and the daily number of vehicles crossing the level crossing, with ratios of $k_6=2.987$ and $k_5=2.869$ also have considerable significance, respectively. According to the data, the number of trains passing through the level crossing $k_4=0.824$ and the train speed $k_7=0.517$ are the least significant for safety of level crossing, correspondingly.

In order to check if the selected logistic regression model is suitable for the data, it is necessary to review the main suitability indicators of the model, taking into account the research data.

1. Classification table is one of the most important suitability characteristics of the model. After completing the logistic regression model when *Y* values are known, it should be checked if classification is working suitably. The classification algorithm of the applied logistic regression model is presented in Table 3.

Y value is predicted for specific contemplations and checked if the prediction coincides with the actual *Y* value. The more coincidences, the better the model. As seen from Fig. 1, the model classifies the outcome of each event with accuracy of 93.5 %. It is important to have the most accurate calculations when independent variables are entered. The classification algorithm with use of independent variables is presented in Table 4.

As may be observed from Table 4, the model classifies 95% of target outcomes after entering independent variables $X_1 - X_7$. Since accuracy of the model and classification of the identified *Y* values improved, compared to the initial result, taking into account the classification row, the selected logistic regression model is suitable for this data sample. Good classification is necessary, yet insufficient condition for suitability of a model.

Table 3

The classification model of logistic regression model without independent variables

Contemplations			Presumptions		
			Safety		percentage of right presumptions
			accident will take place	accident will not take place	
Iteration	safety	accident will take place	0	22	0.0
		accident will not take place	0	315	100.0
	Entire percentage		-	-	93.5

Table 4

The classifications model of logistic regression model after entering independent variables

Contemplations			**Presumptions**		
			safety		percentage of right presumptions
			accident will take place	accident will not take place	
Iteration 1	safety	accident will take place	8	14	36.4
		accident will not take place	3	312	99
	Entire percentage		-	-	95

2. Maximum likelihood chi-square statistics indicates if the model has at least one of the necessary regressors. If the statistics value $p \geq 0.05$, the suitability of the logistic regression model is questionable, since all regressors are unnecessary. If $p < 0.05$, the model is suitable for data. *Chi*–square statistical value is presented in Table 5.

Table 5

The maximum likelihood *chi*-square statistics of the logistic regression model

Contemplations		Chi square ratio	Differential	Value
Iteration 1	Iteration	56.074	7	0.000
	Block	56.074	7	0.000
	Model	56.074	7	0.000

As seen from Table 5, this criterion also acknowledges the model as suitable. The statistic value $p < 0.05$.

3. Hosmer – Lemeshow chi–square statistics – this indicator is usually applied to small samples (< 500 contemplations). Since this model only has 337 contemplations, Hosmer – Lemeshow criterion is suitable for assessment of the model. The results are given in Table 6.

The model is suitable for the data, when the Hosmer – Lemeshow statistics value $p \geq 0.05$. Table 6 shows that in the model $p = 0.550$. Therefore, the model chosen according to this indicator is suitable for the data.

Table 6

The Hosmer – Lemeshow chi–square statistics of the logistic regression model

Iteration	Chi square ratio	Differential	Value
1	6.874	8	0.550

Coefficient of determination (R^2) obtains values between 0 and 1. The higher the value, the weaker the link between X and Y and vice versa. The higher the coefficient value, the more the model is suitable for the data. It is undesirable to have $R^2 < 0.20$; in this case, the model cannot be applied. The minimum value of R^2 at which the model is suitable is 0.25. If $R^2 = 0.89$, the model describes the data appropriately.

The value of the coefficient of determination is provided in Table 7.

Table 7

The value of coefficient of determination *(R^2)* of the logistic regression model

Iteration	Possibility function	Determination ratio
1	106.535	0.153

As may be observed in Table 7, the value of the coefficient of determination is rather low, $R^2 = 0.153$. However, contrary to linear regression in the binary regression, this coefficient plays only a minor/secondary role. Therefore, if R^2 value is low, but the logistic regression suits all other criteria, the model is considered suitable for the data.

The values of independent criteria X_i of estimated level crossings are presented in Table 8.

