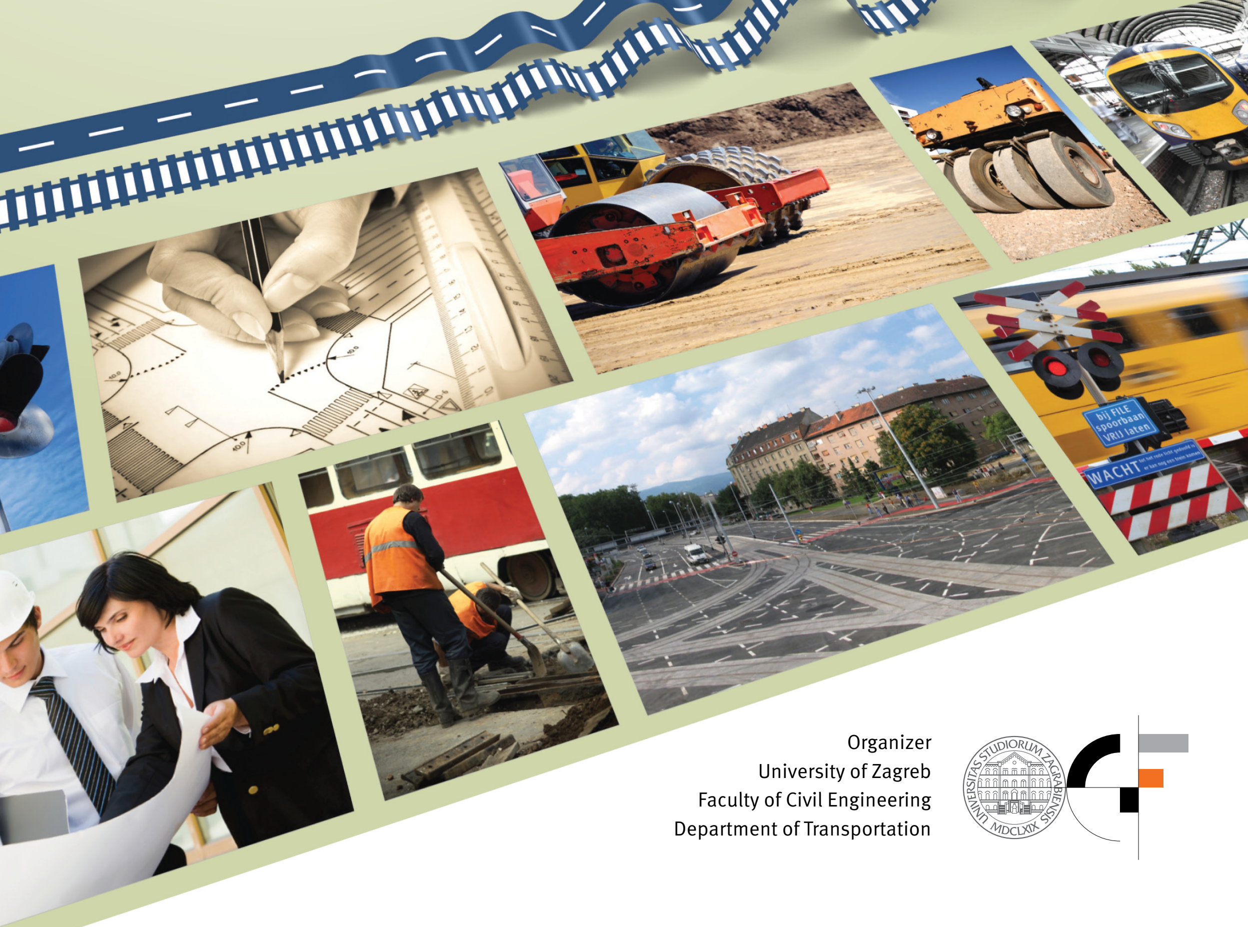
CETRA 2012

2nd International Conference on Road and Rail Infrastructure
7–9 May 2012, Dubrovnik, Croatia

Road and Rail Infrastructure II

Stjepan Lakušić – EDITOR



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Road and Rail Infrastructure II