Table 8

The range of variation of the criteria X_i values of the considered RLCs

RLC parameter	Minimal value	Maximal value
Category of level crossing X_1:		
I	0.3	
II	0.5	
III	0.7	
IV	0.9	
Visibility of RLC from the train driver's cab, m:		
even railway line X_2;	0	1000
odd railway line X_3.	0	1000
The number of trains passing by per day X_4, units	1	202
The number of road vehicles passing by per day X_5, units	0	28700
Width of the level crossing X_6, m	4.2	50.3
The train permissible speed X_7, km/h	5	120

5. METHOD OF CALCULATION OF SAFETY AT RAILWAY CROSSING

By using the binary regression model, the probability that the traffic accident will not occur was calculated for railway level crossing P(*Y*=0). In order to evaluate the risk, this probability needs to be converted into probability that the traffic accident will occur – P(*Y*=1). Calculation of the probability:

$$P(Y=1)=1-P(Y=0); \tag{7}$$

where $P(Y=0)$ – probability that the traffic accident will not occur at the railway level crossing; $P(Y=1)$ – probability that the traffic accident will occur at the railway level crossing.

This way the probability that the traffic accident will occur is calculated. Also, in order to assess the risk of railway level crossings, the damage was identified using score between 1 and 7, and the most usual threats at level crossings were assessed using scores between 1 and 4. With knowledge of the values of threats, the probability of the accident and with identification of damages, the risk at railway level crossings can be calculated. The importance of risk is determined by multiplying the probability of the traffic accident by the damage, thus obtaining complex evaluation. A sample of risk evaluation matrix is provided in Fig. 3.

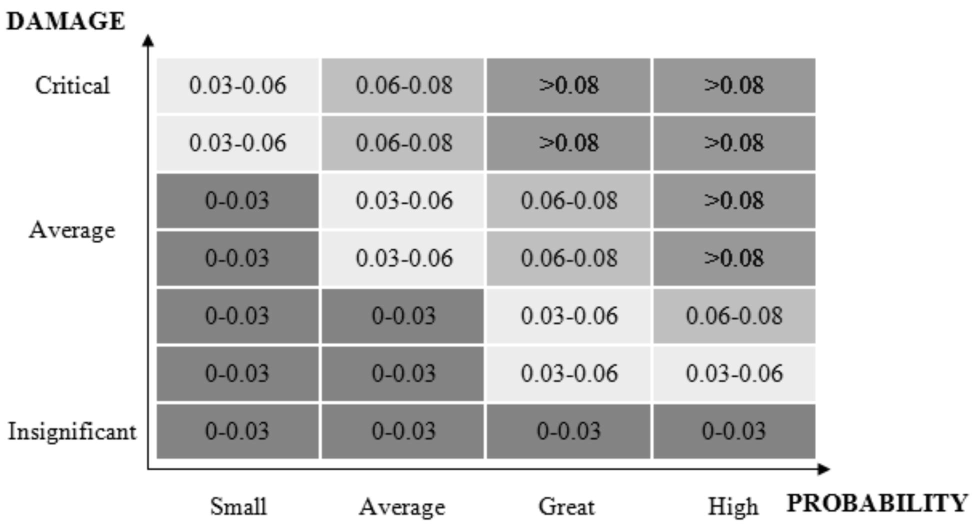

Fig. 3. A sample of safety evaluation matrix: dark grey – high safety, risk value between 0 and 0.03 inclusive; light grey – medium safety, risk value ranges between 0.03 and 0.06 inclusive; medium grey – low safety, risk value ranges between 0.06 and 00.8 inclusive; grey – critical safety, risk value above 0.08

Medium and low safety level is considered acceptable and usually requires no measures. The safety level at level crossings of high safety level must be improved if possible, unless the cost of the applied measures would be excessive and would not buy off. Critical safety is intolerable and requires emergency measures for reduction of the frequency of traffic accidents and the extent of damage. The final ranking data of level crossings are given in the Table 9.

The list of LRC ranking shows (Table 9) that the mostly dangerous 10 crossing of country are of the category I or II. The mostly dangerous crossing is of the category II, but it has a visibility from both sides of only 200 meters. The difference between the risk of the mostly unsafe crossing ranked as the 1st (0.453) and the 22nd ranked crossing risk (0.166) is 2.7 times. The difference between the risk of the most unsafe crossing raked as the 1st (0.453) and the 10th ranked crossing risk (0.297) is 1.5 times. Overall, 10 (45%) of 22 mostly dangerous level crossings of Lithuania are near State border. Moreover, 6 (27%) of 22 mostly unsafe level crossings of Lithuania in 2010-2016 were on Kaunas tunnel roundabout ways.