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SAFETY OF TRAFFIC ON RAIL-ROAD CROSSINGS WITH SPECIAL REVIEW OF EU DIRECTIVES ON TRAFFIC SAFETY- PROPOSALS FOR IMPROVEMENTS

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Abstract

Especially dangerous places for traffic participants are crossings of roads and railway lines in level. The consequences of accidents at rail-road crossings are particularly heavy for participants in road traffic and for pedestrians. Construction of infrastructure facilities and management of the interoperability principles are clearly defined in the EU Directives on the safety of traffic in both branches. Integration of experience with the use of modern innovative solutions can significantly reduce the number of accidents, and the analysis of the current state with international experience can describe the current level of traffic safety and direction of research and selection of tools to improve traffic safety at rail-road crossings. Assessment of safety on site and certification as a tool for improving safety should be uniformed and comparable among all EU countries.

Keywords: rail–road crossings, safety of traffic, accident consequences, SELCAT, EU Directives, safety certificates

1 Introduction

Rail-road crossing (hereafter RRC) is the collision point of the railway and road system on which often events or accidents occur with the most severe consequences and fatal or serious injuries. In traffic accidents at RRC`s, the casualties are mostly road traffic participants and their property is destroyed, although in accidents involving heavy motor vehicles (trucks) there are often serious casualties of railway passengers and workers along with major damage to rolling stock. The conducted analysis of traffic accidents sample on RRC`s point to the conclusion that drivers of road motor vehicles and other participants in road traffic (pedestrians and cyclists) are mostly responsible for causing an accident. Because of these reasons, along with traffic-technical and dynamic features of the railway system and the great stopping length of the train it is necessary to observe the problem from the viewpoint of road users and drivers. It is useful to use international experience, particularly the conclusions of the project SELCAT (Safer European Level Crossing Appraisal and Technology), with the primary objective and purpose of harmonizing approaches to solve this specific problem. SELCAT is a European Commission (hereafter EC) programme for the analysis of safety conditions on RRC`s, which includes 24 partners from 9 European countries, along with Japan, China, India, Morocco and Russia.

2 Rail-road crossings safety analysis

Table 1 The railway network in Republic of Croatia (hereafter RC) in 2010, had total lenght of 2976 km on which there were 1514 RRC (pedestrian crossings included) in level. To illustrate dynamics of solving solutions with elimination an overview is given in Table 1 with data from the period 2005 – 2007. Number of RRC in accordance with security measures and railway importance (HŽ – infrastructure, [6], [12], [15])

Year		2005	2006	2007	2010
International railway (I)	Traffic Sign+ Visibility Triangle	329	320	307	272
	Barrier automatic/mechanic	282	292	309	330
	Total	611	612	616	602
Regional railway (R)	Traffic Sign+ Visibility Triangle	296	297	289	281
	Barrier automatic/mechanic	114	114	114	125
	Total	410	411	403	406
Local railway (L)	Traffic Sign+ Visibility Triangle	471	463	459	433
	Barrier automatic/mechanic	62	60	64	73
	Total	533	523	523	506
Altogether		1554	1546	1542	1514

Safety risk indicator is defined with the density of the RRC in level in relation to the length of the rail network. In Republic of Croatia, it is 0.55 RRC / km which is approximately the density of the RRC in Germany, worse than the density in the UK, but more favourable than the density of the new EU members. (Table 2)

Table 2 Number of RRC per km of railroad (HŽ – infrastructure, [6], [12],[15])

Country	RCC	Km of railway	RCC / km
Germany	21416	37958	0,56
Poland	18517	19599	0,94
Czech Republic	8448	9513	0,89
France	19133	29286	0,65
United Kingdom	7485	16208	0,46
Republic of Croatia	1514	2976	0,50

2.1 Methods of rail-road crossing security measures

In further analysis of the current situation, we can say that in the RC all rail-road crossings are managed in a lawful manner, which includes ensuring road traffic signs and visibility triangle (hereafter TS+VT) or technical security devices: light-sound device (hereafter referred to LI+SO), then LI+SO with half-barriers (hereafter Li +SO+HB), mechanical (half-barriers + guards) or automatic, as well as solution in two levels (denivelation). From the total number of RRC's on HŽ railroads (1514), 986 RCC`s or 65.13% are secured with the TS+VT method. Adverse state of security still exists in nearly 70% of RRC's, of rail and road transport, and it has effect on living and working conditions in local community, further development of the transport system, spatial planning and economic activity where the security of road transport is carried out only with TS+VT especially at the local level. This situation requires continuous systematic measures in finding appropriate technical - technological solutions and an increase in traffic discipline, and traffic culture of the drivers. Due to this fact in 2006th The Program of solving rail-road crossings in Republic of Croatia was adopted (futher PRZCPRH) [5]. The program planned activities and measures: visibility triangle arrangement (VT), the elimination and reduction to the adjacent RRC, elimination without reducing , additional half-barriers to devices, installation of a light-sound device (Li+ SO), installation of a light-sound device with half-barriers (Li+SO +HB) in the period until 2015., and level denivelations that should be completed by year 2020. In the National program [6] it is particularly emphasized that the RRC are neuralgic points in the railway system because most accidents happen there, with the largest number of victims. Solution should respect the PRZCPRH, and ultimately on all remaining RRC's additional safety devices should be installed. Inadequate dynamics of PRZCPRH implementation, among other things, is probably caused by the fact that there is some inconsistency with the 'Program of construction and maintenance of public roads' that were not foreseen or provided sufficient financial resources for successful implementation of PRZCPRH, which should be adjusted in the next period (2012- 2015). This situation requires promotion of the new and partially revised approach in solving this serious problem which involves the analysis of problems and conditions from the point of view of road users. It should be made by synergistic action of all relevant parties and stakeholders responsible for improving the situation. Major role in Croatia should be given to the recently founded Agency of Railway Safety (Act of AZP, Official Gazette 120/08) and the European Agency for road safety on the EU level [10].

2.2 Safety of traffic on rail-road crossings

Traffic safety at the RRC's, as specific intersection places of the railway and road infrastructure, and collision places of the rail and road traffic, should be monitored by the appropriate service in accordance with their legal responsibilities and obligations. Accordingly, in the event of an accident at the RRC in which a person is injured or property damaged police officers perform the investigation. In addition to the standard procedure, the EU Action Plan 2011 - 2020 [14] and the Directive on the management and road safety [9] require active and standardized methods and specific proposals for the elimination of any shortcomings in the areas of traffic accidents. Directive on railway safety in Chapter V, on the other hand also requires the need for an investigation and making safety recommendations, particularly in the case of severe accidents with fatalities [10] . By analyzing data from the Bulletin of safety in road traffic from the Ministry of internal affairs (further MUP) on traffic accidents in the RRC and its consequences in the past decade, in total there are 508 train collision recorded, with an average of 72.5 collisions per year, with a total of 71 persons killed, 98 seriously injured and 209 injured people (Table 3), or an average of 65 collisions with a train.

Table 3 Number of traffic accident-collisions with a train and consequences (Bulletin of the MUP [7])

Year	Number of traffic accident-collision with a train				Consequences of traffic accidents in total		
	Collision with a train	Casualties	Persons died	Injured persons	Persons died	Seriously injured	Less injured
2001	66	28	6	22	7	12	23
2002	72	37	11	26	11	15	26
2003	63	31	6	25	7	11	29
2004	62	28	9	19	11	15	34
2005	87	38	7	31	11	18	34
2006	84	43	15	28	17	18	23
2007	74	31	4	27	7	9	40
2008	44	25	6	19	8	12	20
2009	68	33	9	24	11	13	22
2010	37	19	4	15	6	6	13

2.3 Traffic accidents on rail-road crossings, related with the means of protection

The total number of traffic accidents on RRC's, by type of protection for the period 2001–2010 is presented in Table 4, which also includes those accidents in which there was no collision with a train.