6. CONCLUSIONS

1. A total of 576 traffic accidents occurred in the infrastructure of JSC "Lithuanian Railways" during the period of 2010-2016, including 83 accidents (14.4 %) at railway level crossings. The traffic accidents at level crossings caused 21 deaths and 19 heavy injuries, i.e. 3 deaths or injuries per year.
2. It was determined that the highest risk (0.453) level crossing is on Kaunas station yard track No.18. Remarkably, the visibility from train driver's cabin on both sides is only 200 meters.

Table 9

List of Lithuanian Railways level crossings ranking by safety level

Rank	Stretch (line), in which crossing is located	Location, km	Cross-road / street	Category of crossing X_1	Visibility from even train driver cabin X_2, m	Visibility from odd train driver cabin X_3, m	Road vehicle number per day X_5	Crossing width X_6, m	Train admissible speed X_7, km/h	Risk value (probability of railway accident)
1.	Kauno station yard	Track No.18	H. ir O. Minkovskių str.	II	200	200	10756	18.0	10	0.453
2.	Kaišiadorys–Kybartai – State border	31+159	Ateities highway	I	800	800	18474	8.0	105	0.399
3.	Kauno tunnel roundabout	3+572	Drobės str.	II	100	150	3413	12.0	10	0.365
4.	Radviliškis–Rokiškis–State border	55+001	Smėlynės str.	II	1000	700	24177	11.8	80	0.345
5.	Vilnius–Kena–State border	2+859	Way No.101	II	200	350	2128	9.0	120	0.339
6.	Kazlų Rūda–Šeštokai	26+440	P. Armino str.	II	400	400	990	24.6	70	0.329
7.	Kauno tunnel roundabout	4+550	Skuodo str.	II	50	300	5536	9.0	10	0.325
8.	Vilnius–Vievis	17+442	Way No. 4727	I	1000	400	2621	8.0	90	0.323
9.	Kyviškės–Valčiūnai	18+456	Way A15	I	600	750	6187	12.0	80	0.308
10.	Vilnius–Kena–State border	4+634	Way V	II	600	200	2012	7.6	120	0.297
11.	Kazlų Rūda–Šeštokai	28+441	Way A5	II	800	800	8603	30.0	70	0.272
12.	Radviliškis–Rokiškis–	56+270	Senamiesčio str.	II	400	1000	19635	9.7	90	0.268

Rank	Stretch (line), in which crossing is located	Location, km	Cross-road / street	Category of crossing X_1	Visibility from even train driver cabin X_2, m	Visibility from odd train driver cabin X_3, m	Road vehicle number per day X_5	Crossing width X_6, m	Train admissible speed X_7, km/h	Risk value (probability of railway accident)
	State border									
13.	Šiauliai–Joniškis–State border	3+840	Birutės str.	II	1000	700	12926	20.5	80	0.264
14.	Radviliškis–Rokiškis–State border	52+530	Pušaloto str.	II	1000	1000	22383	17.0	80	0.262
15.	Kauno tunnel roundabout	2+912	Švenčionių str.	III	150	50	3220	12.0	10	0.234
16.	Radviliškis–Rokiškis–State border	42+736	Way A9	III	1000	1000	6118	50.3	90	0.176
17.	Kauno tunelio roundabout	4+987	Geležinkelio str.	IV	100	100	9712	12.0	10	0.175
18.	Šiauliai–Joniškis–State border	5+040	Sodo str.	II	500	1000	12699	10.8	80	0.174
19.	Kauno tunnel roundabout	1+736	Švenčionių str.	III	200	200	2920	10.0	10	0.174
20.	Kauno tunnel roundabout	5+042	Way No.22	III	50	100	120	6.0	10	0.170
21.	Naujosios Vilnios station side-way	Track No.17	Dūmų str.	IV	10	100	1328	22.1	15	0.169
22.	Šiauliai–Joniškis–State border	8+800	Way A12	II	1000	1000	1975	35.0	90	0.166

3. After applying the logistic regression model according to the selected criteria and calculating the risk in the mostly dangerous level crossings of the country, it may be stated that safety in the level crossings of the country is insufficient.
4. The performed assessment of risk at 337 level crossings revealed that there are 22 level crossings in the country which have critical risk value. It is recommended to install urgently technical means for increasing their safety.
5. It is suggested that the decision-makers of Railway Safety Notification Board should use the safety rating calculation as part of performing a rational planning for the annual schedules of inspection of level crossings of the country and provide JSC "Lithuanian Railways" with prioritised plans for improvement of safety at level crossings.

6. The designed model of assessment of level crossings is interactive; thus, it can be adjusted every year, taking into account the installed (upgraded) technical means for increasing safety at level crossings and the recent occurred traffic accidents.

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