Table 4 The total number of traffic accidents by type of RRC protection (Bulletin of the MUP) [7]

Protection of RRC		LI+SO+HB	LI+SO	'Unprotected' (TS+VT)	Total
Year	2001	243	109	226	578
	2002	250	99	181	530
	2003	290	107	120	517
	2004	283	87	117	487
	2005	274	80	100	454
	2006	311	91	94	496
	2007	303	96	115	514
	2008	253	94	68	415
	2009	305	88	69	462
	2010	278	80	51	409
	Total	2790	931	1141	4862

It is important to emphasize that in relation with the type of protection, all RRC`s in RC are protected , so we can conclude that in the Bulletin of the MUP [7] the term 'unprotected' in fact refers to RRC`S protected with only LI+SO or Li+SO+HB. The analysis of the total number of traffic accidents on RRC`s with casualties, in relation with the method of protection, in the past decade shows that 218 (28.9%) occurred on physically protected RRC's LI+SO+HB, 132 (17.5%) on RRC`s protected only with the LI+SO, and 406 (53.7%) accidents have been recorded on the RRC secured with only TS+VT ('unprotected') as shown in the Figure 1.

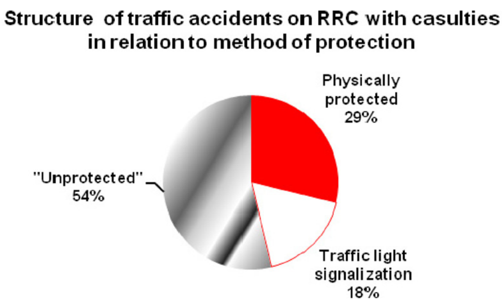

Figure 1 Structure of traffic accidents on RRC with casualties in relation to method of protection (Bulletin of the MUP) [7]

2.4 Consequences of traffic accidents on the RRC`s

Despite detailed analysis of traffic accidents provided by MUP, we must emphasize the need for realistic parameters, and comparable evaluation of absolute and relative data in relation with the number of traffic accidents and casualties and average annual daily traffic (PCU / day) of vehicles that had passed through RRC particular in relation to train kilometres (train km = relative indicator of railroads). Croatian railways (further HŽ) divide extraordinary events (emergencies) on accident, misfortunes and nuisance. The analysis of the condition of traffic safety on RRC follows an extraordinary event with killed and seriously injured people, bigger material damage, or longer interruption of traffic and severe pollution of the environment. HŽ doesn't register minor injuries, mainly due to usually severe consequences of accidents. Methodology for monitoring the consequences of accidents harmonized with the EU directive [10] observes even avoided accidents, or improper passing railroad cars across the RRC, as well as irregular passages of cars and pedestrians. This methodology uses the comparison of the total number of accidents in road traffic and the total number of traffic accidents on the RRC, and compares the total number of people killed in road traffic and the total number of people killed on the RRC in the observed period (Table 5).

Table 5 The ratio of traffic accidents (TA) on the RRC in the total number of traffic accidents (Bulletin of MUP - Table 5)

Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
TA	81911	86611	92102	76540	58132	58283	61020	53496	50388	44394	662877
TA on RRC	578	530	517	487	454	496	514	415	462	409	4862
Ratio (%)	0,706	0,612	0,561	0,636	0,781	0,851	0,842	0,776	0,917	0,921	0,733

Traffic accidents on the RRC in the RC, are 0733% of the total number of accidents in road traffic, which is several times higher than in EU countries where the average number of such accidents is around 0.01%.

2.5 Safety aspects of the RCC`s usage with evaluation

As previously presented, the largest number of accidents on the RRC in the past decade occurred on physically protected RRC`s (2790 - 57%), while twice as many road accidents (1141 - 24%) are recorded on the "unprotected" RRC`s that are not necessarily the most dangerous ones (Table 4). We have recorded that the total number of people killed in the last decade in RC is; 5530 people killed in road transport [7] (p. 80) and a total of 92 persons killed in traffic accidents on the RRC [7] (p. 84) and the proportion of the total number of people killed is 1,664%, which is also a much higher number than in EU countries where the average ratio is below 1% [11]. With long term monitoring and analysis of road traffic at RRC, we noticed an inadequate and improper treatment of participants in road traffic (motorists, bicyclists, pedestrians) and risky manner of the RRC usage and improper crossing of railroad tracks along the worrying trend of increasing accident number at crossings with the highest degree of security and about 550 collisions and fractures of half-barriers annually. This fact confirms the need for systematic training of participants of road traffic on the correct railway line crossing, with the use of repressive measures for contempt of signalling and evasion of half-barriers. Unacceptable form of behaviour of participants in road traffic and violations are often caused by the following reasons and circumstances: insufficient knowledge and perception of the level and types of risk of using RRC's, drivers and pedestrians often have wrong assessment of a sufficient time to cross the railway line before the arrival of the train and they are accepting an improper collateral risk of crossing; Insufficient education and knowledge of proper usage of RRC and understanding of traffic situation and signals due to low frequentation of RRC usage (only several times a year or less); disorientation in certain specific traffic situations, inadequate transport and technical requirements for the safe use of the RRC, the growth of vegetation or newly build objects are often reducing VT on RRC`s that are secured only with TS, then inappropriately placed road traffic signs, and the unacceptably long closure time of RRC for participants in road traffic. The current scope and method of solving the problem with PRZCPRH [5], or the National Railway Infrastructure Programme [6], as previously presented traffic safety indicators at the RRC's are showing the unsatisfactory conditions.

3 International experience – EU Directives and guidelines

Every year, in the EU, on average, more than 1200 accidents occur at RRC where every year 330 persons are killed, which shows the social importance and complexity of the problem of traffic safety on the RRC. Precisely because of this fact a research project 'SELCAT' has been launched. It is a consortium of 24 partners from railway and road sectors, professional institutions and scientific institutions of the EU, Japan, China, India, Morocco and Russia. The project 'SELCAT' carried out the collection of relevant data for the safety of traffic on the RRC, and has published an analysis of the current situation (3.1). In accordance with the EU Directive on the safety of road transport infrastructure [9] it is necessary to audit even an early stage in the planning of each RRC and incorporate the audit tools during building and experience of the 'best' practices. Railway Safety Directive [10] on the other hand also determines the general safety standards and the establishment of model certificates, with periodic audits. With the combination of directives we can form a parallel system with identical guidelines, which can access the system by forming a single audit, security assessment and problem solving on an individual RRC's from the standpoint of both branches.

3.1 SELCAT project

The 'SELCAT' was launched with the support of the European Commission (EC) and with the participation of ADAC (German Automobile Club), which did an extensive research on the safety of traffic on the RRC in Germany with emphasis on use by road traffic participants. Based on the research conducted the following conclusions and assessments of the current situation is: on the RRC's the highest mortality rate from all the European railways was recorded, about 50-80% of all rail accidents (emergencies); altogether with tunnels, specific high-risk areas ("black points") certain sections of roads and rail infrastructure, the RRC`s represent a serious safety issue; Despite the ratification of the Vienna Convention on Road Signs from 1968. by the EU Member States and RC, there is an unevenness of regulations and safety systems that ensure the safety of traffic on the RRC, which implies the necessity of their unification and harmonization at a European level; inadequate VT at a number of RRC, which are not provided with LI+SO, but only with appropriate traffic signs (A49 or A50) 'Andrew's cross' and a STOP sign (B02); disparity of data structures and methodologies and ways of monitoring the safety of traffic on the RRC was determined, which further complicates and impedes uniformity and data comparation (police, road operators, railways); there is no common database and common information system on accidents at the RRC`s in level; the awareness and education of drivers about relevant regulations and functioning of RRC's safety systems has been insufficient; the behaviour of participants in road traffic is dangerous, which mostly happens by accident, and in a smaller number of cases deliberately (Figure 2).

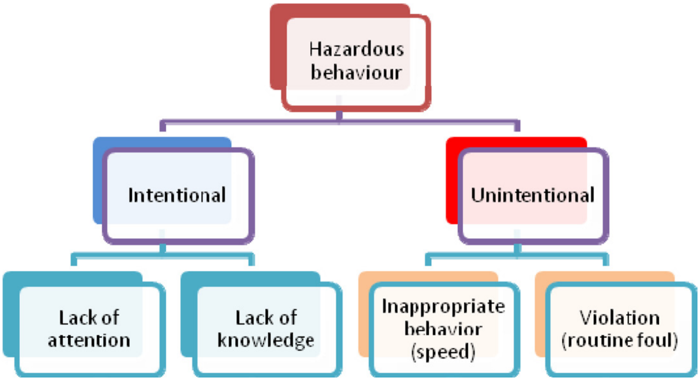

Figure 2 Schematic representation of hazardous behaviour of road traffic participants, Schlag, Fischer, RoBger, TU Dresden, [11]

With conducted extensive research of the reasons and factors that influence the behaviour of participants to make unintentional mistakes in road traffic we came to the realization that it is also conditional upon the following circumstances:

3.1.1 RRC`s usage frequency

Only 18% of road traffic participants use the RRC level on a daily basis while 58% use the RRC`s only a few times a month or less (Figure 3).

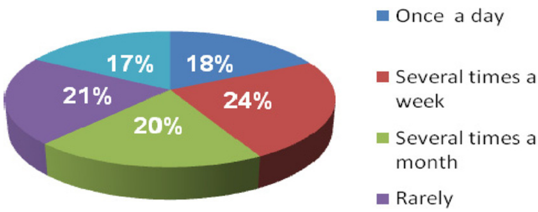

Figure 3 Frequency of RCC`s usage by road participants [11]

Occasional and rare usage of the RRC has resulted in a reduced routine adoption of subconscious patterns of behaviour as opposed to the road intersection with traffic lights that are used daily. It is necessary to bear in mind that the RRC`s are places where complex rules and security systems apply, more then at the regular intersections. For enhancing security of the RRC`s it was suggested that instead of blinking red lights we should use steady red lights like at road intersections, because of the driver routine behaviour (3.1.3).

3.1.2 Driver insecurity on an RRC`s without technical-safety systems

A survey of driver and pedestrian attitudes (Figure 5) shows that more than 50% of participants in road traffic at RRC crossings secured only with the TS + VT feel unsafe, which may adversely affect the acquired forms of routine behaviour, or result in inappropriate reactions.

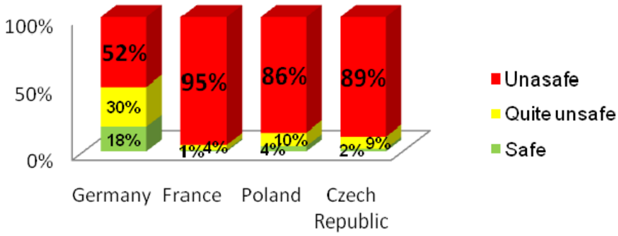

Figure 4 Driver insecurity on RRC`s without technical-safety systems [11]

3.1.3 Misrepresentation of blinking red traffic lights

Blinking red light at the RRC in the level of the signal indicates the term 'Stop' and announces the arrival of the train, which is known to only 57% of surveyed drivers and a high 39% thought that it means 'warning', and that only a steady red light means 'STOP' (Figure 5). This is a result of a routine behaviour adopted at road intersections. This knowledge also indicates the need for changes in regulations and redesigning the RRC in a way to be 'self'–explanatory'. Deliberately dangerous behaviour can be judged as inappropriate behaviour (inappropriate speed), and routine violations.

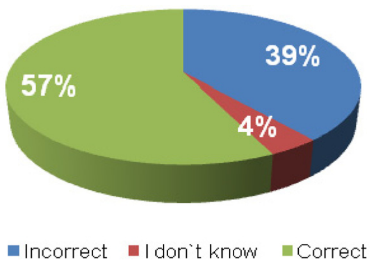

Figure 5 Interpreting the meaning of blinking red lights at the RRC`s [11]

One of the most frequent forms of dangerous behaviour that can be placed in a group of routine offenses is certainly a 'slalom run' (crossing over RRC`s, which are secured by Li+ SO+HB at the time when LI+SO devices are activated, and half-barriers lowered), which is often the result of RRC excessive periods of closure for road traffic. Red phase in road traffic is usually changed to green after 90 seconds (maximum duration), but some RRC`s can be closed to road traffic for up to 10 minutes, or even several times per 10 minutes in one hour (eg. RRC 'Rade Koncar' and 'Krčeni put' in RC). Here, mostly local drivers who daily use this RRC, practice a 'slalom run', and outstrip vehicles waiting at the crossing of the RRC knowingly accepting an increased security risk as collateral, and often 'withdraw' the other drivers behind them.

4 Options and ways of improvement

According to the ratio of traffic accidents and people killed on the RRC's in the total number of traffic accidents and fatalities in road traffic in RC (2.5) we can conclude that the current state of traffic safety at the RRC` is unsatisfactory, and there is a need to undertake and implement series of measures and activities to improve the situation.

4.1 The framework for a multidisciplinary approach

First we need to do a mutual research and safety assessment of the RRC`s (4.2) from the standpoint and with the help of experts from both branches. Then it is necessary to conduct the study of participant attitudes on RRC road traffic in RC. It is also necessary to prepare a revised and harmonized PRZCPRH for the period from 2012 - 2020. By carrying out activities on the standardization of regulations and their harmonization with EU regulations, preconditions for the successful integration of Croatian Railways in the trans-European rail network can be achieved, as well as the achievement of strategic objectives (3). There is an obligation to resolve the issue of certification of equipment and devices as well as the entire RRC and establish a unified database on road accidents and their consequences on the RRC's. It is essential to adopt new technologies and develop alternative design of roads, and enable faster and more effective implementation of administrative and management procedures for obtaining construction permits to perform a procedure for solving the RRC's. An extensive campaign should be launched with the goal to enhance education on regulations, proper behaviour, and knowledge about the dangers and risks of using RRC's for all those involved in road traffic.

4.2 Rail–road crossings safety assessment programme

According to the guidelines and directives of the EU [9], [10] and [13] we suggest the establishment of an international security assessment, which could be implemented within the already wildly accepted EuroTest programme, which has produced very good results in road traffic and has a constant media attention of nearly 120 million Europeans. Testing methodology would be based on parameters that define the safety from the perspective of all RRC users, the machinist, the driver and the pedestrian. Nearly three hundred security parameters would be grouped into categories and evaluated with the help of the Analytic Hierarchy Process method [16]. The 'knockout' system of scoring would be used on a group of parameters (if one of the key parameters is evaluated negatively the whole group gets a lower grade). Along with safety assessment and evaluation on the field, modification factors would be applied in terms of level safety potential and security risk degree coefficients. The safety potential coefficient refers to innovative methods and solutions to reduce the consequences of accidents (safety systems on the vehicle, train or car, modern light signalling, advanced control systems, etc.) and security risk degree coefficient would be calculated from assessment based on analysis of accidents and serious incidents (close encounters and fractures of half-barriers).The parameters would be grouped in following categories with relative proportions of the total score given according to the importance: spatial and temporal design of the RRC (39%) - assessment of the spatial design and technical performance of the crossing, road and railway alignment, built-in materials and state of infrastructure, phases of traffic light signals and crossing signalization design as well as approach signs (traffic signs, 'Andrew's Cross'). Possible intersections and the synchronization of the traffic light before and after RCC would also be taken into account; daylight visibility (20%) - evaluation of VT from the standpoint of the machinist, driver and pedestrian in the daytime visibility conditions documented with photos and the georeferenced video from road vehicle; night time visibility (23%) – same test conducted in night time condition. Improved lighting systems and the application of modern solutions for light signalling can contribute to a better overall score in this two visibility categories; accessibility (18%) - accessibility and assessment of the importance of RCC on the road network (reducing the importance of RCC in the network by redirecting or reducing two or more RRC`s to one). Here, attention is specially drawn to the accessibility for all groups of pedestrians and persons with limited mobility and reduced perception (people with disabilities in a wheelchair, blind or visually impaired and deaf or hard of hearing). In this category the use of modern innovative signalling solutions would be calculated (counting phase, the LED lights) and pedestrians would be directed how to prevent improper crossings. Enormous importance of periodic testing from the standpoint of the consumer is set by the EU directives and guidelines [9] , [10], [13] and [14], where as a tool they recommend implementation of the international comparable tests. The proposal for the certification of the RRC`s, proceeds from the need to raise awareness of public about the problem, and in order to force the legislators and operators to make concrete measures on site. After the testing and certification an international large-scale media campaign would be launched.

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